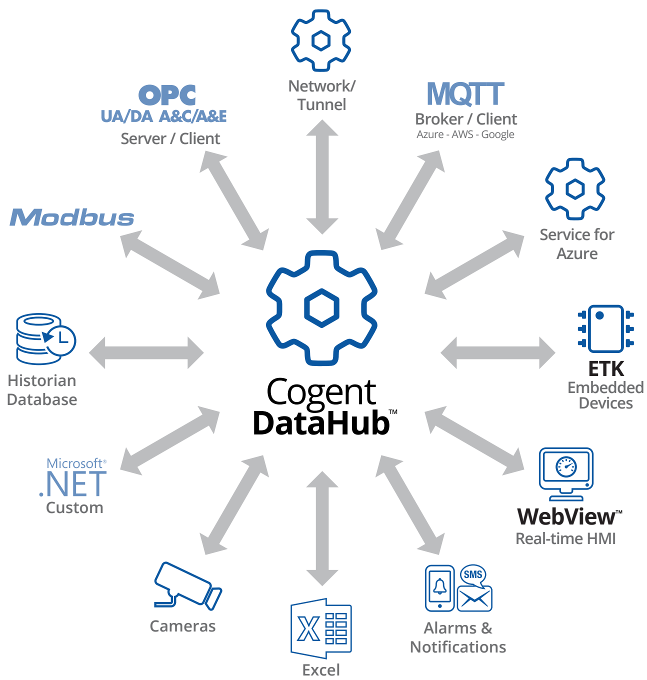
Cogent DataHub™

User Guides



July 3, 2025

Cogent DataHub™ software

Version 11.0

A real-time database used to aggregate and distribute process data among sources and users across secure connections.

Quick Links:

OPC UA | OPC DA | OPC A&E | Tunnelling | Bridging | Redundancy | Write to a Database | Query a Database | Web Server | WebView | MQTT Client | MQTT Broker | Historians | Notification | Modbus | Email/SMS | Camera | Remote Config | Scripting | Security

Data Browser | Connection Viewer | Event Log | Script Log

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System Requirements and Installation

System Requirements

Cogent DataHub software is compatible with the following versions of Windows:

Operating System	Minimum Requirements
Windows Server 2008 & R2	Service Pack 1 (SP1) + .NET 4.6.2
Windows 7	Service Pack 1 (SP1) + .NET 4.6.2
Windows Server 2012 & R2	.NET 4.6.2
Windows 8.1	.NET 4.6.2
Windows 10	.NET 4.6.2
Windows Server 2016	.NET 4.6.2
Windows Server 2019	.NET 4.6.2
Windows 11	.NET 4.6.2
Windows Server 2022	.NET 4.6.2

Installation

To install the DataHub program from an archive downloaded from the Cogent web site, follow these steps:

1. Double-click on the program archive `CogentDataHub-11.0-`*`xxxxxx`*`-Windows.exe`.
2. Follow the instructions.

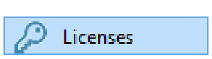
Uninstall

1. From the **Start** menu, select the **Control Panel** and then choose **Add or Remove Programs**.
2. Find **Cogent DataHub** on this list and double-click it.
3. Click the **Remove** button and follow the instructions.

Installing Licenses

You can install DataHub licenses purchased from Cogent using the **Licenses** option in the Properties window.

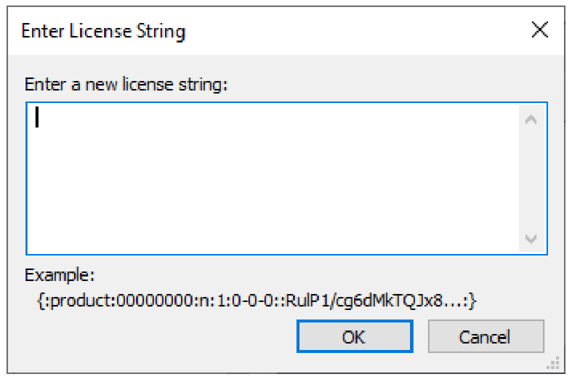
Having trouble with a license? See Troubleshooting below.



The Licenses option lets you view and install Cogent DataHub licenses. When the DataHub program starts up it will run in demo mode (one hour time limit) if no licenses are found. If any license is found on a DataHub instance running on any connected machine, the DataHub instance switches to license mode, and each connected DataHub instance then requires a license.

Licenses can be entered individually or loaded from a file.

- The **Enter a License...** button opens the **Enter License String** window:



  Here you can paste or manually enter the text string for the license provided by Cogent.

  - For DataHub version 10 and later, select everything including the `{:` and `:}` characters.
  - For DataHub versions 8 and 9, select everything including the first and last `:` characters.

  Running a DataHub instance on a Microsoft Azure virtual machine requires a special license key. Contact Cogent for details. Normal practice is to use the Cogent DataHub service for Azure managed application.

  The license string may contain the characters `l` (lower case L) and `1` (one) which can look nearly identical in some type fonts. If possible, it is best to copy and paste the string, rather than retyping it.

- The **Load License File...** button opens a Windows file selection window. Browse to find the directory and license file that you want to load. License files end with a `.lic` extension. Once you have found the license file, click the **Open** button to load the file. (Please refer to Configuration and License File Locations in Configuration Files for more information on license file locations.)

To remove a license from your system, select one or more licenses in the **Details** window, then click the **Remove Selected** button.

Troubleshooting License Installation

The possible causes of a license installation problem are:

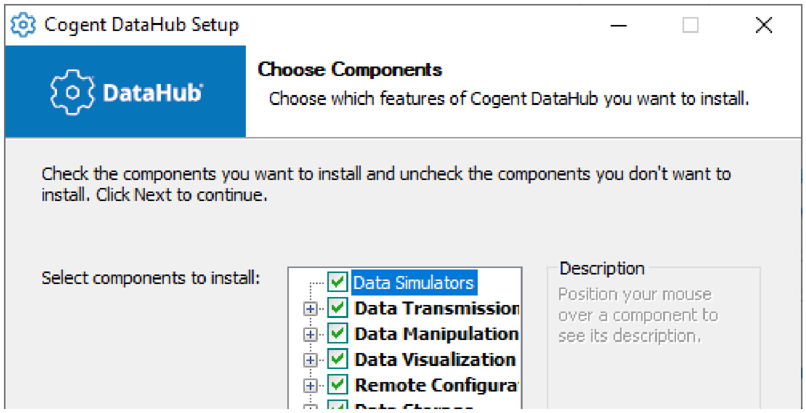
1. **Different DataHub version.** Each DataHub version (v7, v8, v9, v10, etc.) has a different license.
2. **Running on Azure.** The DataHub program requires a special license key when running on a Microsoft Azure virtual machine. Contact Cogent for details. Normal practice is to use the Skkynet DataHub managed application for Azure.
3. **A typographical error.** If you are hand-entering the license key, watch out for mistakes between lower case letters `L` and `1`, and between the upper case letter `O` and the numeral `0`.
4. **A copy/paste error.** If you are copying and pasting the key, make sure that you include the correct leading and trailing characters in the key.
   - For DataHub version 10 and later, include the `{:` and `:}` characters.
   - For DataHub versions 8 and 9, include the first and last `:` characters.

   If you are having trouble with a copy/paste, try opening Notepad and copying the license keys into it. Once the license keys are in Notepad, replace all of the "-" (minus sign) characters in the license keys by selecting and re-typing the - sign. You might notice that minus signs in the key are actually converted to something else, like a box or an exclamation mark. You need to change them back, then try adding the license code to the DataHub instance again.
5. **Unicode characters.** If you copy a space into the entry field, it may be a Unicode space instead of an ASCII space. The entry field will automatically strip ASCII spaces, but it cannot distinguish Unicode spaces. This could happen if you are working with a non-English character set that defines its own space, such as Japanese.
6. **Invalid duplicate key.** The DataHub `licenses.lic` file may contain an invalid license key with the same license number. To fix:
   1. Delete the `licenses.lic` file from the DataHub configuration folder (usually `C:\Users\`*`username`*`\AppData\Roaming\Cogent DataHub`).
   2. Restart the DataHub instance.
   3. Install the new license key.

If none of these are helpful, please contact support@skkynet.com and send a copy of the `licenses.lic` file, along with the version number of the DataHub instance you have installed it on.

Missing features

If the licenses are installed correctly, but you are not seeing all of the licensed features in the Properties window, then it is possible that they were not enabled during the initial install of the DataHub instance. You can check this by re-installing the DataHub software, and ensuring that all of the features you need are checked in the Choose Components step of the installation.



Installing as a Service

To install the Cogent DataHub program as a Windows service, follow these steps.

1. Start up the DataHub program. (Select the program using the Windows **Start** menu, or double click the desktop icon.)
2. Configure the DataHub Security and Remote Config options as described in Preparation for Remote Config section of this book. You will need the Remote Config program to access and configure your DataHub instance while it is running as a service.
3. Test the Remote Config program by following the steps for Configuring a Local DataHub Instance.
4. When you are sure that the Remote Config program is working properly, exit the DataHub instance. (Right-click the DataHub icon in the system tray, and select **Exit** from the pop-up menu.)
5. Use the Service Manager to install the DataHub software as a Windows service. You should be able to configure it using the Remote Config program.

If you are upgrading to a newer major version of the DataHub program, please refer to Running a DataHub instance as a service in Windows 10 and Server 2016 in Known Issues on the Cogent DataHub website for more information.

Performing a Silent (Unattended) Install

To perform an unattended install of Cogent DataHub software, you can run this command:

```
CogentDataHub-version number-date-Windows.exe /S
```

For a non-default installation directory, use:

```
CogentDataHub-version number-date-Windows.exe /S /D=C:\install\path
```

`/S`	indicates a silent install
`/D`	indicates the base installation directory

There are certain restrictions with the `/D` argument:

- `/D` must be the last argument on the line
- The path name for `/D` must NOT contain quotes, even if the path contains spaces.
- There must not be spaces around the = sign in the `/D` argument

The installation will create two directories beneath the directory indicated by /D:

- The `Cogent DataHub` directory contains the DataHub installation.
- The `DataSim` directory contains the two data simulators.

Upgrading to a new version

Minor Version Upgrades

To upgrade to the latest minor release of the DataHub version you are currently using:

1. Go to the Downloads page of the DataHub website.
2. Check to see if there is a more recent release of the DataHub program than your version.
3. If so, download it and install it over your existing DataHub installation. The new version will automatically pick up any existing licenses and configuration.

Major Version Upgrades

To upgrade to a major new DataHub release, you need to first contact Cogent to obtain an upgrade license. Then download the latest DataHub archive and follow one of these two procedures:

Upgrade an existing DataHub installation

1. Install the new DataHub archive over your existing software.

   The installer will automatically detect your existing license and configuration. Since your license is not yet valid on this new version, it will not be used, and the DataHub program will run in one-hour demo mode, with all features available.
2. Select the Licenses option. To see your existing license, check the **Show unused license keys** box.
3. Install the upgrade license you received from Cogent. The license number of the upgrade license must match the original license. If you have multiple upgrade licenses for several add-on features, install each one, ensuring that it matches its original.

Example: version 7 to version 9 upgrade:

```
:winCDHOTv70:00078649:n:1:0-0-0:2i9d...:
:upg_winCDHOTv70_winCDHOTv90:00078649:n:1:0-0-0:234d...:
```

Example: version 9 to version 10 upgrade:

```
:winCDHOBv90:00090067:n:1:0-0-0:...
{:upg_winCDHOBv90_winCDHOBv10:00090067:n:1:0-0-0::...
```

The End User License Agreement stipulates that each DataHub license may be used on only one machine at a time. So you may not use the original license on any other DataHub installation.

Upgrade and move to a new computer

Often part of the upgrade process is to move the DataHub program to a new computer. Please see the section called “Backing Up or Moving a DataHub Installation” for information on moving configuration and license files.

1. If you want to use your existing configuration, copy and move it.
2. Install the new DataHub archive. (You do not need to install the earlier version of the DataHub program.)
3. Continue with step 2 in **Upgrade an existing DataHub installation** (above).

Installing over previous versions

Please refer to the relevant pages on the Cogent DataHub website.

- Installing the v11 DataHub program on a system running an earlier DataHub version.
- Installing the v10 DataHub program on a system running an earlier DataHub version.
- Installing the v9 DataHub program on a system running an earlier DataHub version.
- Installing the v8 DataHub program on a system running an earlier DataHub version.

Downgrading to a previous version

Downgrading version 10 to version 9 or earlier

If you install DataHub software v10 on your system and then decide you want to move back to an earlier version, you must uninstall the DataHub v10 software and then install the previous version. Failure to do so results in unexpected behavior. Installers for DataHub software v9.0.11 (and later) will do this automatically for you.

If you run into trouble, re-run the DataHub v10 installer and then uninstall it before installing the earlier version.

Downgrading version 9 or 10 to version 8 or earlier

When DataHub Version 9 or 10 first runs, it makes a copy of the configuration folder from your previous version, and then upgrades the configuration to be compatible with v9 or v10. Your previous configuration is stored in the same folder, with an extension of `#.bak`, where # is a numeric sequence number. For example, if your DataHub configuration folder is:

```
C:\Users\MyName\AppData\Roaming\Cogent DataHub
```

Then the configuration backup folder will be:

```
C:\Users\MyName\AppData\Roaming\Cogent DataHub.1.bak
```

When you revert to a previous DataHub version, you need to manually restore this backup to its original name. The full process is:

1. Stop every DataHub instance and all tools, like WebView, the Remote Config program, DataPid, etc.
2. Uninstall DataHub Version 9 or 10.
3. Install the older DataHub version, but do not start it.
4. Using the Windows file explorer, rename or delete the configuration folder (e.g., `C:\Users\MyName\AppData\Roaming\Cogent DataHub`)
5. Using the Windows file explorer, copy the backup folder to the configuration folder name. For example, copy:
   ```
   C:\Users\MyName\AppData\Roaming\Cogent DataHub.1.bak
   ```
   to
   ```
   C:\Users\MyName\AppData\Roaming\Cogent DataHub
   ```
6. Start the DataHub program.

Configuration Files

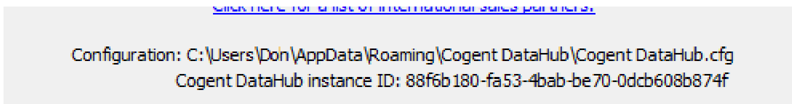
The DataHub program uses multiple configuration files. When the program is first started it creates its primary configuration file, `Cogent DataHub.cfg`, along with other `.cfg` files that correspond to various DataHub plug-ins. These files get edited automatically when you make changes to features in the Properties window. When you shut down and restart a DataHub instance, it reads and uses the last saved configuration from each file.

There are two syntaxes used in DataHub configuration files. DataHub Command syntax is used in some, and XML syntax is used in others, depending on the complexity of the corresponding plug-in, and its implementation. Occasionally an experienced user might have reason to edit a configuration file directly, but in general modifications should be made through the Properties window.

DataHub configuration files are stored as UTF-8 text, without a byte-order marker (BOM). If you do choose to edit a DataHub configuration file, ensure that your text editor is storing the file in this format. The presence of BOM characters will cause the configuration file to fail. Also, if you choose to edit a DataHub configuration file, whether by hand or through a text generation program, it is good practice to stop the DataHub program before modifying the file.

Configuration and License Files Location

The DataHub program stores its configuration and license (`licenses.lic`) files in the current user's directory, in a subdirectory named `Cogent DataHub`. You can find its configuration path in the DataHub About panel, by clicking the **About** button in the DataHub Properties window.



Here are the typical locations:

- For Windows Vista, Windows 7, 8, 9, or 10, or Windows Server 2008, 2012, or 2016:
  `C:\Users\`*`UserName`*`\AppData\Roaming\Cogent DataHub\`
- For Windows XP and Windows Server 2003:
  `C:\Documents and Settings\`*`User Name`*`\Application Data\Cogent DataHub\`

If you ever need to back up or move the DataHub configuration, please refer to the section called “Backing Up or Moving a DataHub Installation”.

The `Application Data` or `AppData` directory might be a hidden directory.

If there is no private configuration when a DataHub instance starts, it will search for configuration files and license files from previous versions in the application installation directory, and copy them to the user's private configuration. If there are no old configuration files, the DataHub instance will copy all the current configuration files from the application installation directory. Thereafter, changes to the DataHub program's properties (made through the Properties window) will only change the user's private configuration.

You can modify this behaviour in two ways with the following command line options:

1. Provide the `-H` *`home`* option which will indicate to DataHub program that it should store the private configuration and license files in the directory specified by *home*, rather than in a subdirectory of `Application Data`. The DataHub program will still search for previous and default configuration files and licenses in the application installation directory as described above.
2. Provide the `-U` option which will indicate to the DataHub program that it should

not create private configuration files for each user, but store its configuration in the application installation directory.

If both `-H` and `-U` are specified, the `-U` flag is ignored.

You can also set the configuration folder globally using the DataHub Service Manager, even if the DataHub software is not installed as a Windows service. Here's how:

1. Open the DataHub Service Manager.
2. Click the button **Set Global Configuration Folder**.
3. Type or browse to the folder you want to use for configuration, and click **OK**.
4. Close the DataHub Service Manager window.
5. Start a DataHub instance normally.

This should result in a DataHub instance using the specified folder as its configuration folder whenever it is started without the `-H` option.

Custom Configuration Files

When the DataHub program starts up, you may wish to have certain points and data structures get created immediately. To do this, you can create one or more custom configuration files. These files must be listed in the bottom of the **Scripting** option of the Properties Window.

Creating and editing custom configuration files should only be attempted by experienced users. If you do create a custom configuration file, we strongly recommend that it only be used for creating points and data structures, and not for standard configuration commands, such as those that are created and modified through entries in the Properties window. Doing otherwise could result in irregular behavior in the DataHub program.

The following sets of commands are the only ones that should be used in a custom configuration file:

General commands allowed in config files

create	**mult**
set	**div**
cset	**lock**
write	**quality**
cwrite	**secure**
force	**append**
cforce	**dump**
add	**include**

Model-related commands allowed in config files

- alias
- assembly
- attribute
- defaultprop
- instance
- private_attribute
- property
- subassembly
- type

Only allowed in Windows config files

- execute_plugin
- load_plugin
- unload_plugin
- load_scripts
- show_data
- show_debug_messages
- show_event_log
- show_icon
- show_properties
- show_script_log

Custom configuration files can be created using a text editor like Notepad, and are written in Lisp syntax. They should be put in the same directory as the Cogent DataHub executable, such as `C:\Program Files (x86)\Cogent\Cogent DataHub\` (it may be different for your installation). Each entry of the file contains either a command or a comment. Comments are marked with a semicolon character (`;`) at the beginning of each line.

For more information about commands and their syntax, please refer to Cogent DataHub Command Set.

A small custom configuration file might look like this:

```
;;; Create some points in the default data domain and assign values.
(cset default:Point1 5)
(cset default:Point2 67.234)
(cset default:Point3 Hello)

;;; Create a new data domain
(create_domain NewDomain)

;;; Create some points in the new data domain and assign values.
(cset NewDomain:Point1 "A string")
(cset NewDomain:Point2 95)
(cset NewDomain:Point3 3.1519)
```

Backing Up or Moving a DataHub Installation

It is possible to back up a DataHub installation, either for archival purposes, or for moving it to a different machine.

The Cogent DataHub End User License Agreement prohibits installing any DataHub license on more than one machine at a time. So, if you are moving the Cogent DataHub software from one machine to another, after copying the license file from the first machine, you must delete it from that machine before installing it on the second machine.

To back up the necessary DataHub files, you will need to copy everything in the following directories:

- For DataHub version 9, 10 or 11:

  ```
  C:\Users\UserName\AppData\Roaming\Cogent DataHub\
  ```

  All custom scripts and configuration files must be copied from their directory on the first machine to an identical directory on the second machine.

- For DataHub versions 7 or 8 running in Windows XP or Windows Server 2003:

  ```
  C:\Documents and Settings\User Name\Application Data\Cogent DataHub\
  C:\Program Files\Cogent\Cogent DataHub\scripts\
  C:\Program Files\Cogent\Cogent DataHub\Plugin\WebServer\html\
  ```

- For DataHub versions 7 or 8 running in any other Windows version:

  ```
  C:\Users\UserName\AppData\Roaming\Cogent DataHub\
  C:\Program Files (x86)\Cogent\Cogent DataHub\scripts\
  C:\Program Files (x86)\Cogent\Cogent DataHub\Plugin\WebServer\html\
  ```

In addition to this, if you have created any custom configuration files, they should also be copied from their directory on the first machine to an identical directory on the second machine.

You will need to restart the DataHub instance receiving the new configuration files before they will take effect.

Known Issues

Please refer to Known Issues and Breaking Changes on the Cogent DataHub website.

FAQ

Here are some questions people typically ask about using DataHub software.

How do I?

Installing and Licensing

1. See technical specs and known issues.
2. Move a license.
3. Back up a license.
4. Get my license working.

5. Missing features.
6. Upgrade my software.
7. Install as a Windows service.
8. Run DataHub software on Azure.

Configuration and Performance

9. Configure a large number of DataHub points.
10. Delete data points.
11. Find out DataHub performance limitations.
12. Decide between 32-bit and 64-bit versions.

Networking

13. Configure Security for remote connections.
14. Choose the right tunnelling scenario.
15. Secure my tunnel connections.
16. Make custom connections—Windows or non-Windows.

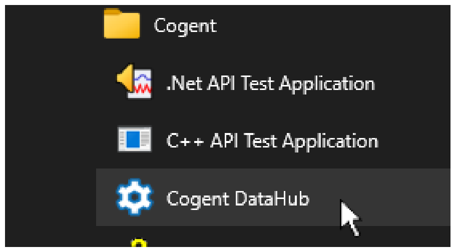
Troubleshooting

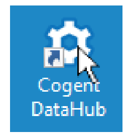
17. Report a problem.

Getting Started

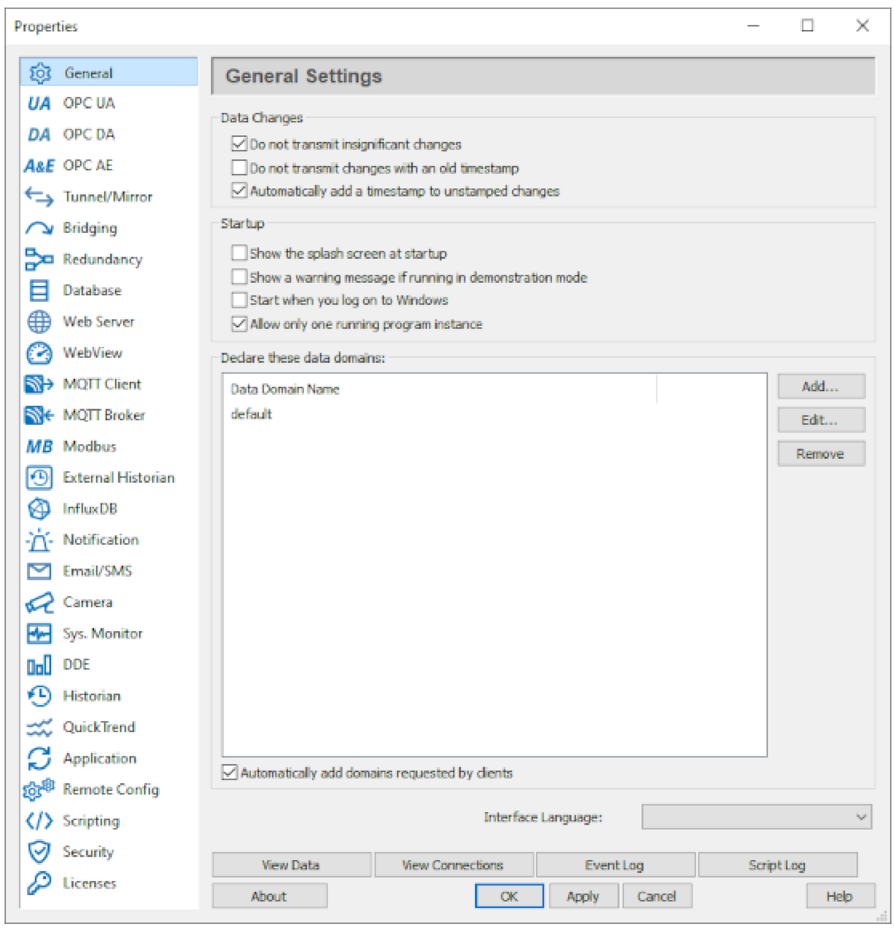
Running the DataHub Program

To run the DataHub program, select it using the Windows **Start** menu, or double click the DataHub shortcut icon.

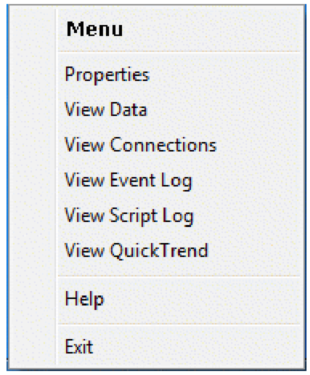




Once started, the DataHub program opens the Properties window:

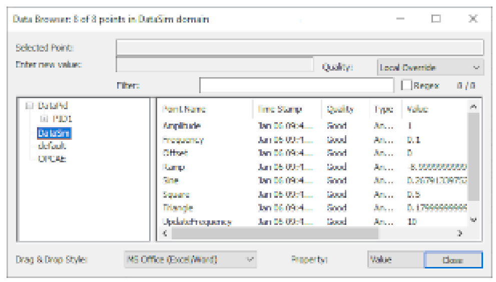


It also puts an icon in the system tray. If you right-click on the icon, you will get a menu with several options, explained below:

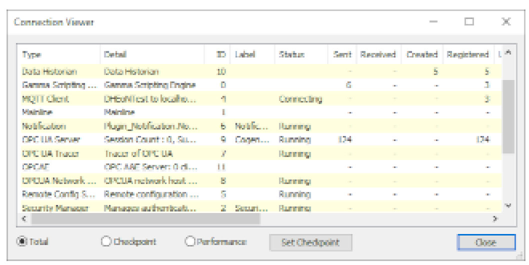


Touch-screen users: press the DataHub icon for about one second. When you release, the pop-up menu will appear.

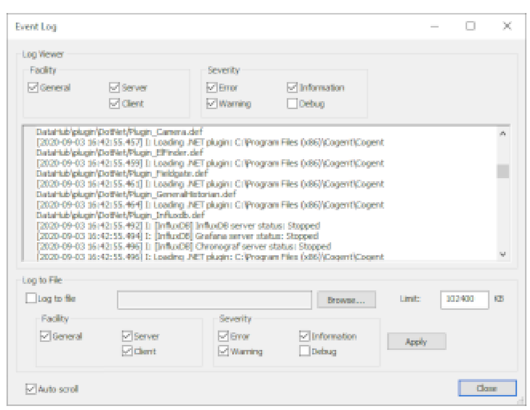
Data Browser



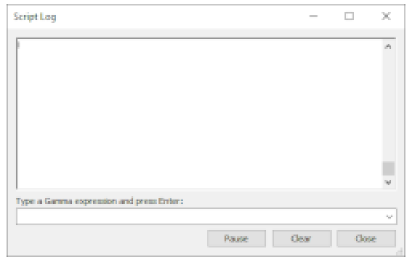
Connection Viewer



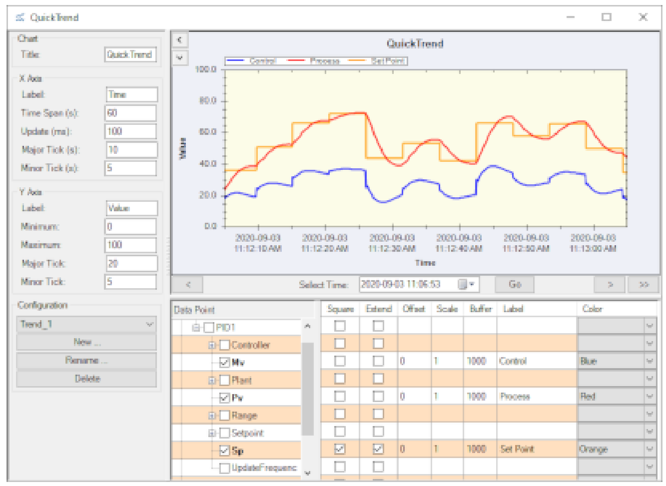
Event Log



Script Log



QuickTrend

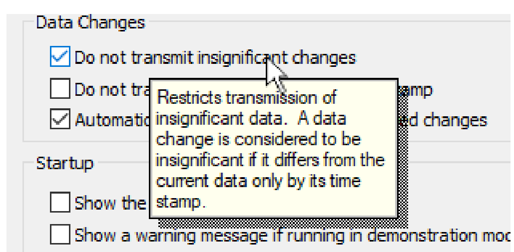


The pop-up menu also lets you exit the DataHub program.

It is possible to start a DataHub instance using command-line options. Please refer to Appendix A, *Command Line Options* for more information.

Pop-up Help

You can get pop-up help in many parts of the Properties window by right-clicking the mouse over buttons or text.



Exit

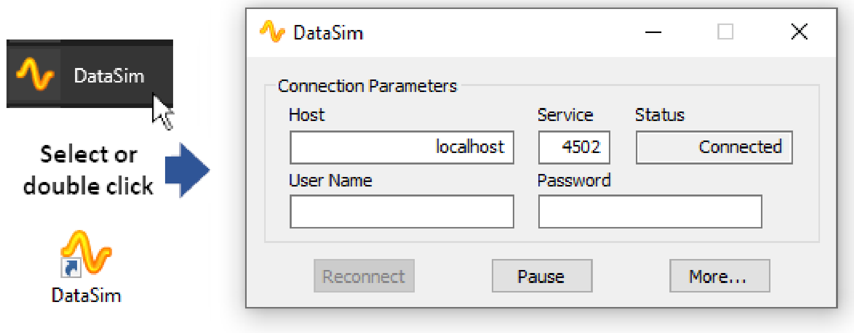
You can terminate a DataHub instance by right-clicking the DataHub icon in the system tray, and selecting **Exit** from the pop-up menu. After a few seconds the icon should disappear, indicating that the DataHub instance has terminated.

You must explicitly exit a DataHub instance to terminate it. Otherwise it continues to run in the background even if you close the Properties, Data Browser, and Event Log windows.

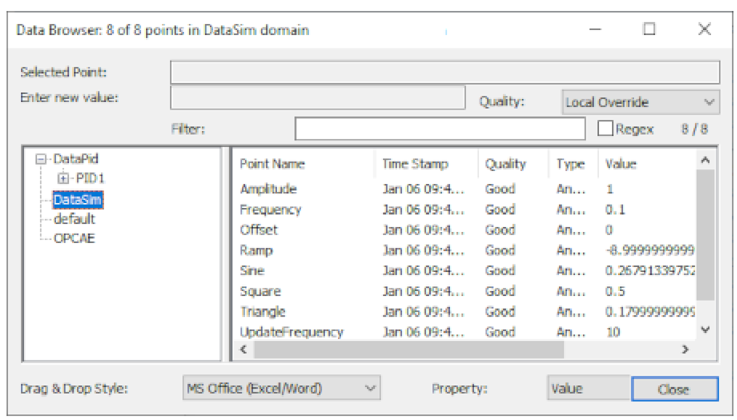
Test with simulated data

There is a data-generating program that comes with the Cogent DataHub software called DataSim. You can run DataSim locally to create data for various connection scenarios.

1. Start a DataHub instance if one isn't already running.
2. Start DataSim using the Windows **Start** menu, or by double clicking the desktop icon.



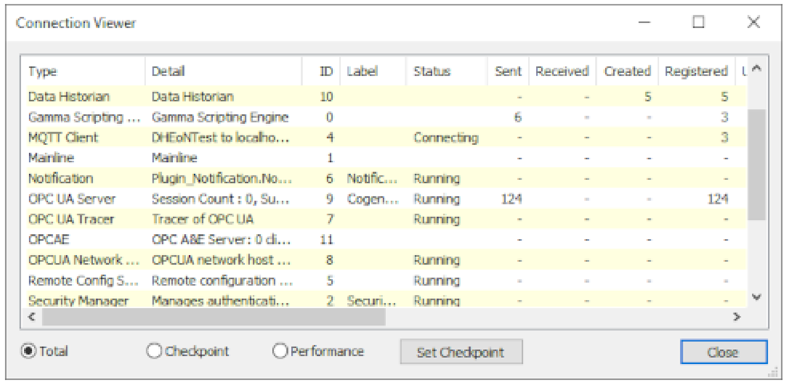
3. Open the DataHub Data Browser by right clicking on the DataHub system-tray icon and choosing **View Data** from the pop-up menu.



4. Select the **DataSim** data domain in the left-hand pane of the window.

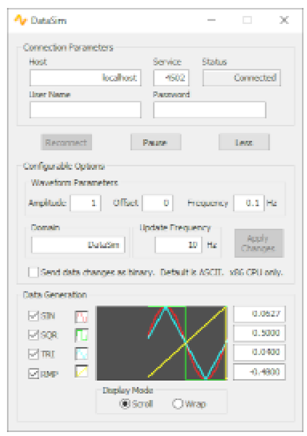
   The Data Browser window should fill with simulated data updating in real time. The four updating data points are `Ramp`, `Sine`, `Square`, and `Triangle`.

5. You can also click the **View Connections** button near the bottom of the Properties window to see your currently configured connections:



The Connection Viewer shows all active connections in your DataHub instance.

6. You can click the **More...** button in DataSim to access some options for changing the data feed.



Briefly, you can change the **Configurable Options** and click the **Apply Changes** button to apply them. The **Waveform Parameters** and **Update Frequency** are all points in your DataHub instance, and the corresponding points change their values in the Data Browser as you make the changes. Changing the **Data Domain** from `DataSim` will yield no results until custom data domains are configured for your DataHub instance.

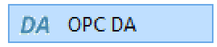
> If you shut down DataSim, its points will still appear in your DataHub instance until it is shut down and restarted. Please refer to the section called "Data Points" for more information on creating and deleting points.

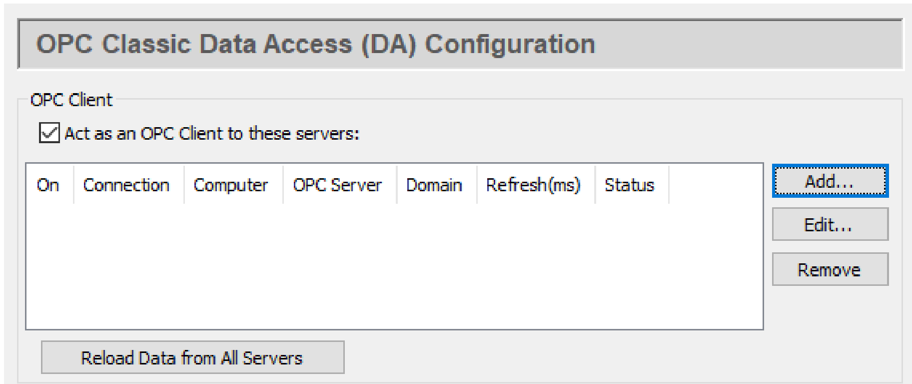
Now you are ready to start using the DataHub program.

Connect to an OPC DA server

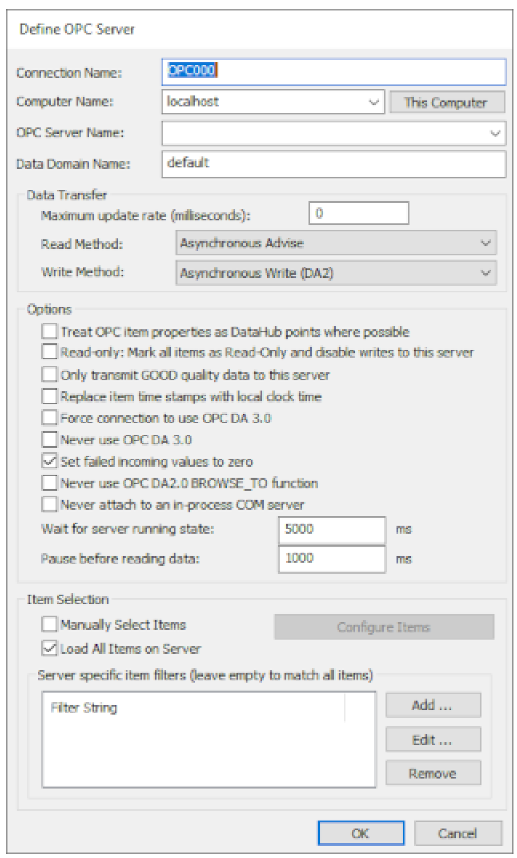
To connect to an OPC DA server, you need to configure the Cogent DataHub program to act as an OPC Classic client. Here's how:

Click here to watch a video.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **OPC DA**. 

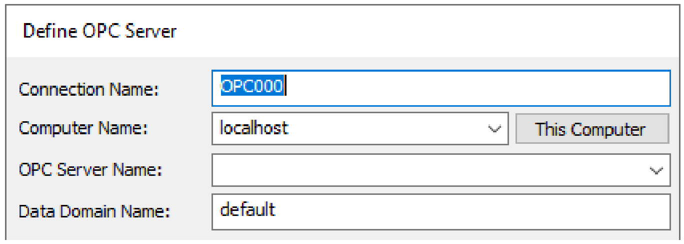


3. Check the **Act as an OPC Client** box. Since a DataHub instance can be a client to more than one OPC server, you need to specify which OPC DA server you are going to connect to. To add a server, click the **Add** button and fill in the fields in the **Define OPC Server** Window:



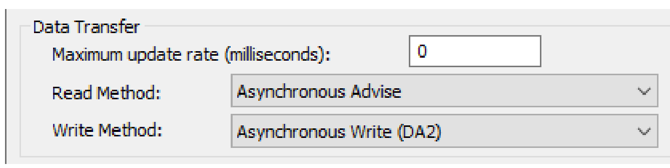
4. Type in or select the necessary information as appropriate.

a. The first four fields define the OPC server:



- **Connection Name** Type a name to identify this connection. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other connection names.
- **Computer Name** Type in or select from the drop-down list the name or IP address of the computer running the OPC server you want to connect to.
- **OPC Server Name** Select the name of the OPC server that you are connecting to from the list of available servers.
- **Data Domain Name** Type the name of the DataHub data domain in which the data points will appear.

b. You can specify how the data is to be transferred.



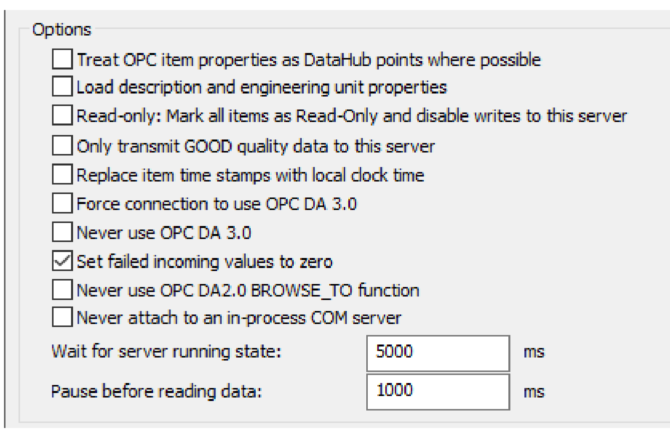
- **Maximum update rate (milliseconds)** Enter the maximum rate you wish the data to be updated. This is useful for slowing down the rate of incoming data. The default is `0`, which causes values to be updated as soon as possible. This value is also the polling time used by asynchronous and synchronous reads (see below).
- **Load description and engineering unit properties** This causes the DataHub instance to load any engineering unit and range information associated with each point. These values are then made available to all DataHub clients, and are displayed in the DataHub Data Browser. Activating this feature will increase the time needed for making the initial connection to the server.
- **Read Method** Choose how to read data from the OPC server:
  - **Asynchronous Advise** The OPC server sends a configured point's data to the DataHub instance immediately whenever the point changes value. This is the most efficient option, and has the least latency.
  - **Asynchronous Read** The DataHub instance polls the OPC server for all configured points on a timed interval (set by the **Maximum update rate**). This option is less efficient than Asynchronous Advise, and has higher latency.

- **Synchronous Cache Read** The DataHub instance polls the OPC server for all configured points on a timed interval (set by the **Maximum update rate**), and this thread waits for a reply. This option is less efficient than Asynchronous Advise or Read, and has higher latency than either of them.
- **Synchronous Device Read** The DataHub instance polls the PLC or other hardware device connected to the OPC server for all configured points on a timed interval (set by the **Maximum update rate**), and this thread waits for a reply. This is the least efficient of all of these options, and has the highest latency.

- **Write Method** Choose how to write data to the OPC server:
  - **Asynchronous Write** provides higher performance. The DataHub instance writes changes in point values to the OPC server without waiting for a response.
  - **Synchronous Write** elicits a quicker response from the OPC server, but results in lower overall performance. The DataHub instance writes changes in point values to the OPC server without waiting for a response. This option is useful if the OPC server doesn't support asynchronous writes at all, or if it can't handle a large number of them.

    Depending on the OPC server you are configuring, you might have an option to use OPC DA 2.0 or 3.0. Please refer to the Data Transfer explanation in the OPC section of the Properties Window chapter for more information.

c. There are several optional entries:



- **Treat OPC item properties as DataHub points** lets you register and use non-standard OPC item properties as points in the DataHub instance. Generally you won't need this unless you plan to use the DataHub instance to distribute changes to values of the non-standard properties on your OPC items.

  The DataHub instance will monitor these properties only if the OPC server exposes them as OPC items. If the properties do not show up when using this check-box, this means that the server does not expose the non-standard properties as items.

Some OPC DA servers are slow to register their OPC items and properties. Using this option with one of these servers can significantly slow the start-up time of the DataHub instance.

- **Read only: Mark all items as Read-Only** lets you specify that the OPC server be read-only, regardless of how individual items are specified. Items in the DataHub instance that originate from such an OPC server will be read-only to all DataHub clients.
- **Replace item time stamps with local clock time** allows you to set the timestamps for the items from this server to local clock time.
- **Force connection to use OPC DA 3.0** lets you choose the DA 3.0 write methods from the **Write Method** drop-down box. It will also instruct the DataHub instance to attempt to browse the server using DA 3.0 browsing. This setting will override any automatic information that the DataHub instance may determine about the server based on the server's registry entries.
- **Never use OPC DA 3.0** removes the DA 3.0 write methods from the **Write Method** drop-down box, and will instruct the DataHub instance to only use DA 2.0 browsing. This setting will override any automatic information that the DataHub instance may determine about the server based on the server's registry entries.

  For more information about OPC DA 2.0 and 3.0, please refer to the Data Transfer explanation in the OPC section of the Properties Window chapter.
- **Set failed incoming values to zero** The OPC DA spec requires an OPC DA server to send an `EMPTY` (zero) value whenever it sends a failure code in response to an item change or a read request. Some OPC servers, however, send a valid value with the failure code under certain circumstances. To ignore any such value from the OPC server and assume `EMPTY`, keep this box checked (the default). If instead you want to use the value supplied by your OPC server, uncheck this box.

  Unchecking this box will make the DataHub instance's behavior non-compliant with the OPC specification.
- **Never use OPC DA 2.0 BROWSE_TO function** disallows the `BROWSE_TO` function when communicating with OPC DA 2 servers. Sometimes an OPC server will have problems with this function that prevent the DataHub instance from connecting to it. Checking this box might allow the connection to be established in those cases.
- **Never attach to an in-process COM server** Most vendors include both an in-process and out-of-process COM server with their OPC DA server installation. If both options are available, the DataHub instance connects to the in-process server, as it is generally the better choice. This option forces the DataHub

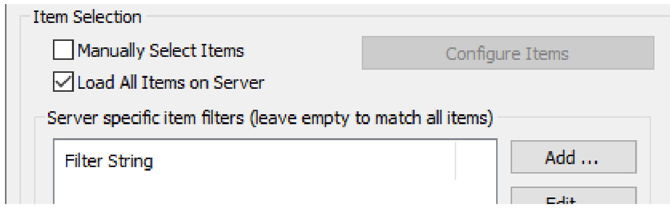
instance to consider only out-of-process servers.

Why is this useful? An in-process server is implemented as a DLL that is loaded into the client's address space. This makes the client very dependent on the good implementation of the server. If there is a crash in an in-process server, the client also crashes. An out-of-process server is implemented as a separate executable. The client communicates with an out-of-process server using the inter-process communication mechanisms in DCOM. In theory an in-process server will be faster than an out-of-process server, but sometimes the in-process server is less robust than the out-of-process server and leads to instability or malfunction in the client.

- **Allow VT_EMPTY canonical type for OPC DA2** The `VT_EMPTY` canonical type may be incompatible for a particular combination of OPC server and client. For example, some clients or servers that were built before 64-bit integers were common may fail when presented with a 64-bit number. These options (**DA2** and **DA3**) allow you to enable or disable the `VT_EMPTY` canonical type, either for trouble-shooting or as a permanent part of your configuration.
- **Allow VT_EMPTY canonical type for OPC DA3** See above.
- **Wait for server running state** Every OPC DA server takes a little time to initialize before it will allow client connections. This option lets the user specify the time to wait for the OPC server to initialize. The wait time is a maximum; if a server initializes before this time, the DataHub instance will connect right away. If the server doesn't initialize within this time, the DataHub instance will report this in the Event Log, and then try to connect anyway.
- **Pause before reading data** specifies a time for the DataHub instance to pause before reading the OPC server's data set. Some OPC DA servers report that they are running, but have not yet received the full data set from the process. If the DataHub instance attempts to connect right away, it might get a partial data set. The pause is fixed; it will always last for the full time specified.

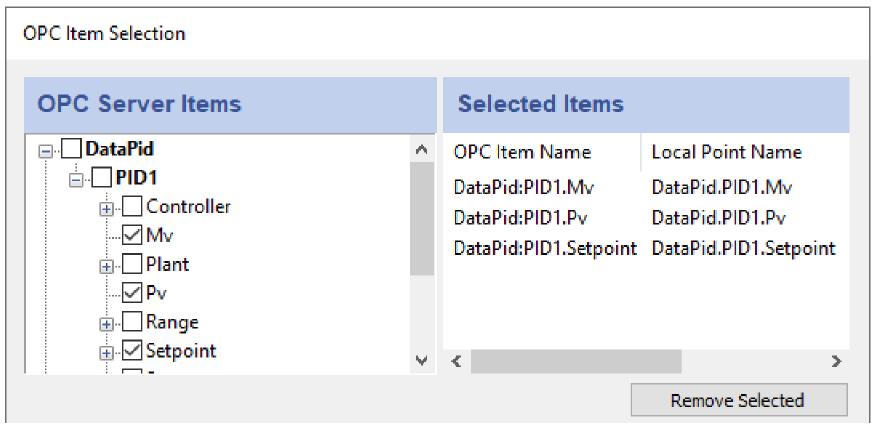
The two above times are added together. The DataHub instance will wait until the server is initialized (or until the specified "wait" period is complete) and then pause for the specified "pause" time, before trying to read data from the server. For example, with the defaults of `5000` and `1000`, at least 1 second and at most 6 seconds will elapse before the DataHub instance tries to read the data set.

d. Finally, you can specify how the OPC items get selected. You can select them manually or load all of them.



Manually Select Items

Check the **Manually Select Items** box and press the **Configure Items** button to open the OPC Item Selection window, where you can specify exactly which points you wish to use:



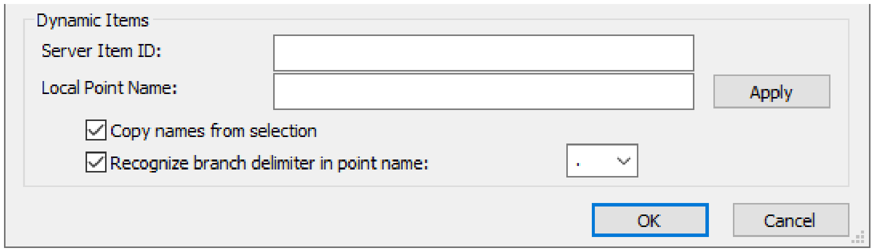
You can browse through the tree in the left pane, selecting points as you go. The selections will appear in the right pane. Follow these guidelines for making selections:

- To select a server item from the right-hand pane, click its check-box.
- To highlight a list of consecutive server items, click the first item, hold down the **Shift** key, and then click the last item. To highlight separate server items, hold down the **Ctrl** key as you click each item. To select a group of highlighted items, use the **Spacebar**.

  These may not function as described for Windows NT or Windows 2000 operating systems.

- Selecting a server item does not automatically add any of its child items. Each child item must be added separately. To view child items, click the + sign in front of the item. If an item has one or more children that have been selected, the item name(s) will appear in bold.
- To delete selected items from the right-hand pane, highlight them and press the **Remove Selected** button. Use the **Shift** and **Ctrl** keys as above to

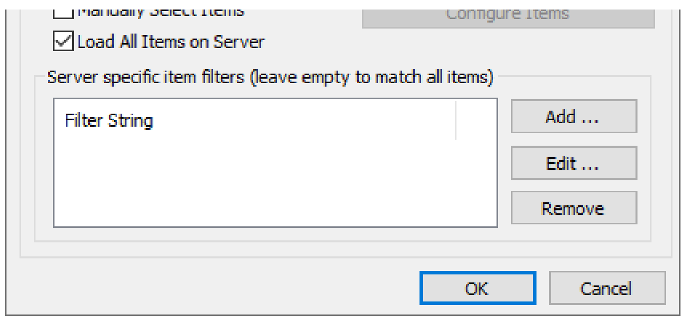
highlight groups of selected items.



You may also configure dynamic items on the server. As you type in the **Server Item ID**, the system will fill in an identical **DataHub Point Name** for you (which you can change at any time). Press the **Enter** key or the **Apply** button to create the item. Checking the **Copy names from selection** box will fill in the entry with the name you select from the **Selected Items** list (above). The **Recognize branch delimiter in point name** option lets you select and apply a point delimiter for your dynamic items.

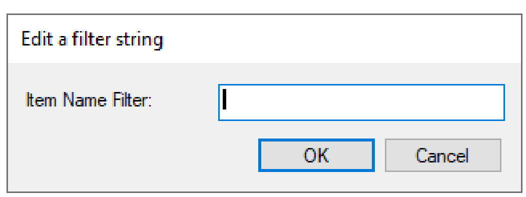
Load All Items on Server

In addition to manually loading items, you have the option in the Define OPC Server dialog to register all points, or filter for groups of points, from the OPC server.



In the **Server specific item filters** you have the option create filters to select partial data sets. If you don't enter anything here, the DataHub instance will query the OPC server for all of its items and register them. The filters are all applied on a logical 'OR' basis, i.e. if a point satisfies the condition of any filter, it gets registered with the DataHub instance.

- Click the **Add...** button to add a filter. The **Edit a filter string** window will appear:



Enter a string or a pattern to match one or more item names in the OPC server. Each server has its own syntax for pattern matching, so you may have to experiment a little to get exactly the points you need. Commonly, the symbol * matches any number of characters, while the symbol ? often matches a single character. In that case, an entry of ?a* would bring in all items with a as the second letter in their names.

- Click the **Edit...** button to open the **Edit a filter string** window and edit an existing filter. You can do the same thing by double-clicking a filter string in the list.
- Click the **Remove** button to remove a selected filter from the list.

5. Click the **Apply** button in the Properties Window. The DataHub instance should begin to act as a client to the OPC server. Messages will appear in the **Status** column indicating the status of the connection:

   Configuring After you click the **OK** button in the Define OPC Server dialog until you click the **Apply** button in the Properties window.

   Server Lookup The DataHub instance is looking for the OPC server.

   Server Attach The DataHub instance has found the OPC server and is connecting. It may be waiting for the server running state, as explained previously.

   Pause *NNNN* ms The DataHub instance is paused before reading data, as explained previously.

   Running The DataHub instance is connected to the OPC server and exchanging data.

   Disconnected The DataHub instance has disconnected from the OPC server.

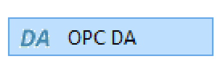
You can verify the connection using the Data Browser or the Connection Viewer. You can change server settings at any time. The DataHub instance will reconnect and apply the changes when you click the **Apply** button in the Properties Window.

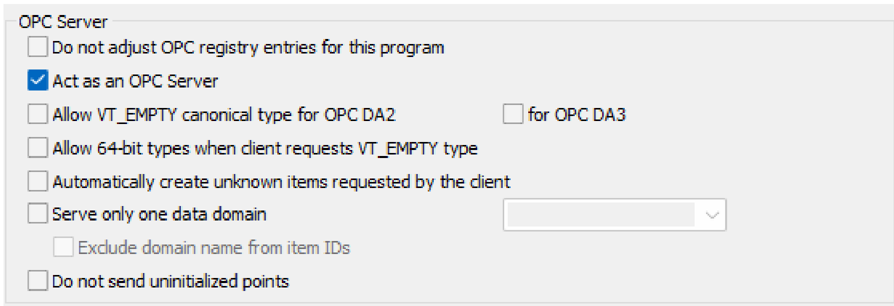
Connect from an OPC DA client

When you start an OPC DA client it should immediately be able to connect to the DataHub program, because it is preconfigured to act as an OPC DA server. If no DataHub instance is running, the OPC client will attempt to start it.

If your client does not connect, you can check the DataHub configuration as follows:

You must allow Remote Connections in Security for any incoming connections over the network.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **OPC DA**. 



3. Ensure that the **Act as an OPC Server** box is checked.

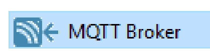
   If your OPC client requires that you hand-enter the OPC server name, use either `Cogent.DataHub` or `Cogent.DataHub.1`.

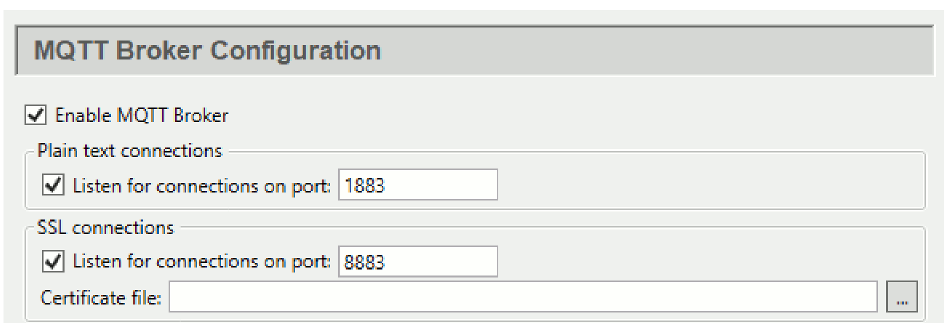
4. For information on any of the other options, please refer to the OPC DA Server section in Properties.
5. Click **Apply** button at the bottom of the Properties window to apply the change. You can view connections with the Connection Viewer.

Test MQTT

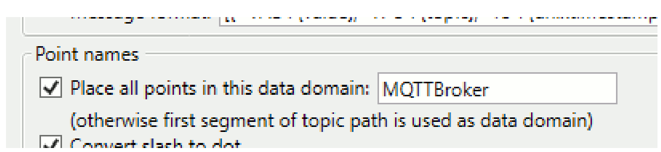
Here is a quick way to test both the DataHub MQTT Broker and MQTT Client, by connecting them to each other.

Configure the MQTT Broker

1. In the Properties window, select **MQTT Broker**. 



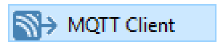
2. In the Point Names options, check the **Place all points in this data domain** box, and enter **`MQTTBroker`** for the domain name.

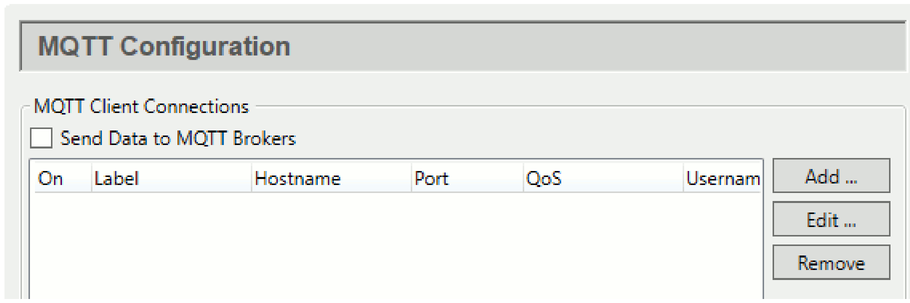


3. Click **Apply**.

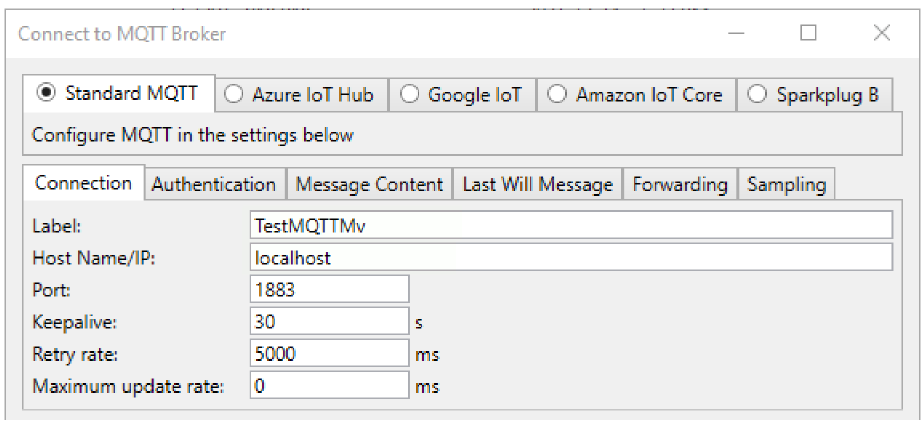
The DataHub MQTT Broker is now ready to accept MQTT client connections for the **MQTTBroker** domain. For more information about the MQTT Broker feature, please refer to the section called “MQTT Broker”.

Configure the MQTT Client

1. In the Properties window, select **MQTT Client**. 

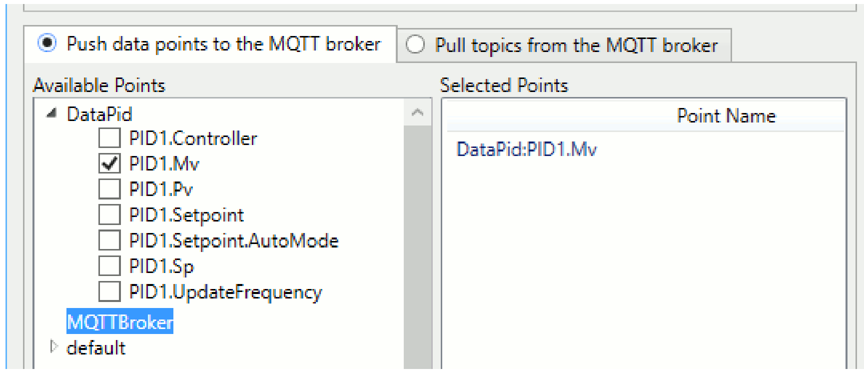


2. Click the **Add** button to open the Connect to MQTT Broker window:

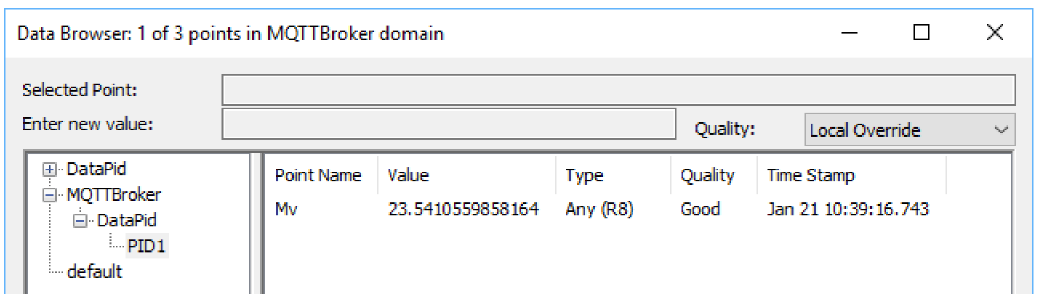


3. In the **Standard MQTT** section, **Connection** tab, enter the following:
   - **Label:** `TestMQTTMv`
   - **Host:** `localhost`
   - **Port:** `1883` (the default)
   - **Keepalive:** `30` (the default)
   - **Retry rate:** `5000` (the default)
   - **Maximum update rate:** `0` (the default).

4. In the **Push data points to the MQTT broker** section, **Available Points** list, open the **DataPid** tree and select the point `Mv`. (If you don't see the `DataPid` domain, start DataPid.)



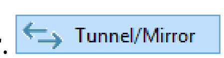
5. Click the **MQTTBroker** domain in the domain list to highlight it.
6. Click **OK**, and then **Apply**.
7. Click the **View Data** button in the Properties window to open the Data Browser. In the **MQTTBroker** domain you should see the value for **DataPid.Mv** updating.



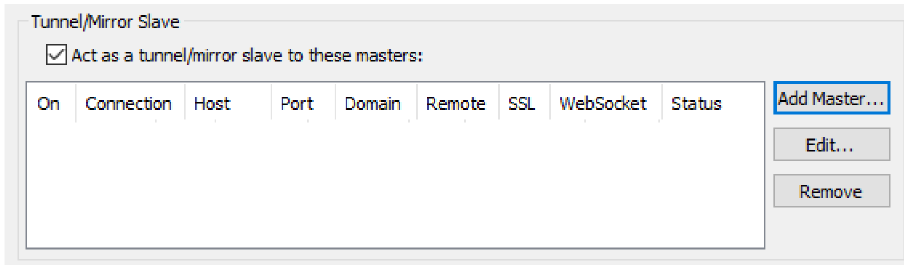
You have now configured the DataHub MQTT Client to send a value to the DataHub program via the MQTT Broker. For more information about the MQTT Client feature, please refer to the section called “MQTT Client”.

Connect to remote data

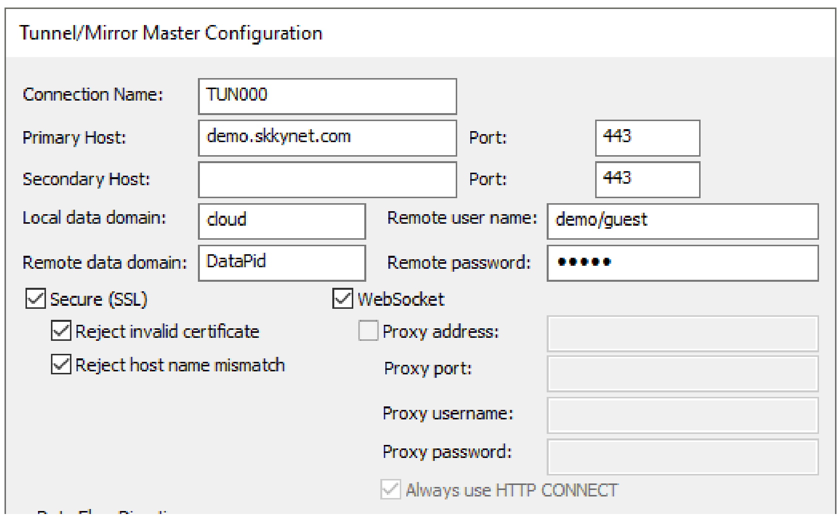
You can connect to Cogent DataHub service for Azure for testing. To configure your DataHub instance to receive that test data, just follow these steps:

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 

3. In the **Tunnelling/Mirror Slave** section, check the **Act as a tunnelling/mirroring slave to these masters** box.

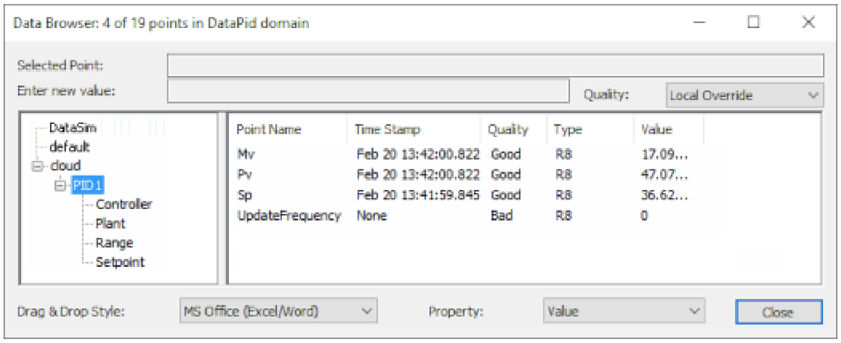


4. Click the **Add Master...** button to open the Tunnel/Mirror Master Configuration window:



5. Fill in these entry fields as follows:
   - **Primary Host** `demo.skkynet.com`
   - **Port** will be set automatically by the system to 443 for **Secure (SSL)** (see below).
   - **Local data domain** `cloud`
   - **Remote data domain** `DataPid`
   - **Remote user name** `demo/guest`
   - **Remote password** `guest`
   - **WebSocket** must be selected.
   - **Secure (SSL)** must be selected.

   There is no need to make or change any other entries.
6. Click **OK** to close the Tunnel/Mirror Master window, and then click **Apply** in the Properties Window.
7. Open the Data Browser and click the **cloud** data domain name and the **PID1** branch in the left-hand pane of the window.



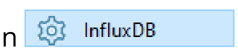
The Data Browser window should show some data updating in real time. Any delays in updates to these points are due to slow network speed or high traffic volumes.

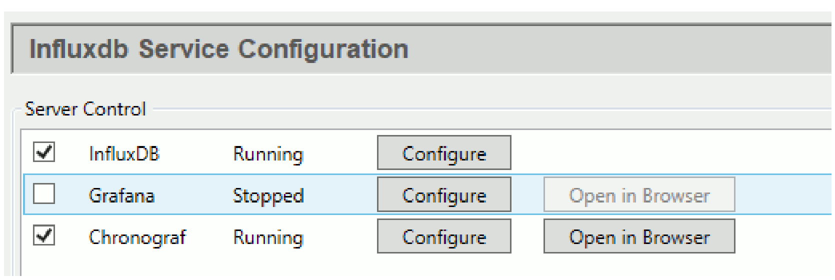
You can also use the Connection Viewer to see all active connections in the DataHub program.

For more information on tunnelling/mirroring, please refer to the section called "Tunnel/ Mirror".

Connecting to InfluxDB

Preliminaries

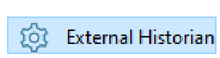
1. Ensure that the DataHub program is installed and running.
2. In the DataHub Properties window, go to the InfluxDB option  and check the boxes for InfluxDB and Chronograf, and click **Apply**.

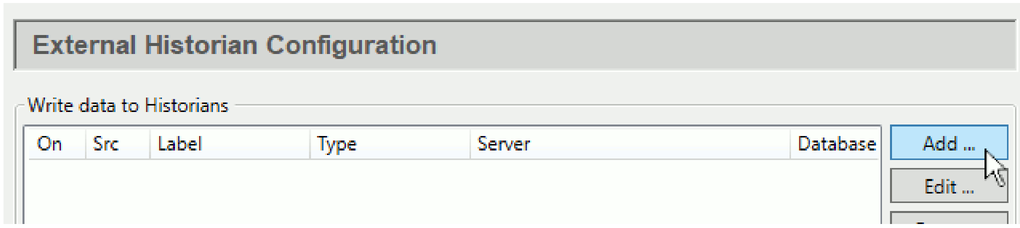


The online product documentation for InfluxDB and Chronograf can be found here.

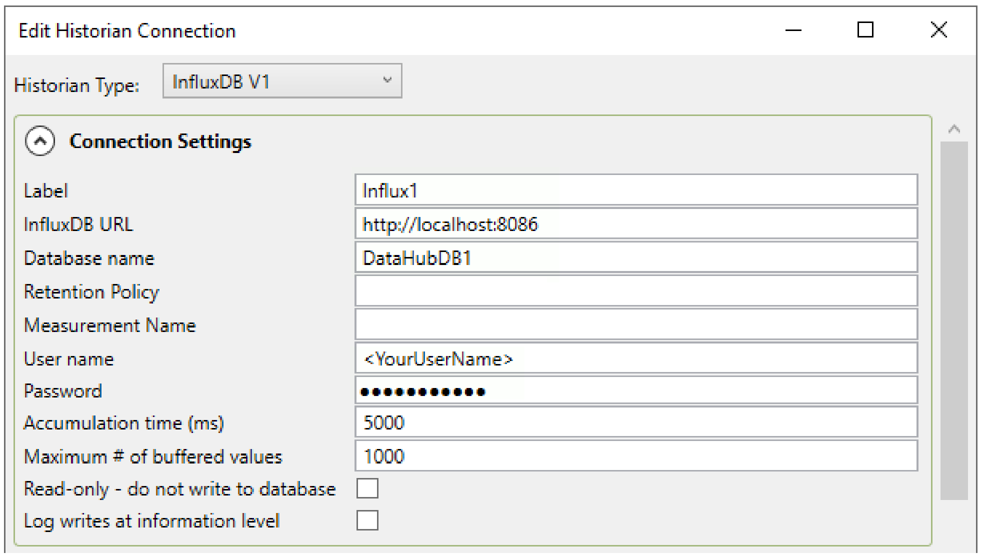
3. Start DataPid, and check the Data Browser to ensure that its data is updating.

External Historian

1. In the DataHub External Historian option  click the **Add** button.

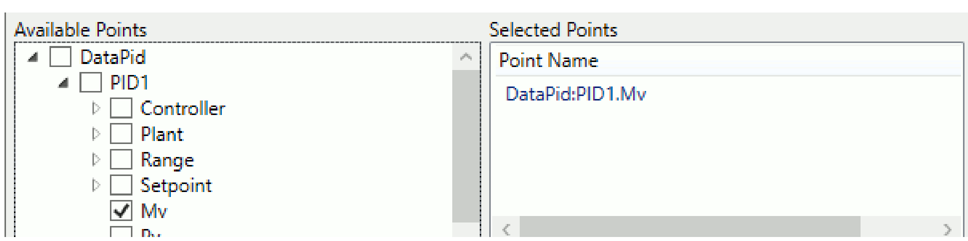


2. In the Edit Historian Connection window, configure a local InfluxDB connection as follows:



If you don't have a user name or password for InfluxDB, you can leave those fields blank. If you have previously installed InfluxDB independently of the DataHub program installation, then you'll need to use your existing InfluxDB URL.

3. In **Available Points** select just the `Mv` point in the `DataPid` domain, under `PID1`. You can add more points later, if you'd like.



The point `DataPid:PID1.Mv` will appear in **Selected Points**.

When finished, click **OK** and **Apply**. You have now created an InfluxDB database and are collecting a history of values for the `DataPid:PID1.Mv` point.

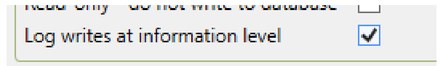
Checking Updates

It is possible to check updates using the DataHub Event Log.

1. Select your connection in the **Write data to Historians** list and click the **Edit** button

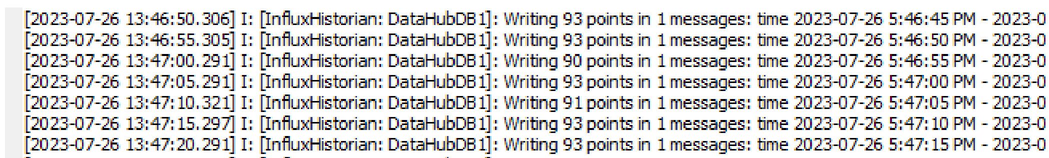
to open it.

2. In the **Connection Settings**, check the **Log writes at information level** box, and click **OK** and **Apply**.



If this box is not checked, this information is only displayed in the Event Log when its **Debug** option is selected.

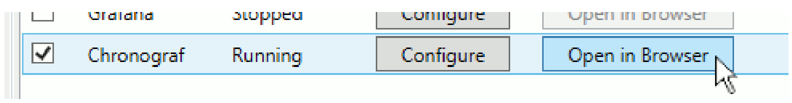
3. Open the Event Log to view data updates.



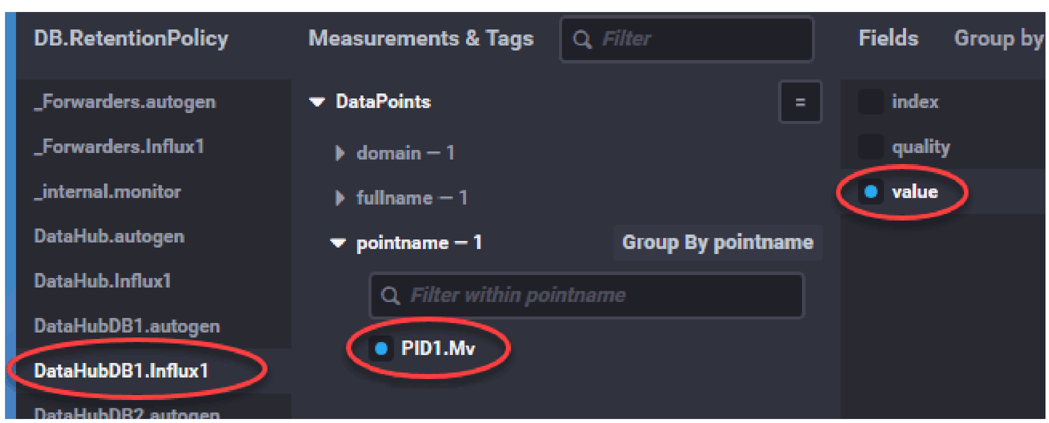
Check Chronograf

You can check Chronograf to view updates to the InfluxDB database.

1. In the InfluxDB option, ensure that both InfluxDB and Chronograf are running, and click the Chronograf **Open in Browser** button.



2. Go to **Dashboards** and click **+ Create Dashboard**, then **+ Add Data**.
3. Choose **DataHubDB1.Influx1**, in **DataPoints** choose **pointname** then **PID1.Mv**.



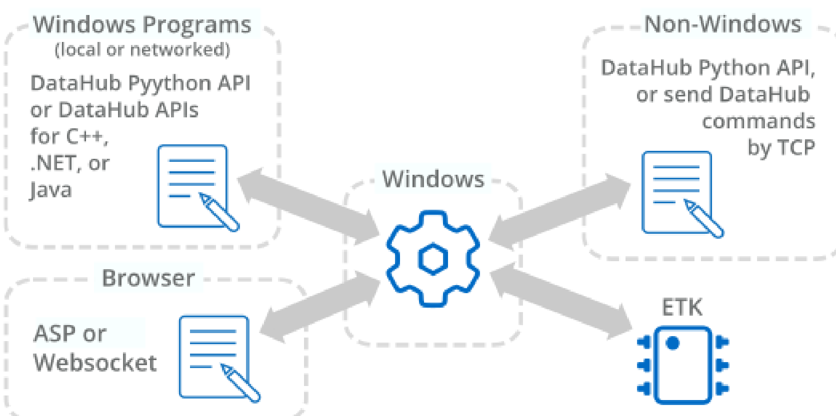
4. Under **Fields** select **value**.

   You should start to see some data appear in the trend at the top of the display. You can change the dashboard name from `Untitled Graph` to `Source (DH1) Logged to Influx1`, and click the green checkbox to save the dashboard.

Please refer to the Chronograf documentation for more details.

Custom Connections

There are several ways to make custom connections to the DataHub program from Windows and non-Windows programs, as well as web browsers and embedded devices, using TCP, SSL, or WebSocket protocols.



- For Windows programs see DataHub™ API for Python or DataHub APIs for C++, Java, and .NET.
- For non-Windows programs see DataHub™ API for Python or Sending Commands by TCP.
- For web browsers see Connecting Browser Applications.
- For embedded devices see Embedded Toolkit (ETK).

Performance Limitations

Data points and update rates

There are no hard limits on the number of data points or the update rates for the data in DataHub program. More data points require more memory, and more updates require more CPU. Different protocols require different amounts of CPU and memory.

The DataHub program imposes a limit of 128 MB on the length of an individual data point value. Very large values will take some time to be transmitted over a network, and can impose a large CPU and memory burden. If you intend to share data with Linux computers through a custom connection, the limit is 128,000 bytes. Please see Point Size Limits for more information.

Minimum hardware

The minimum hardware needed to run a DataHub instance depends on the number of data points, update rates, and other factors. This makes it difficult to determine in advance what hardware will be needed for any given system. At the very least, for 100 data points updating 10 times per second with one server and one client connecting by any supported protocol, any modern computer capable of running Windows is sufficient. For larger systems, you will need to test, which can be done by downloading free DataHub demo software from our website.

Total throughput

The total throughput of a running DataHub instance will depend on the total load, not just the input rate. If the DataHub instance is receiving 10,000 point changes per second, and there is 1 client connection, that will count as 10,000 point changes per second. If there are 5 client connections receiving that data, that becomes effectively 50,000 total changes per second being processed.

Data Domains

There are no hard limits on the number of data items or data updates per domain.

Event Log

Configuring the DataHub Event Log to log to disk has a big impact on performance. If you are seeing slow performance, try disabling logging to disk.

32-bit vs 64 bit

Both the 32-bit and 64-bit versions of DataHub software will run at approximately the same speed, and will use the same number of processor cores.

The 32-bit version will run on 32-bit Windows or 64-bit Windows. It is limited to approximately 1.5 GB of total memory. It is more compatible with OPC programs, which are almost all 32-bit.

The 64-bit version will only run on 64-bit Windows, and it has no memory limit.

If you are using the Database feature (ODBC database connectivity) the bit depth of the ODBC driver must match the bit depth of the DataHub executable. Your choice of DataHub bit depth may be limited by the available ODBC drivers for your database.

If you are accessing an OPC Classic in-process server, the bit depth of the DataHub executable must match the bit depth of the OPC server. The bit depths of the DataHub executable and the OPC Classic server executable do not need to match for an out-of-process OPC server.

In general, we recommend using the 32-bit version if you are accessing OPC Classic applications, unless you need the extra memory capacity of the 64-bit version.

Specific protocols and features

OPC DA and UA

There are no hard limits on the number of OPC tags or values that can be sent or received by OPC servers or clients, and no limits on the number of servers or clients that can connect. The number of data points and throughput is limited by memory and CPU. In test situations for OPC DA on reasonably modern hardware we have achieved over 100,000 data point changes per second. The OPC client and server code in the DataHub program automatically combines multiple point changes into a single OPC message whenever it can. Generally, OPC DA is faster than OPC UA on the same machine, and DHTP (DataHub tunnelling) is the fastest way to network OPC data. OPC UA requires much more memory than other protocols.

Redundancy

There are no hard limits on the number of points for the Redundancy feature. It is limited by memory and CPU. The total data point count is the sum of the data points counts in each domain. The number of domains is the total of all input and output domains for all redundant connections. For example, a single redundant configuration has 2 inputs and 1 output, for a total of 3, requiring enough memory for 3 times the number of points as are in one of the source domains.

Bridging

There are no hard limits on the number of points that can be bridged. The Bridging feature is built directly into the data path of the point change-handling code of the DataHub program, so it is as efficient as a normal point change. CPU load is based on point changes, while the memory load is based on the number of points, plus a small amount for the Bridging configuration itself.

ODBC

Our testing of the Database Write (logging) feature on MS-SQL and MySQL shows that typically the database server can handle up to about 1,000 transactions per second on a reasonably fast computer. The limiting factor is the speed of the database server. We have tested DataHub software with Times Ten database, which is faster than a typical SQL database. On that, a DataHub instance can send about 10,000 transactions per second. The limiting factor in that case is the speed of the DataHub program.

OPC A&E

OPC A&E conditions contain many individual properties. When you select the option to **Make A&E Status available as individual data points**, it will result in multiplying the number of A&E conditions by 50 or more. So, an A&E server with 1000 conditions could multiply to 50,000 data points or more when that option is selected.

DHTP (Tunnel) Bandwidth

The per-point transmission size for DHTP is approximately 60 bytes plus the length of the data point name. The tag name is UTF-8 encoded, so for names that can be represented in the 7-bit ASCII character set, that is 1 byte per character. Where possible the DataHub program combines point transmissions into single TCP/IP packets to reduce TCP header overhead, up to 1 kB in size.

The DataHub program does not transmit all points. It transmits only those that have changed since the previous scan. Consequently, the size of an OPC scan group does not matter. The important calculation is how many points within the scan group change with each scan. You can see the point transmission rate in the DataHub "View Connections" window.

If the data transmission is write-only then there is no acknowledgement back from the server. If the data transmission is read/write then the server will send back an equivalent message for every point change, effectively doubling the bandwidth requirement.

There is some overhead in SSL when the connection is established—typically around 10 kB. Once the connection is established there is about a 2% increase in bandwidth. The biggest overhead is when establishing the connection, not during data transmission.

DHTP (Tunnel) Buffering

Tunneling takes advantage of the TCP/IP buffer to smooth changes in network speed. The buffer is set to 8 kB, which roughly translates into about 100 data point messages. If this buffer fills, you will see that manifest in the DataHub Connection Viewer as an increment to the "Blocked" counter for the connection. If a data point value changes while the connection is blocked, the oldest value for that point is dropped, and the **Dropped** counter in the connection viewer will increment. If the **Dropped** counter remains at zero then all data point changes are successfully being transmitted through the tunnel. If the **Blocked** counter is increasing then the average data rate is faster than the network can handle.

MQTT Broker

There are no hard limits in the MQTT Broker on the number of connections or topics. The message size limit follows the MQTT specification, which is 256 MB. For values that will be stored in a DataHub instance, that maximum is 128 MB. Large messages will result in large RAM use, as each message is stored a minimum of twice (once in the DataHub engine and once in the MQTT Broker), and will be copied during transmission, possibly resulting temporarily in several more copies.

Troubleshooting

Reporting Problems

We have designed DataHub software to be easy to use, but understand that problems can arise. Many can be solved reading the documentation or watching our technical videos, but sometimes more assistance is necessary. We are happy to help.

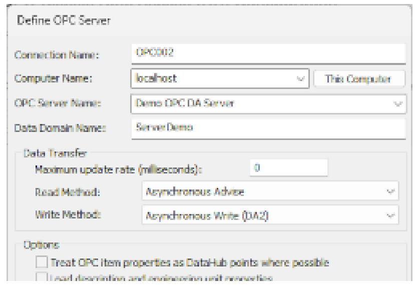
Before contacting us, please check:

- Are you running the latest version of the DataHub software?
- Is the DataHub program installed and configured correctly?
- Does it run OK?
- If you are tunnelling, is your connection to the network and/or Internet up and functioning normally? Do your firewall settings allow the necessary access? Can you ping between machines?

System and Problem Descriptions

If a problem persists, please send the following information to our support team:

1. A **system description** including all data connectivity information:
   - Data communication protocols used (OPC, MQTT, Modbus, etc.)
   - The number of DataHub instances in use
   - DataHub features in use at each node
   - The DataHub version number
   - A system diagram, if relevant
2. A **problem description**, containing as much detail as possible, such as:
   - When was the problem first noticed?
   - What kind of action triggers it?
   - What has changed in the system recently?
   - How often does it happen?
   - How to reproduce it?
3. The DataHub **Event Log output**. You can copy the text of the log right from the display window, if the whole problem is visible. Otherwise, we recommend selecting **Log to file** and zip up and send the whole file. (See more.)
4. Screenshots of relevant **configuration dialogs** to help us locate any configuration problems.



5. If you have any **error messages** or related **error logs** produced by connected software, such as a client program, please include a screenshot or text copy of those messages.

The more complete the information we receive, the easier it is to solve your problem.

Contact Skkynet

Please send all of the above information to `support@skkynet.com`

Other Useful Information and Tools

Often the information mentioned above is enough to help us to solve the problem. Sometimes we will need more, as listed below. Occasionally it is helpful to view the problem in MS Teams or other desktop sharing application. If that becomes necessary, we will arrange a meeting.

Configuration Directory

Sometimes we will need a copy of the DataHub configuration files. These are all in one directory, located here:

For all recent Windows versions:

```
C:\Users\UserName\AppData\Roaming\Cogent DataHub
```

For Windows XP and Windows Server 2003:

```
C:\Documents and Settings\UserName\Application Data\Cogent DataHub
```

If necessary, the directory can be zipped up and emailed to us.

Script Log

In addition to the Event Log, another useful DataHub log is the Script Log. This records any errors in DataHub scripts. Also, the Database (ODBC) feature uses DataHub scripting, so any errors connecting to a database will appear in the Script Log as well.

Connected Programs

Screenshots and information about connected programs like OPC servers or database tables can be helpful.

Crash Dumps

Crash dumps are frequently helpful in narrowing down the cause of a crash, allowing us to try to reproduce the problem. Windows can create crash dumps in one of the following locations:

```
C:\Windows\Minidump
C:\Windows\CrashDumps
C:\Users\UserName\AppData\Local\CrashDumps
C:\ProgramData\Microsoft\Windows\WER\ReportQueue
```

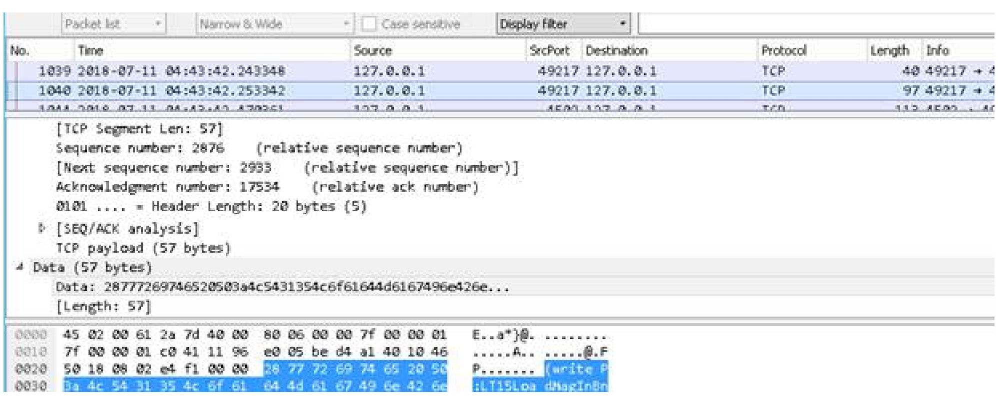
A full crash dump file will likely be 200 MB or more in size, with the word `CogentDataHub` in its name somewhere, and a `.dmp` suffix.

If you can find a dump, please ZIP it and send it to us, or put it on a file sharing system where we can download it.

If there is no crash dump, you can set a registry entry to cause Windows to create one on the next crash by setting `DWORD - HKEY_LOCAL_MACHINE\Software\Microsoft\Windows\Windows Error Reporting\LocalDumps\DumpType` to `2`. If this registry value does not exist then you will need to create it.

Wireshark

For OPC UA and Modbus connections, Wireshark is a very useful tool. It lets you trace the conversation and identify where an error might have occurred. You can download the Wireshark software from here.



To use Wireshark for DataHub troubleshooting:

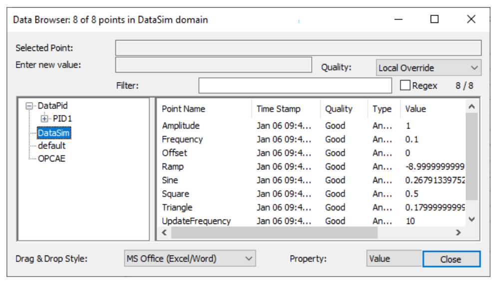
1. Disable all connections except the one that is having trouble.
2. Configure an unencrypted connection, since Wireshark cannot normally decode an SSL stream. For OPC UA, use the `opc.tcp` protocol with security policy `None` and user token type `Anonymous`.
3. Start Wireshark and start the Event Log logging to a file with all options on.

4. Perform any actions that demonstrate the problem, making a note of the clock time.
5. Stop the Wireshark log, and stop the Event Log logging to a file.
6. Uncheck the Debug option in the Event Log.
7. Zip and send both Wireshark trace, DataHub log, and clock time of the problem demonstration to `support@skkynet.com`.

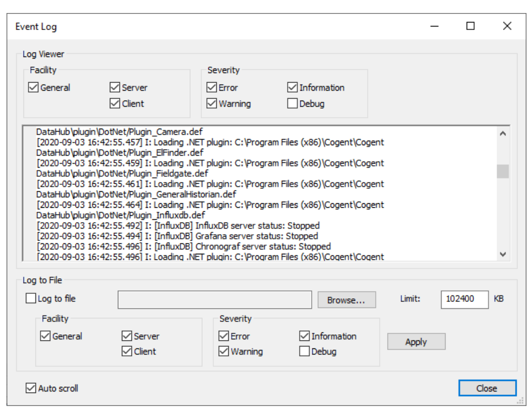
Tools

These troubleshooting tools are all available from the DataHub Properties window, typically used in this order for troubleshooting:

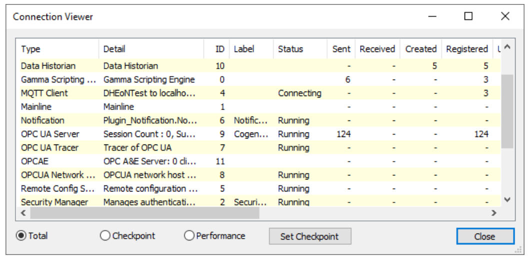
1. **Data Browser:** Use the **View Data** button to open the Data Browser to get a general overview of your data. You can check current values, timestamps and quality for all points, and confirm that the quality and data updates are as expected.



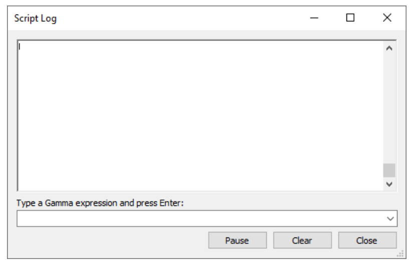
2. **Event Log:** The best place to root out problems is the Event Log. If you need help understanding the output, you should contact Cogent. If you do, you should include the relevant Event Log output—as a screen shot if it is very short, or by enabling **Log to file** and zipping up the results. You can also check the **Debug** options for detailed debugging information, keeping in mind that this will slow down logging and create large files. Be sure to uncheck it when done troubleshooting.



3. **Connection Viewer:** To troubleshoot connectivity, use the Connection Viewer. Here you can see data point change rates, confirm connections, and monitor possible CPU overload.



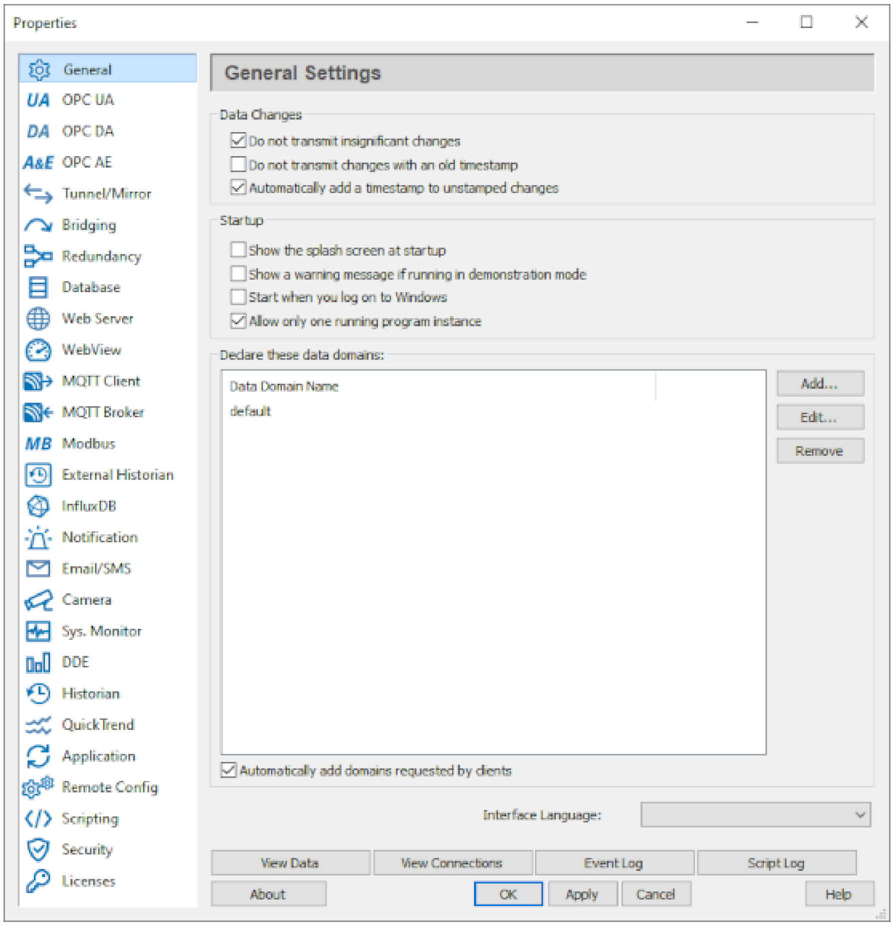
4. **Script Log:** If you are doing DataHub scripting, you can use the Script Log to view output from scripts, and interact with the Gamma scripting engine. You will also find troubleshooting information here for the DataHub Database (logging) feature.



All of these tools, and particularly the Event Log, are useful for reporting problems.

Properties Window

This is where you can configure the DataHub program.



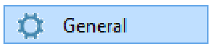
For All Options

For all the options (General, OPC, Tunnel, Bridging, etc.) in this window:

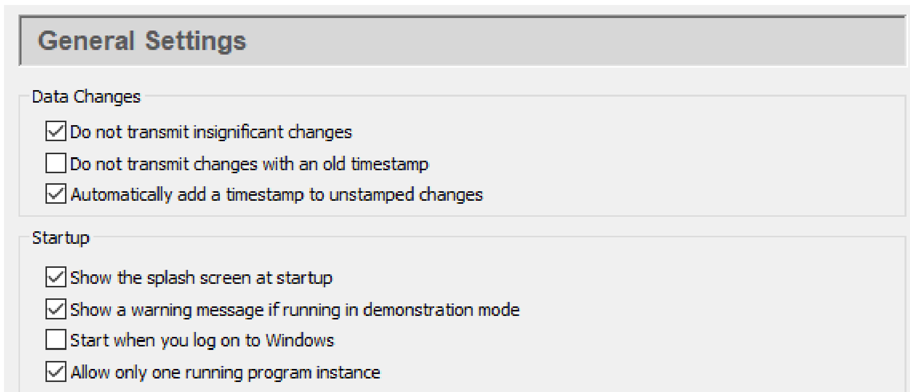
- The **Interface Language** list lets you choose a language for the interface. If you don't find your language, you can contact Cogent for instructions on how to add a translation to the DataHub source code.
- The **View Data** button starts Data Browser.
- The **View Connections** button starts Connection Viewer.
- The **Event Log** button starts Event Log.
- The **Script Log** button starts Script Log.
- The **About** button provides some general information about the software.
- The **OK** button applies changes and closes the window.

- The **Apply** button applies changes but leaves the window open.
- The **Cancel** button closes the window without applying any changes.
- The **Help** button opens the help window for the current option.

General



This first option in the Properties Window lets you control how a DataHub instance starts up, and how changes to data are transmitted.



Data Changes

Do not transmit insignificant changes will reduce traffic by allowing only significant changes to the data to be sent. A change is *significant* if a property of the point other than the time-stamp changes. That normally means a change to either the value or the quality of the point. A change in only the time-stamp is considered insignificant. Some polled data sources change the time-stamp on each cycle, even if the value doesn't change. If network bandwidth is a concern, you can use this option to update the point only when the value has changed.

Do not transmit changes with an old timestamp allows only current or future changes to be sent.

Automatically add a timestamp to unstamped changes stamps the current time onto any changes that haven't already been time stamped.

> This should stay checked unless you have specific reason to uncheck it. Unchecking it may cause changes made through DataSim, the Data Browser, and other programs to receive timestamps of 0 (`Dec 31 19:00:00.000`). If this button is *unchecked* and the **Do not transmit change with an old timestamp** is *checked*, then any changes with a 0 timestamp won't get transmitted at all.

Startup

Show the splash screen at startup lets you hide or show the start-up screen with the DataHub image.

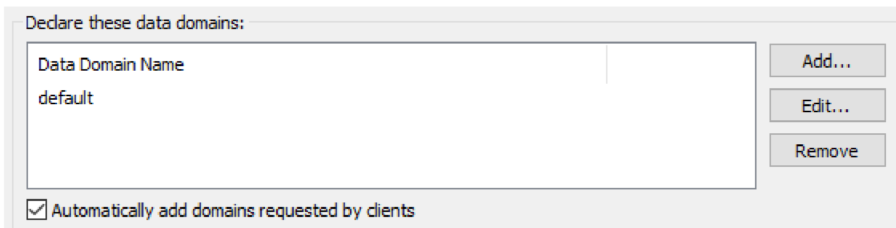
Show a warning message if running in demonstration mode lets you hide or show the message telling you the demo will terminate in one hour.

Start when you log on to Windows causes a DataHub instance to start up whenever you log on to Windows.

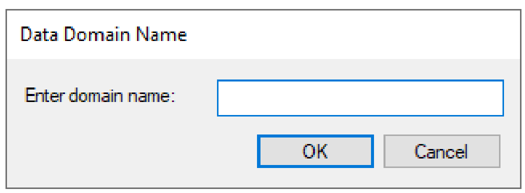
Allow only one running program instance prevents more than one DataHub instance from running at the same time.

Declare these data domains

In this area you can add, edit, or remove data domains for this DataHub instance. For more information about data domains, please refer to the section called "Data Domains".



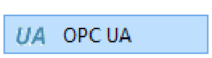
To add a data domain, click the **Add** button and fill in the name in the **Data Domain Name** Window:



To change a data domain, double-click it or select it and click the **Edit** button. To remove a data domain, highlight it and click the **Remove** button.

Checking the **Automatically add data domains requested by clients** box automatically adds a data domain whenever a client requests it. If for some reason you want to limit the data domains to those listed, you should make sure this box is not checked.

OPC UA



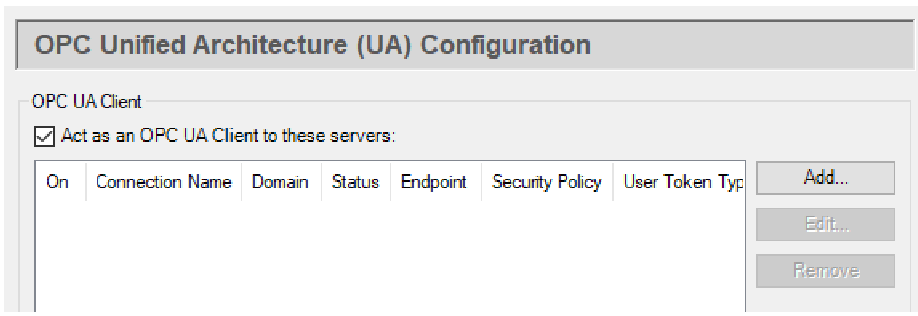
The OPC UA option lets you configure the DataHub program to act as an OPC UA (Unified Architecture) server, an OPC UA client, or both simultaneously. For more information on OPC, please refer to the section called "OPC Protocol" and Appendix F, *OPC Overview*.

For step-by-step instructions to configure a DataHub instance as an OPC UA client or OPC UA server, along with more information about the DataHub program's implementation of the OPC UA standard, please refer to *OPC UA Connections*.

Click here to watch a video.

OPC UA Client

The DataHub program can act as a client to OPC UA servers.

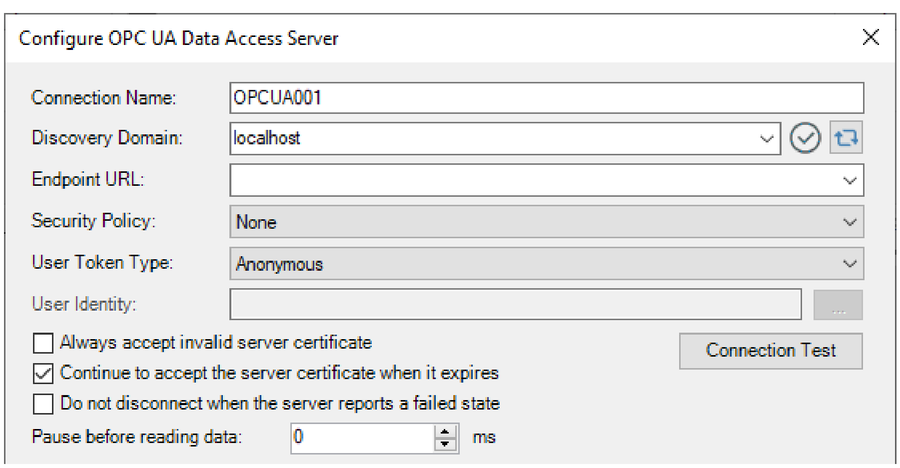


Check the **Act as an OPC UA Client to these servers** box to activate OPC UA client functionality. Since a DataHub instance can be a client to more than one OPC UA server, you need to specify server information for each OPC UA client connection. Once you have a server listed, you can activate or deactivate the connection using its **On** check box.

To add a server, press the **Add** button to open the **Configure OPC UA Data Access Server** window described below. To edit a server, double-click it or select it and press the **Edit** button to open that window. To remove a server, highlight it and click the **Remove** button.

The Configure OPC UA Data Access Server Window

To define or change an OPC UA server connection, click the **Add** or **Edit** button to open the **Define OPC Server** Window:



Connection Name

A name used by this DataHub instance to identify the connection. It doesn't matter what name is chosen, but it should be unique to other connection names.

Discovery Domain

A list of UA Discovery Servers to which you can connect.

Endpoint URL

A list of available Endpoint URLs for the chosen Discovery Server. For each Discovery Domain, the system will attempt to list its endpoint(s), providing feedback as follows:

Indicates that the endpoint discovery is in process.

Indicates that the endpoint discovery has failed.

Indicates that the endpoint discovery has succeeded.

If a connection has already been configured, and the **Configure OPC UA Data Access Server** Window is opened for editing. the **Endpoint URL** will first appear as previously configured. The DataHub instance will then attempt to validate the endpoint, with the status icon changing first to In Process ( ), and then to either Failure ( ) or Success ( ). If at any time you initiate a search by pressing the server refresh button ( ), and the system fails to locate an endpoint URL, then it will leave the **Endpoint URL** entry field empty.

DataHub software supports OPC UA over both IPV4 and IPV6.

Security Policy

A list of available security policies available on the OPC UA server for this connection.

User Token Type

The log-in method used for this OPC UA server and session. Some possible options are:

Anonymous

The UA server allows any user to connect.

User Name

The UA server requires a user name and password.

Another Certificate

The UA server requires a certificate other than your DataHub instance's own certificate.

My Certificate

The UA server allows you to use your DataHub instance's own certificate.

User Identity

This will change depending on the **User Token Type** (above), allowing for the entry of a certificate file path or a user name and password, as appropriate.

Always accept invalid server certificate

Tells the client to always accept the server certificate, even if the certificate is invalid, or if it changes in the future.

Selecting this option will disable server certificate verification for this connection, exposing the connection to man-in-the-middle attacks. Use with extreme caution.

Continue to accept server certificate when it expires

This option allows a UA certificate to be accepted outside of its valid time window, meaning that expired certificates can continue to be used. Checking this box also keeps the UA server and client connected if their system clocks ever get out of synch. And this option also supports connectivity for OPC UA clients running on embedded systems without system clocks, or whose system clocks cannot be adjusted.

If you are using the http protocol along with a security policy, then the clocks on the UA server and client machine must match within 5 minutes at all times. This is a requirement of the WCF subsystem that implements the HTTP security. If you are not able to synchronize the clocks on the server and client machines this closely, you should try either the opc:tcp or https protocol, which do not rely on WCF for the underlying security and so do not exhibit this problem.

Do not disconnect when the server reports a failed state

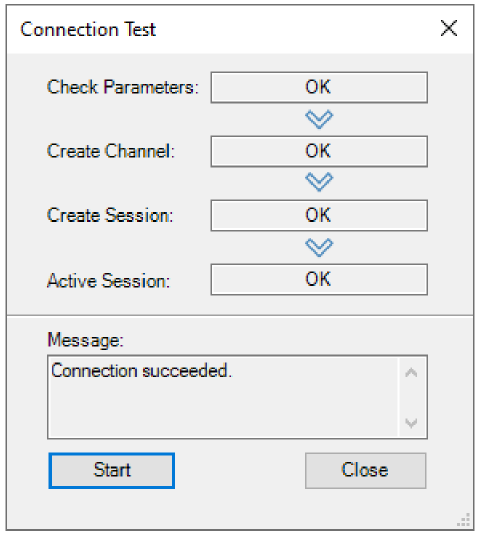
By default, if the server is in a non-`RUNNING` state the DataHub instance disconnects and puts a message in the Event Log. Checking this box lets you override that behaviour and maintain the connection to the server.

Pause before reading data

Specifies a time for the DataHub instance to pause before reading the OPC server's data set. Some OPC servers report that they are running, but have not yet constructed their full data set. If the DataHub instance attempts to browse the server immediately after connecting, it might get a partial data set. This option tells the DataHub instance to wait the specified amount of time after a successful connection before it browses the server's data set.

Connection Test

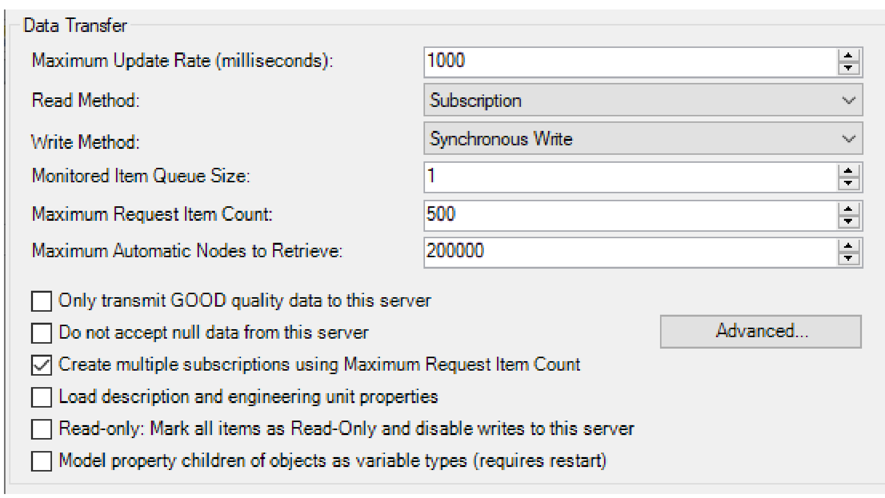
To test the connection, click the **Connection Test** button. The system will open the Connection Test window, and you can watch as it checks the parameters, then creates a channel and session, and then activates the session.



If there is a problem at any point, the **Message** box will provide some trouble-shooting tips. The **Start** button restarts the test.

Data Transfer

There are several options for specifying how the data is to be transferred:



Maximum update rate (milliseconds)

This option lets you specify an update rate, useful for slowing down the rate of incoming data. The minimum value is `10`. This value is also used as the polling time for asynchronous and synchronous reads (see below).

Read Method

Choose how to read data from the OPC UA server:

- **Subscription** The DataHub instance registers with the UA server for all configured points, to be received on an event-driven basis. Whenever a point value changes, the new value is sent immediately to the DataHub instance. This option is more efficient than **Synchronous Read** or **Asynchronous Read**, and has lower latency than either of them.

- **Asynchronous Read** The DataHub instance polls the UA server for all configured points on a timed interval (set by the **Maximum update rate**), and does *not* wait for a reply. This option is less efficient than **Subscription**, and has higher latency.
- **Synchronous Cache Read and Synchronous Device Read** The DataHub instance polls the UA server for all configured points on a timed interval (set by the **Maximum update rate**), and this thread waits for a reply. The difference between **Synchronous Cache Read** and **Synchronous Device Read** is the maximum age (maxAge). This mimics the cache and device reads in OPC DA, where a device read requests a new read from the underlying device. A device read can be substantially slower than a cache read.

  Synchronous Cache Read is approximately equivalent to **Asynchronous Read** in terms of efficiency and latency. If you are trying to read data at a rate that is near the limit of the server's capability, **Synchronous Cache Read** is a better choice because it will naturally slow down to what the server can handle, whereas **Asynchronous Read** will generate overlapping requests that could ultimately result in the connection being closed by the server. For this reason, given a choice between these two, we recommend **Synchronous Cache Read**.

Write Method

Choose how to write data to the OPC UA server:

- **Asynchronous Write** The DataHub instance writes to the UA server and does not wait for a response. This provides the highest overall performance.
- **Synchronous Write** The DataHub instance writes to the UA server and waits for a response each time. This elicits a quicker response for a given item from the UA server, but results in lower overall performance. This option is useful if the UA server doesn't support asynchronous writes at all, or if it can't handle a large number of them.

Monitored Item Queue Size

The maximum number of items between polls that get stored on this server.

Maximum Request Item Count

The OPC UA spec allows a UA server to specify the number of items it will allow per request. Here you can adjust the DataHub default of `500` to what the server allows, if necessary.

Maximum Automatic Nodes to Retrieve

Allows you to change the number of nodes that the DataHub instance will attempt to retrieve when you choose **Load All Nodes on Server**. If you are working with a server with a large number of nodes, you can increase this value. Be aware that very high OPC UA point counts will have a substantial effect on the DataHub instance’s memory usage.

Only transmit GOOD quality data to this server

Restricts point updates from the DataHub instance to the server to only those with

"Good" quality.

Do not accept null data from this server

Restricts point updates from the server to the DataHub instance to only those with non-null values.

Create multiple subscriptions using Maximum Request Item Count

The **Maximum Request Item Count** (above) specifies the maximum number of nodes per subscription. With the **Create multiple subscriptions...** option checked (the default), the DataHub instance will use this number to decide the maximum number of nodes per subscription. However, if this number is small and the total number of nodes is large then the number of requested subscriptions could exceed the subscription count limit of the server. Unchecking this box will solve that problem by putting all of the nodes into a single subscription.

Load description and engineering unit properties

causes the DataHub instance to load any engineering unit and range information associated with each point. These values are then made available to all DataHub clients, and are displayed in the DataHub Data Browser. Activating this feature will increase the time needed for making the initial connection to the server.

Read-only: Mark all items as Read-Only and disable writes to this server

Lets you specify that the connection to the OPC server be read-only, regardless of how individual items are specified. Items in the DataHub instance that originate from such an OPC server will be read-only to all DataHub clients. The DataHub instance will reject any attempt to force the value of a point when the server is marked as read-only.

Model property children of objects as variable types (requires restart)

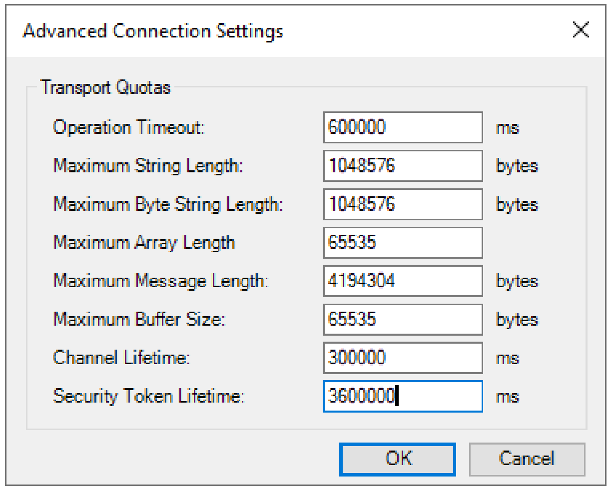
Normally an OPC UA property will be modeled in OPC DA as a property. In OPC UA properties can be direct children of either structural nodes, like objects, or value nodes. Similarly in OPC DA, properties can be direct children of branches or leaves. The DataHub program attempts to preserve this structure as much as possible. However, many OPC DA clients cannot subscribe to properties, making the UA properties inaccessible to those OPC DA subscriptions. Selecting this option will promote OPC UA properties that are direct children of structural nodes to become values, which will in turn promote them to leaf items in OPC DA. This option will not have an effect if the parent of the property is a value node in OPC UA, because promoting the property to be a value child of a value would make it unrepresentable in OPC DA.

Changing this option may require restarting the DataHub instance for its effects to apply.

Advanced

OPC UA communication is governed by a number of timeout and length limits. Normally you do not need to adjust these, but in some cases you may need to extend timeouts for poorly behaved networks, or to reduce message length limits to accommodate servers with limited buffer sizes. Most commonly you would need this with resource-constrained embedded servers.

Clicking the **Advanced** button opens the Advanced Connection Settings window:

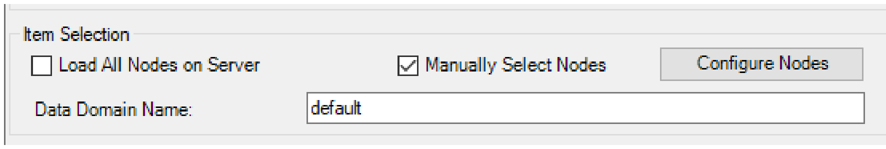


Here you can enter the following **Transport Quotas**:

- **Operation Timeout**: If a network operation does not complete within this time, abandon the operation. This will normally cause the DataHub instance to drop the connection and re-attempt it after a few seconds.
- **Maximum String Length**: The longest permissible string, in bytes. UTF-8 strings may use up to 5 bytes per character.
- **Maximum Byte String Length**: The longest permissible byte string (data type `Byte String`), in bytes. Byte strings are uninterpreted sequences of bytes that may represent any data.
- **Maximum Array Length**: The maximum number of array members for any data value.
- **Maximum Message Length**: The longest permissible message, in bytes.
- **Maximum Buffer Size**: The maximum buffer size, in bytes. The buffer size determines how much data can be read in a single network read call and does not limit the maximum size of a message. You could use this setting to optimize memory usage or reduce the number of network reads in this DataHub instance.
- **Channel Lifetime**: The lifetime of the client channel, in milliseconds. This specifies how long the server will keep a broken channel around while waiting for a client to reconnect.
- **Security Token Lifetime**: The lifetime of a security token, in milliseconds. This specifies how long a security token can be used without renewal.

Item Selection

You can select all nodes, select nodes manually, or both.



Load All Nodes on Server

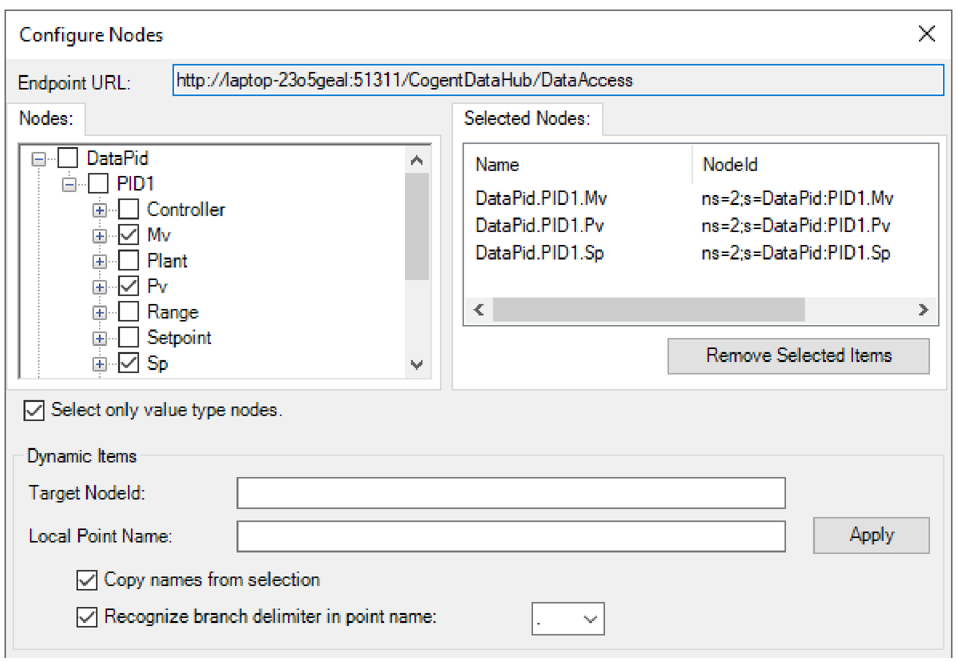
With this option you can load all data nodes on the OPC UA server, or filter for groups of nodes.

When you choose this option, the DataHub instance is configured to provide all data nodes, but not the Server nodes. This is done as a convenience, because in most cases few, if any, Server nodes are needed. To additionally get Server nodes, you can select them manually.

Manually Select Nodes

Select the **Manually Select Nodes** option and press the **Configure Nodes** button.

This opens the Configure Nodes window, where you can specify exactly which nodes you wish to use:



You can browse through the tree in the left pane, selecting points as you go. The selections will appear in the right pane. To view sub-branch and leaf items, click the + sign in front of the item to show the children. You can select many items together like this:

1. Expand all of the branches containing points that you want to add.
2. Click the name of the first point (not the check box).
3. Go down to the last point, hold down the **Shift** key and click the name. All of the names should become highlighted.

4. Press the **Space Bar**.

That should select all of the highlighted points. It will not select nodes that are not visible.

Selecting just a branch by itself will not include any of its sub-branches or leaves, but selecting a leaf item will automatically include all of its branches.

In the Remote Config tool, the following options are available:

- Left-click the checkbox to select/deselect only that item.
- Right-click the checkbox to select/deselect all direct children of that item, but not the item itself.
- Control-right-click the checkbox to select/deselect all children of that item recursively, but not the item itself.

Checking the box **Select only value type nodes** will ensure that the only nodes you choose are data nodes.

A + in front of an item does not necessarily mean that the item has children. You must click the + sign to find out.

Dynamic Items

This feature allows you to explicitly map OPC UA nodes to DataHub point names. Use this when you cannot find the node by browsing, or when the OPC UA server supports dynamically created nodes.

Target NodeId

A text string to identify the node in the OPC UA server.

Local Point Name

The name of the point within the DataHub instance to map to the **Target NodeId**.

Copy names from selection

When checked, automatically fills in the **Target NodeId** and **Local Point Name** fields whenever you select a node in the **Selected Nodes** list.

Recognize branch delimiter in point name

When checked, the **Local Point Name** will be split using the delimiter character, and a DataHub point hierarchy will automatically be created. For example, if the point name is `Plant1.Tank2.Temperature` and the delimiter is a dot character, then this will automatically create a root branch named `Plant1` and a sub-branch within `Plant1` named `Tank2`, then add a point named `Temperature` within the `Tank2` branch. When unchecked, the point name will be created without modification in the root of the target data domain.

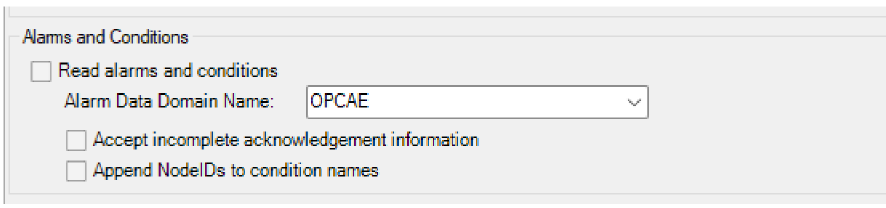
Changes in this **Dynamic Items** section are applied to the Selected Nodes list when you press the **Apply** button.

Data Domain Name

The name of the DataHub domain into which the data points will be placed.

Alarms and Conditions

This feature allows the DataHub instance to function as an OPC UA Alarms and Conditions client. It will read alarms and conditions from the server and write the resulting information to the specified data domain. The data generated from this connection is compatible with DataHub OPC A&E Classic data format, allowing the DataHub instance to convert OPC UA Alarms and Conditions to OPC A&E.



The Alarms and Conditions feature requires a separate license, in addition to the OPC UA license.

Read alarms and conditions

Enables OPC Alarms and Conditions support. You can keep the default DataHub domain, `OPCAE`, or enter a different one. If you configure the DataHub OPC A&E and/or OPC A&C servers to use the same data domain, then these alarms and conditions will be made available to any attached OPC A&E and OPC A&C clients.

Accept incomplete acknowledgement information

This option tells the DataHub A&C feature to acknowledge an alarm when a non-zero value is written to the `OPCAE:Ack.`*`condition_name`* point. Normally, you must write a complete acknowledgement string that includes a user name, message, timestamp and cookie in order for an acknowledgement to be accepted. This option will accept any non-zero value as sufficient information for acknowledgement.

Append NodeIDs to condition names

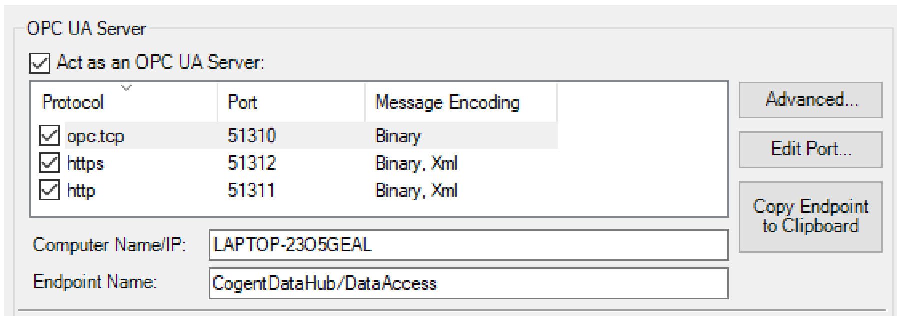
Some OPC UA servers generate conditions that have identical condition and source names, but different node IDs. These conditions represent independent conditions, but overlap because they share the same source and condition name. Selecting this option appends the UA `NodeId` to the condition name to make it unique.

A connection status point is available for monitoring the connection. Please see A&E / A&C Connection Status Point for more information.

OPC UA Server

The DataHub program can act as a server to any number of OPC UA clients.

You must allow Remote Connections in Security for any incoming connections over the network.



Any changes made here will restart the OPC UA server when you click the **Apply** button.

Check the **Act as an OPC UA Server** box and click the **Apply** button to have the DataHub instance function as an OPC server. You can choose one or more of the available protocols, modify the default selection using the **Advanced** option (explained below), or change the port number by double-clicking or using the **Edit Port...** button. You can also use the **Copy Endpoint to Clipboard** button to make a copy of this server's endpoint.

Computer Name/IP

The host name or IP address of the computer on which the DataHub instance is running. This will be integrated into the server URL visible to a connecting client. The default is the host name.

Endpoint Name

The endpoint name that will be integrated into the server URL visible to a connecting client. The default is `CogentDataHub/DataAccessServer`.

Some UA clients cannot connect to a UA server unless the server name is left blank. For these cases, the DataHub program can be configured with a blank server name as follows:

1. Clear the **Endpoint Name** entry field so that it is blank.
2. Uncheck the **HTTP** and **HTTPS** protocols, as these are not supported when the **Endpoint Name** is blank.
3. Click **Apply** to save the changes.

The DataHub UA server will restart with a blank user name, allowing a UA client to connect to it using a simple Endpoint URL, for example:

```
opc.tcp://192.168.1.1:52310/
```

Some UA clients may require some or all of the following information about the DataHub OPC UA server:

- **Namespace** http://www.cogentdatahub.com/DataHub
- **Namespace ID** 2
- **ID type** This information should not be exposed to the user.
- **NodeID syntax** The syntax of NodeIDs in a DataHub instance is `ns=2;s=`*`pointname`*. The namespace is always 2. For example: `ns=2;s=DataPid:PID1.Mv`.
- **Type** Typically the canonical type of the node (ID above) retrieved from the server through a client request.
- **Access to data point** The client application developer will need to provide this information, such as read-only or read-write.

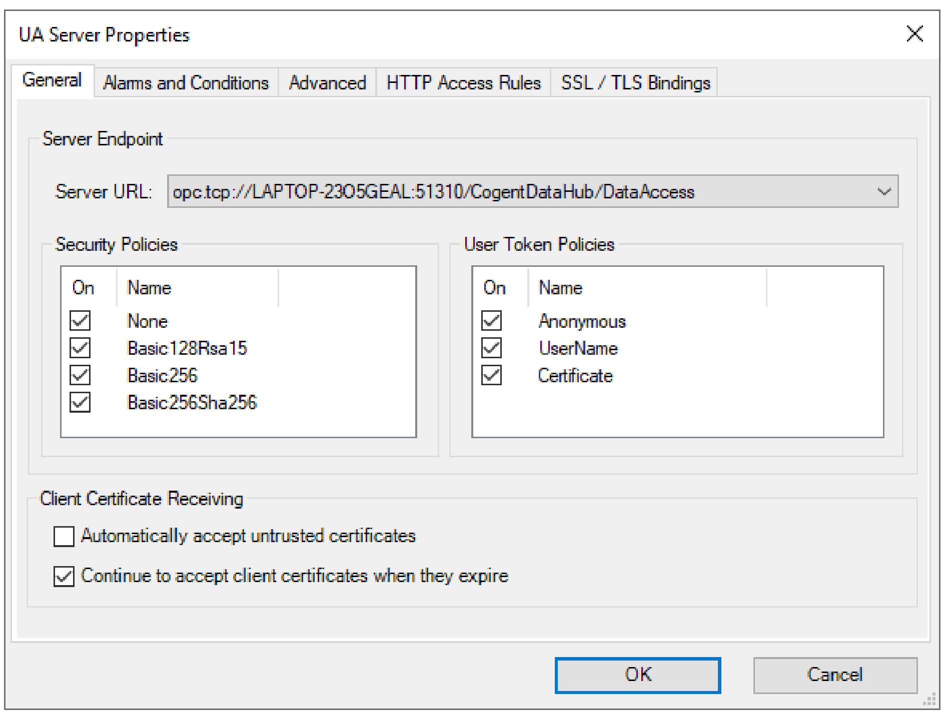
DataHub software supports OPC UA over both IPV4 and IPV6.

Advanced

The default configuration covers most typical client connection requirements. If you need to modify these, you can click the **Advanced** button.

Advanced

Clicking the **Advanced** button opens the UA Server Properties window:



This window allows you to configure the following options for how DataHub instance functions as a UA server: Some of these settings will require you to restart the OPC server, others will not, as indicated.

General

Allows you to specify the security policies for each endpoint.

Any changes made here will restart the OPC UA server when you click the **Apply** button.

Server URL

Allows you to choose the server endpoint for the security and user token policies explained below. The URL for the service endpoint is constructed from the **Protocol**, **Computer Name/IP**, **Port** and **Endpoint Name**, shown and/or described above.

Security Policies

None

Authentication, but no encryption.

Basic128Rsa15

Authentication and encryption (AES, key length 128).

Basic256

Authentication and encryption (AES, key length 256).

User Token Policies

The authentication options available, which are used when starting a session. Multiple options can be selected, and are applied consecutively.

Anonymous

No authentication.

UserName

Authenticates with a user name and password.

Certificate

Authenticates using a certificate.

Client Certificate Receiving

Automatically accept untrusted certificates

Checking this box will allow any client on the network to connect to this DataHub instance without verification. Use with extreme caution.

If this option is selected, any client attempting to connect will be accepted temporarily. Its certificate will be placed in the Temporary Certificate Store, and stay there as long as DataHub instance continues to run. When the DataHub instance shuts down, all certificates in the Temporary Certificate Store get deleted.

To become permanent, a certificate in the Temporary Certificate Store must be accepted, which puts it into the OPC UA Client Certificate Store. Any client whose certificate is in the OPC UA Client Certificate Store can connect whenever this DataHub instance is running, whether **Automatically accept untrusted certificates** is selected or not.

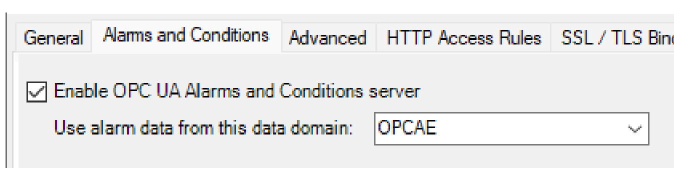
Continue to accept client certificates when they expire

This option allows a UA certificate to be accepted outside of its valid time window, meaning that expired certificates can continue to be used. Checking this box also keeps the UA server and client connected if their system clocks ever get out of synch. And this option also supports connectivity for OPC UA clients running on embedded systems without system clocks, or whose system clocks cannot be adjusted.

If you are using the http protocol along with a security policy, then the clocks on the UA server and client machine must match within 5 minutes at all times. This is a requirement of the WCF subsystem that implements the HTTP security. If you are not able to synchronize the clocks on the server and client machines this closely, you should try either the opc:tcp or https protocol, which do not rely on WCF for the underlying security and so do not exhibit this problem.

Alarms and Conditions

This feature allows the DataHub instance to function as an OPC UA Alarms and Conditions server. It reads its alarm information from the specified data domain, which in turn can be populated by any attached OPC A&E server, OPC A&C server, DataHub tunnel, redundancy pair or DataHub Notification action. Among other things, this allows the DataHub instance to convert OPC UA Alarms and Conditions to OPC A&E, and vice-versa.



The Alarms and Conditions feature requires a separate license, in addition to the OPC UA license.

Enable OPC Alarms and Conditions server

Check the box to enable OPC A&C server functionality. You can keep the default

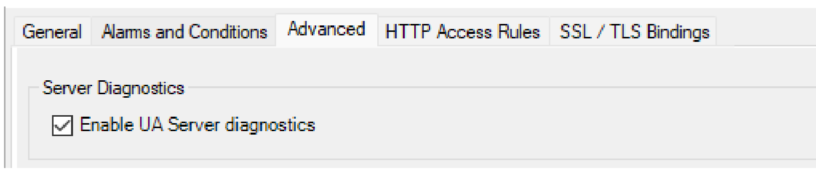
DataHub domain, `OPCAE`, or enter a different one. If you use the same data domain here that you use for the OPC A&E server, the OPC A&E client and the OPC A&C client settings, then the DataHub instance will automatically convert among OPC A&E and OPC A&C clients and servers.

A connection status point is available for monitoring the connection. Please see A&E / A&C Connection Status Point for more information.

Advanced

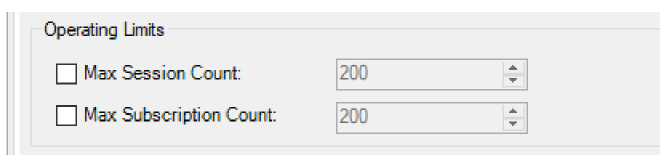
Changes made here will **not** restart the OPC UA server.

Server Diagnostics



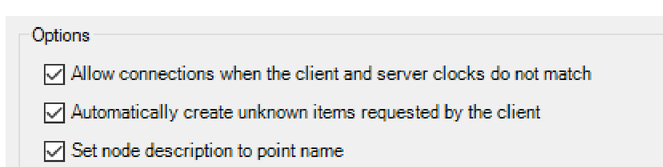
Allows you to enable or disable diagnostics, which may appear in the Event Log or node configuration.

Operating Limits



The **Operating Limits** allow you to limit the number of *sessions* and *subscriptions* on the UA server. A session is a connection, made over a secure channel, which offers the UA client a means to create one or more subscriptions. Each subscription is a selection of monitored items, or in our case, DataHub points. If either of these boxes is not checked, then no limit is applied.

Options



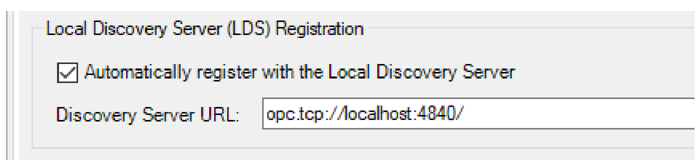
- The **Allow connections when the client and server clocks do not match** option helps to ensure a connection gets made despite any differences in clock times between the client and server.

- The **Automatically create unknown items requested by the client** option is provided to allow this DataHub instance to dynamically add items as clients request them. To be OPC compliant, the DataHub program would normally return an error if a client requests an item that does not currently exist. The primary purpose of this option is to eliminate a start-up race condition where a client using a data item starts before the data item is available from its source. With this option checked, this DataHub instance will create the item with a null value and bad quality, and return it to the client. Later, when the item's source becomes available, the DataHub instance will be able to update the client with the correct value.

  This box must be *unchecked* for the DataHub instance to be fully OPC UA compliant.

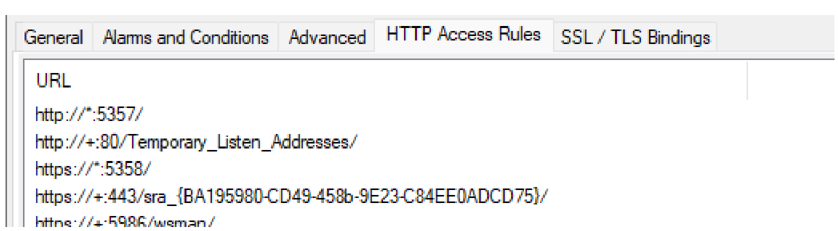
- The **Set node description to point name** option is on by default. Disabling it prevents the UA server from adding the point name to the OPC UA description field. Instead, a value of `null` will be sent as the node description.

Registration of UA Server



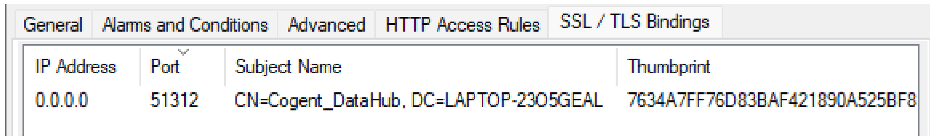
The **Discovery Server URL** default entry of `localhost:4840` is used when this DataHub instance acts as the Discovery Server. As `4840` is the OPC UA specified port for a Discovery Server, we don't recommend changing it without good reason.

HTTP Access Rules



A list of HTTP endpoints for which permission is granted to OPC UA clients to connect. These cannot be added to or modified, but can be removed from the list by selecting one or more, and pressing the **Delete** button.

SSL/TLS Bindings



Provides the details about available SSL/TLS bindings, including the **IP Address**, **Port**, and **Subject Name**, in which `CN` is the "Common Name" or application name, and `DC` is the machine name. The **Thumbprint** is the output of the certificate's hash function.

Server Information

Status

Indicates the server status, such as `Shutdown`, `Start Server`, `Running`, `Stopping`, etc.

Sessions

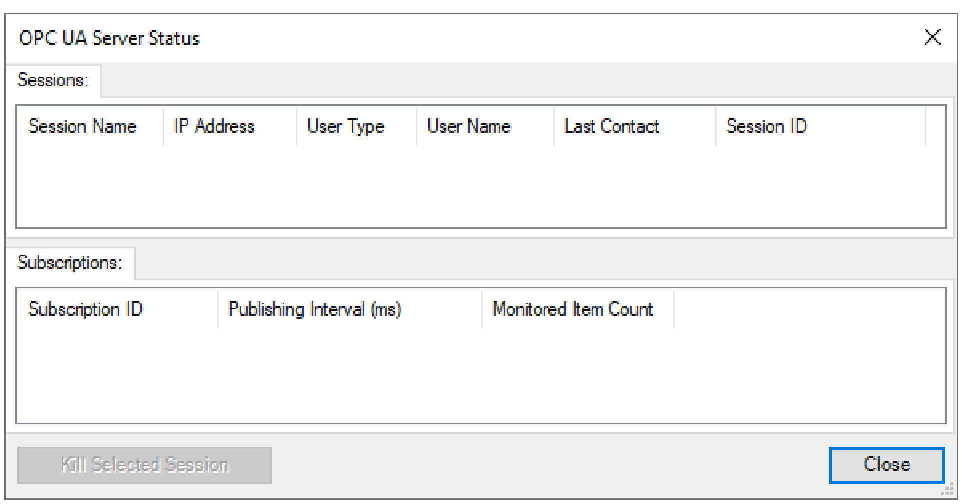
The total number of connections from all UA clients, each of which may include one or more subscriptions.

Subscriptions

The total number of subscriptions from all clients, each of which may contain one or more selections of monitored DataHub points. Subscriptions may migrate from one session to another, if a session gets terminated.

Server Status...

This button opens the OPC UA Server Status window:



This window provides more information about each session. Clicking on a session displays details about each of its subscriptions.

Certificates

OPC UA security is managed using certificates. When an OPC UA client and server communicate, they exchange certificates to ensure each other's validity. The following options let you determine which certificates are used, and how they are managed.

Rejected Certificates

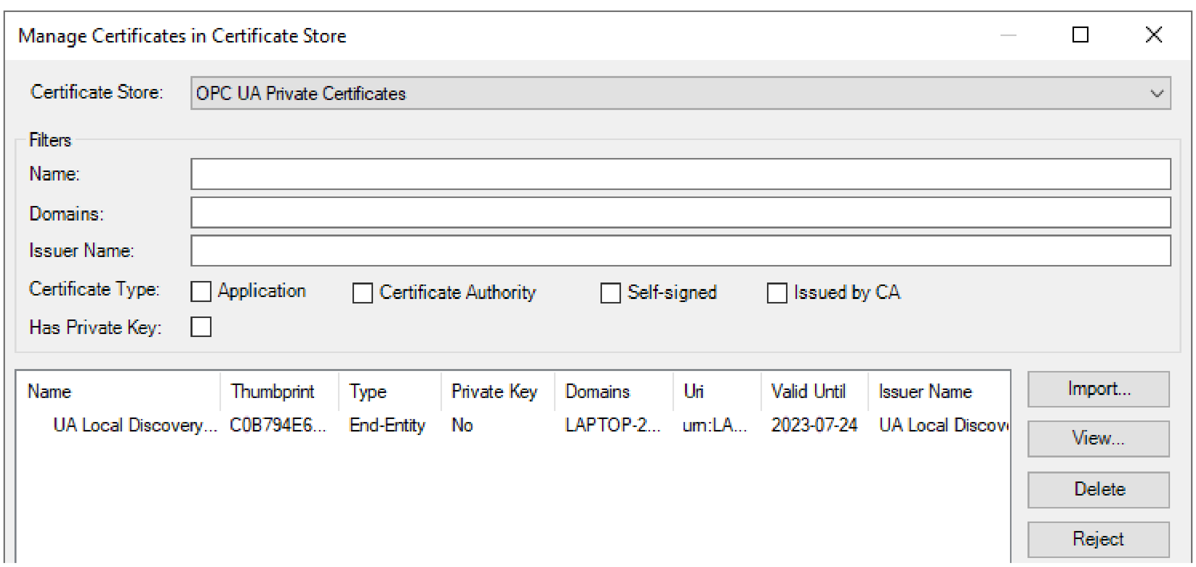
The number of security certificates in the Rejected Certificate Store. This status can be changed by clicking **Accept All**, or **Manage Certificates**.

Temporary Certificates

The number of security certificates in the Temporary Certificate Store. This status can be changed by clicking **Accept All**, or **Manage Certificates**.

Manage Certificates

This button opens the Manage Certificates in Certificate Store window:



Certificate Store

Lets you choose which certificate store to display:

- **Rejected Certificates** (not trusted)
- **OPC UA Private Certificates** (not in the Windows certificate store)
- **OPC UA Global Certificates** (in the Windows certificate store)

- **Certificate Authorities**
- **Temporary Certificates** (valid for this session only)

Filters

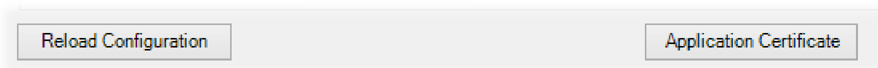
Allow you to filter the certificates listed according to name, domain, and issuer name, as well as certificate type, and whether the certificate has a private key.

Actions

Using the buttons or the right-click context menu, you can **Import** other certificates, or select a certificate and **View**, **Delete**, **Reject** it. You can also **Accept** it for the private store or **Global Accept** it for the Windows certificate store.

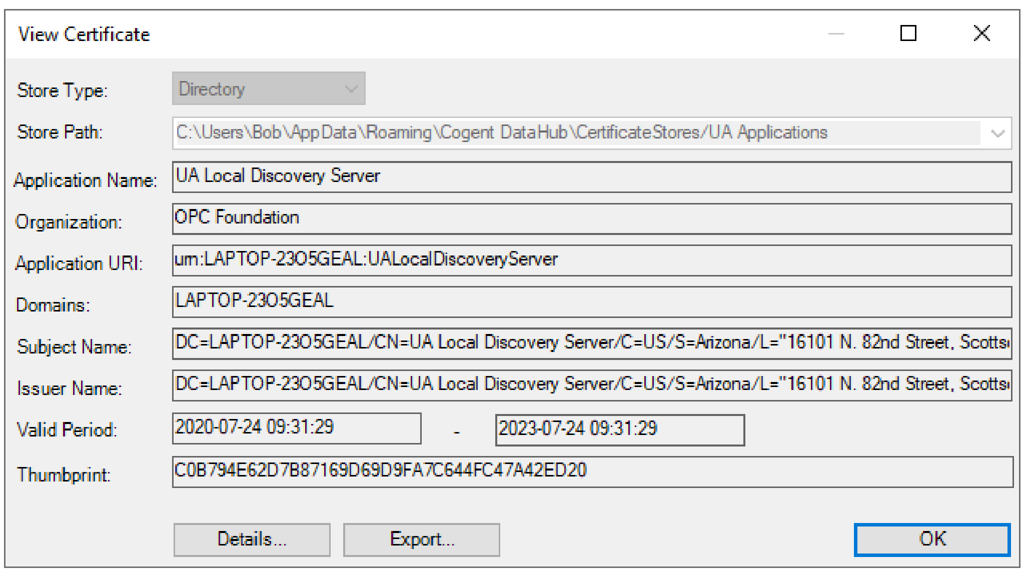
Reload Configuration

Reloads your entire OPC UA configuration



Application Certificate

Allows you to view the certificate assigned to this DataHub instance.



Store Type

The type of store for this certificate.

Store Path

The file path to the directory store. If the **Store Type** is `Directory`, it will be in the path.

Application Name

The name of the application, typically `DataHub Data Access Server`.

Organization

The organization name.

Application URI

A URI that uniquely identifies the application.

Domains

The host name.

Subject Name

The subject name of the certificate, in which `CN` is the "Common Name" or application name, and `DC` is the machine name.

Issuer Name

The publisher of the **Subject Name** that issued the certificate.

Valid Period

The period of time that the certificate is valid.

Thumbprint

The certificate's thumbprint.

Details

Opens the View Certificate Details window that displays the above information, and additional details.

Export

Writes the certificate to a file in your file system, without a key. This is necessary when a UA application needs to manually install the certificate.

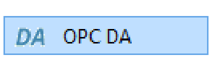
Assign

Lets you assign a different certificate to the DataHub program. It must contain a private key to be able to be assigned.

Regenerate

Regenerates the certificate. This is useful if you think that the certificate has been compromised, or if you change your computer name. Regenerating the certificate automatically restarts the OPC UA server.

OPC DA



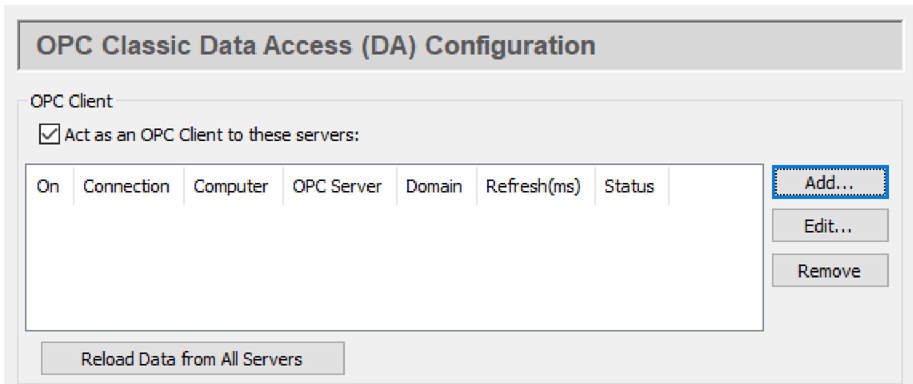
The OPC DA option lets you use the DataHub program as an OPC DA server, an OPC DA client, or both simultaneously. For more information on OPC, please refer to the section called "OPC Protocol" and Appendix F, *OPC Overview*.

For step-by-step instructions to configure the DataHub program as an OPC DA client, please refer to the section called "Connect to an OPC DA server".

Click here to watch a video.

OPC DA Client

The DataHub program can act as a client to one or more OPC DA servers.



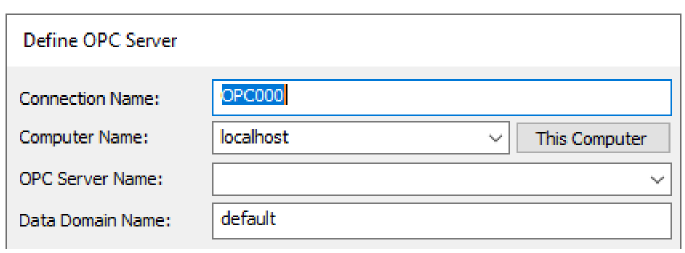
Check the **Act as an OPC Client** box for OPC DA client functionality. Since a DataHub instance can be a client to more than one OPC server, you need to specify server information for each OPC client connection. Once you have a server listed, you can activate or deactivate the connection using its **On** check box.

To add a server, press the **Add** button to open the **Define OPC Server** window described below. To edit a server, double-click it or select it and press the **Edit** button to open that window. To remove a server, highlight it and click the **Remove** button.

Pressing the **Reload Data from All Servers** button causes the DataHub instance to disconnect from all OPC DA servers, and then reconnect and refresh the data set for each server.

The Define OPC Server Window

To define or redefine an OPC DA server connection, click the **Add** or **Edit** button to open the **Define OPC Server** Window:



Connection Name

A name used by the DataHub instance to identify the connection. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other connection names.

Computer Name

The name or IP address of the computer running the OPC server you want to connect to. Select it from the drop-down list, or type it in.

OPC Server Name

The name of the OPC server that you are connecting to, selected from the list of available servers.

Data Domain Name

The name of the DataHub domain in which the data points are received.

Data Transfer

The DataHub program supports OPC DA 2.0 and OPC DA 3.0 client protocols. DA 3.0 support consists of browsing support and support for the `WriteVQT` (Value, Quality, Timestamp) methods of the DA 3.0 specification. Normally, a DataHub instance will determine whether a particular server is DA 3.0 compliant based on the registry entries made by the server when it was installed.

If the server is DA 3.0 compliant, then the DataHub instance will always use DA 3.0 browsing, as it is substantially faster than DA 2.0 browsing. If the server claims to be DA 3.0 compliant, but does not offer the DA 3.0 browsing interface, the DataHub instance will attempt to drop back to the DA 2.0 browsing interface.

In some cases, the server's DA 3.0 compliance cannot be determined. This is true if the server name is specified as a GUID in the form {*nnnnnnnn-nnnn-nnnn-nnnn-nnnnnnnnnnnn*} where each *n* is a hexadecimal digit. In this case, the DataHub instance will default to only use the OPC DA 2.0 browsing interface. You can force the use of DA 3.0 or DA 2.0 using the respective option, as explained below.

For testing purposes, there is also a registry key that can be used to globally override the use of DA 3.0 browsing for all OPC connections. If the `DWORD` registry value:

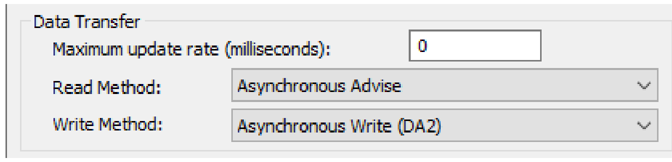
```
HKEY_CURRENT_USER\Software\Cogent\Cogent DataHub\BrowseDA3
```

exists, its value will be interpreted as follows:

- `1`: Always use DA 3.0 browsing, regardless of the server settings
- `0`: Never use DA 3.0 browsing, regardless of the server settings

Since this key is global to all OPC client connections, it should not be created at all unless a particular testing scenario requires it. The setting will take effect the next time a connection to the OPC server is made.

With all of these considerations in mind, you have several options for specifying how the data is to be transferred:



Maximum update rate (milliseconds)

This option lets you specify an update rate, useful for slowing down the rate of incoming data. The default is `0`, which causes values to be updated as soon as possible. This value is also the polling time used by asynchronous and synchronous reads (see below).

Read Method

Choose how to read data from the OPC server:

- **Asynchronous Advise** The OPC server sends a configured point's data to the DataHub instance immediately whenever the point changes value. This is the most efficient option, and has the least latency.
- **Asynchronous Read** The DataHub instance polls the OPC server for all configured points on a timed interval (set by the **Maximum update rate**). This option is less efficient than Asynchronous Advise, and has higher latency.
- **Synchronous Cache Read** The DataHub instance polls the OPC server for all configured points on a timed interval (set by the **Maximum update rate**), and this thread waits for a reply. This option is less efficient than Asynchronous Advise or Read, and has higher latency than either of them.
- **Synchronous Device Read** The DataHub instance polls the PLC or other hardware device connected to the OPC server for all configured points on a timed interval (set by the **Maximum update rate**), and this thread waits for a reply. This is the least efficient of all of these options, and has the highest latency.

Write Method

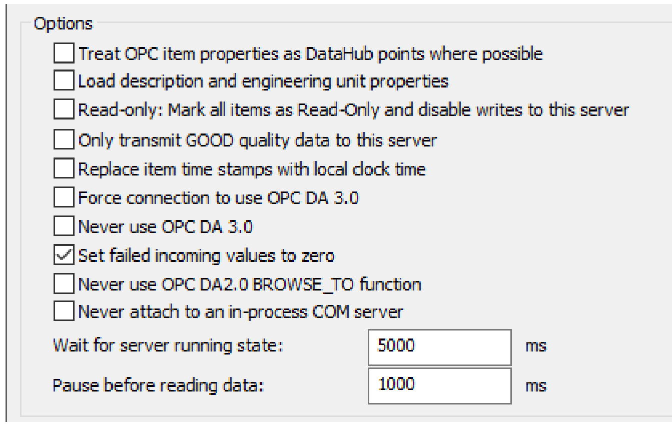
Choose how to write data to the OPC server:

- **Asynchronous Write** The DataHub instance writes to the OPC server and does not wait for a response. This provides the highest overall performance.
- **Synchronous Write** The DataHub instance writes to the OPC server and waits for a response each time. This elicits a quicker response for a given item from the OPC server, but results in lower overall performance. This option is useful if the OPC server doesn't support asynchronous writes at all, or if it can't handle a large number of them.

For these options, the DA 2.0 write methods only transmit a point's value, allowing the server to assign a quality and timestamp as it sees fit. The DA 3.0 methods (`WriteVQT`, supported by DA 3.0 servers only) transmit the Value, Quality, and Timestamp of a point.

Options

There are several optional entries:



Treat OPC item properties as DataHub points

This option lets you register and use each OPC item property as a point in the DataHub instance.

> Some OPC servers are slow to register their OPC items and properties. Using this option with one of these servers can significantly slow the start-up time of the DataHub program.

Load description and engineering unit properties

This causes the DataHub instance to load any engineering unit and range information associated with each point. These values are then made available to all DataHub clients, and are displayed in the DataHub Data Browser. Activating this feature will increase the time needed for making the initial connection to the server.

Read only: Mark all items as Read-Only

Here you can specify that the connection to the OPC server be read-only, regardless of how individual items are specified. Items in a DataHub instance that originate from such an OPC server will be read-only to all DataHub clients.

Only transmit GOOD quality data to this server

This option prevents any data except that with a quality of `Good` from being sent to the OPC server.

Replace item time stamps with local clock time

This option allows you to set the timestamps for the items from this server to local clock time.

Force connection to use OPC DA 3.0

This setting will allow the user to choose the DA 3.0 write methods from the **Write Method** drop-down box. It will also instruct the DataHub instance to attempt to browse the server using DA 3.0 browsing. This setting will override any automatic information that the DataHub instance may determine about the server based on the server's registry entries.

Never use OPC DA 3.0

This setting will remove the DA 3.0 write methods from the **Write Method** drop-down box, and will instruct the DataHub instance to only use DA 2.0 browsing. This setting will override any automatic information that the DataHub instance may determine about the server based on the server's registry entries.

Set failed incoming values to zero

The OPC spec requires an OPC server to send an `EMPTY` (zero) value whenever it sends a failure code in response to an item change or a read request. Some OPC servers, however, send a valid value with the failure code under certain circumstances. To ignore any such value from the OPC server and assume `EMPTY`, keep this box checked (the default). If instead you want to use the value supplied by your OPC server, uncheck this box.

Unchecking this box will make this DataHub instance's behavior non-compliant with the OPC specification.

Never use OPC DA 2.0 BROWSE_TO function

This setting will disallow the `BROWSE_TO` function when communicating with OPC DA 2 servers. Sometimes an OPC server will have problems with this function that prevent the DataHub program from connecting to it. Checking this box might allow the connection to be established in those cases.

Never attach to an in-process COM server

Most vendors include both an in-process and out-of-process COM server with their OPC server installation. If both options are available, the DataHub instance connects to the in-process server, as it is generally the better choice. This option forces the DataHub instance to consider only out-of-process servers.

Why is this useful? An in-process server is implemented as a DLL that is loaded into the client's address space. This makes the client very dependent on the good implementation of the server. If there is a crash in an in-process server, the client also crashes. An out-of-process server is implemented as a separate executable. The client communicates with an out-of-process server using the inter-process communication mechanisms in DCOM. In theory an in-process server will be faster than an out-of-process server, but sometimes the in-process server is less robust than the out-of-process server and leads to instability or malfunction in the client.

Allow VT_EMPTY canonical type for OPC DA2

The `VT_EMPTY` canonical type may be incompatible for a particular combination of OPC server and client. For example, some clients or servers that were built before 64-bit integers were common may fail when presented with a 64-bit number. These options (**DA2** and **DA3**) allow you to enable or disable the `VT_EMPTY` canonical type, either for trouble-shooting or as a permanent part of your configuration.

Allow VT_EMPTY canonical type for OPC DA3

See above.

Wait for server running state

Every OPC server takes a little time to initialize before it will allow client connections. This option lets the user specify the time to wait for the OPC server to initialize. The wait time is a maximum; if a server initializes before this time, the DataHub instance will connect right away. If the server doesn't initialize within this time, the DataHub instance will report this in the Event Log, and then try to connect anyway.

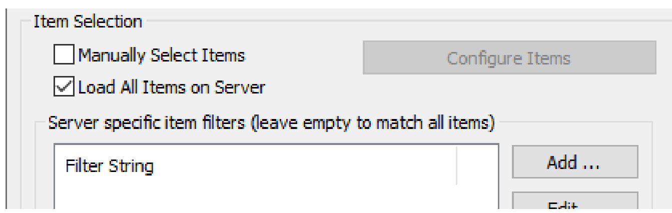
Pause before reading data

This parameter specifies a time for the DataHub instance to pause before reading the OPC server's data set. Some OPC servers report that they are running, but have not yet received the full data set from the process. If the DataHub instance attempts to connect right away, it might get a partial data set. The pause is fixed; it will always last for the full time specified.

The two above times are added together. The DataHub instance will wait until the server is initialized (or until the specified "wait" period is complete) and then pause for the specified "pause" time, before trying to read data from the server. For example, with the defaults of `5000` and `1000`, at least 1 second and at most 6 seconds will elapse before the DataHub instance tries to read the data set.

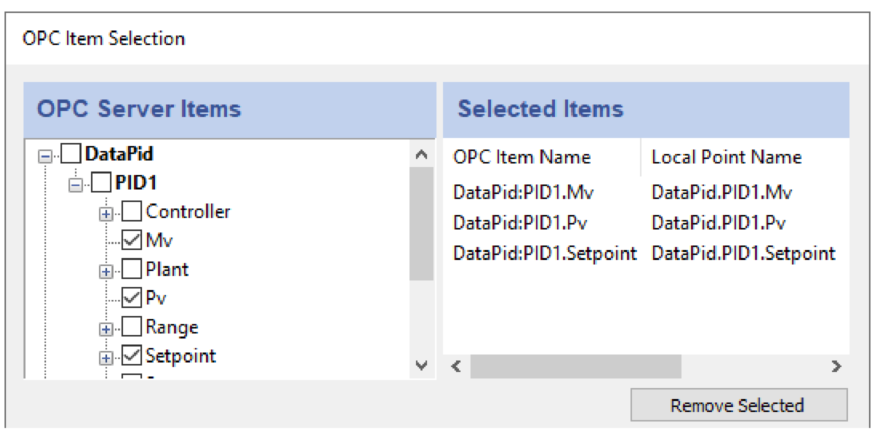
Item Selection

You can select all items, filter for specific items, or select items manually.



Manually Select Items

Check the **Manually Select Items** box and press the **Configure Items** button to open the OPC Item Selection window, where you can specify exactly which points you wish to use:

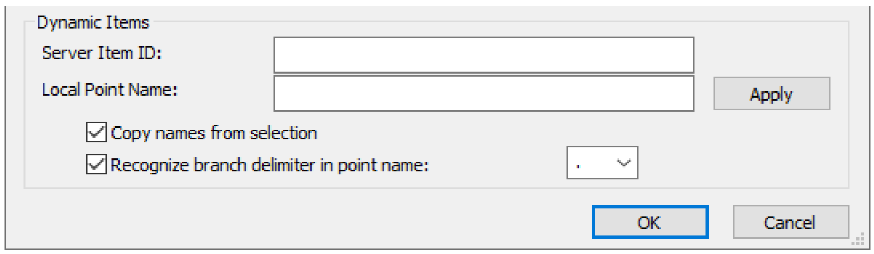


You can browse through the tree in the left pane, selecting points as you go. The selections will appear in the right pane. Follow these guidelines for making selections:

- To select a server item from the right-hand pane, click its check-box.
- To highlight a list of consecutive server items, click the first item, hold down the

Shift key, and then click the last item. To highlight separate server items, hold down the **Ctrl** key as you click each item. To select a group of highlighted items, use the **Spacebar**.

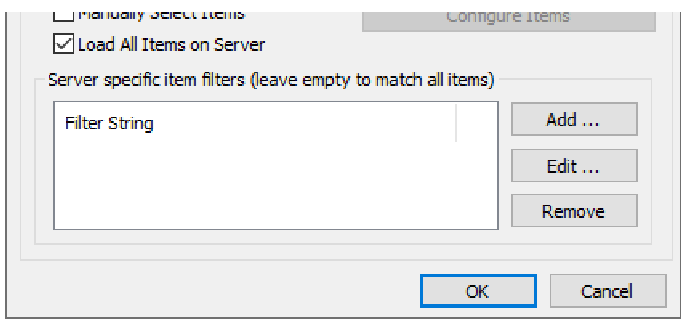
- Selecting a server item does not automatically add any of its child items. Each child item must be added separately. To view child items, click the + sign in front of the item. If an item has one or more children that have been selected, the item name(s) will appear in bold.
- To delete selected items from the right-hand pane, highlight them and press the **Remove Selected** button. Use the **Shift** and **Ctrl** keys as above to highlight groups of selected items.



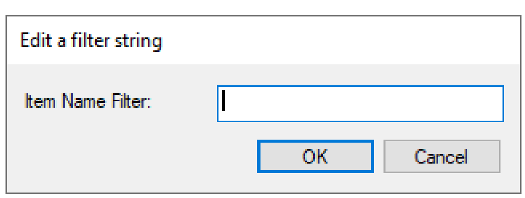
You may also configure dynamic items on the server. As you type in the **Server Item ID**, the system will fill in an identical **DataHub Point Name** for you (which you can change at any time). Press the **Enter** key or the **Apply** button to create the item. Checking the **Copy names from selection** box will fill in the entry with the name you select from the **Selected Items** list (above). The **Recognize branch delimiter in point name** option lets you select and apply a point delimiter for your dynamic items.

Load All Items on Server

In addition to manually loading items, you have the option in the Define OPC Server dialog to register all points, or filter for groups of points, from the OPC server.



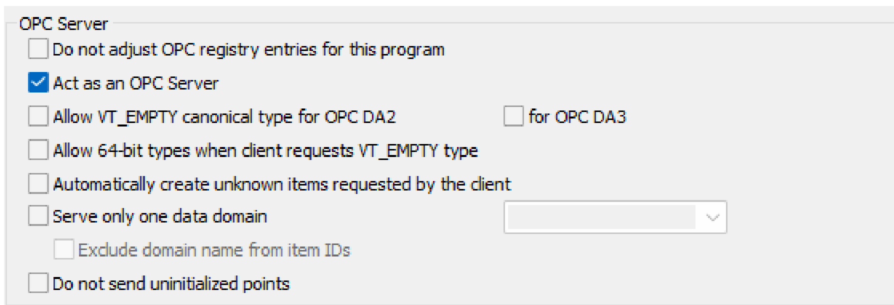
In the **Server specific item filters** area you can enter one or more strings to filter for groups of items in the OPC server. Use the **Add** or **Edit** button to open the **Edit a filter string** window:



Enter a string that matches an item name, or a pattern to match multiple names. Each OPC server has its own syntax for pattern matching, so you may have to experiment a little to get exactly the points you need. Commonly, the symbol * matches any number of characters, while the symbol ? often matches a single character. In that case, an entry of `?a*` would bring in all items with a as the second letter in their names.

OPC DA Server

The DataHub program can act as a server to any number of OPC DA clients.



Check the **Act as an OPC Server** box to have the DataHub program function as an OPC DA server.

If your OPC client requires that you hand-enter the OPC server name, use either `Cogent.DataHub` or `Cogent.DataHub.1`.

You must allow Remote Connections in Security for any incoming connections over the network.

The **Do not adjust OPC registry entries for this program** option tells the DataHub instance not to alter its registry settings. This is useful if you want to use the DataHub instance with a redundancy server or some other program that modifies DataHub registry independently. Without this box checked, the DataHub program will overwrite any external changes when it starts or when a change to the **Act as an OPC Server** status is applied.

These two boxes work together, because turning the OPC server behavior on or off necessarily makes changes to the registry. Here is how you can change OPC DA server behavior when you also need to maintain registry settings:

1. Uncheck **Do not adjust OPC registry entries for this program**. This will make the **Act as an OPC Server** checkbox visible.
2. Check or uncheck the **Act as an OPC Server** as needed, and click **Apply**.
3. Check **Do not adjust OPC registry entries for this program** and click **Apply**.

The **Allow VT_EMPTY canonical type for OPC DA2 / DA3** options allow the DataHub instance to send `VT_EMPTY` canonical data types for OPC DA2 clients, OPC DA3 clients, or both. By default the DataHub instance does not send data with a canonical type of `VT_EMPTY` because many OPC DA2 clients will not accept that data type.

Leaving the **Allow 64-bit types when client requests VT_EMPTY types** option unchecked forces the server to send all values of `VT_EMPTY` canonical type as 32-bit numbers.

Normally clients tell the server what number format they intend to accept, and the server has the responsibility to provide that number format. However, a client can send VT_EMPTY as the requested type, which means that the client will accept any number format. Some clients that do this were built before 64-bit integers became common, and fail when presented with a 64-bit number, even when they have requested VT_EMPTY. Keeping this box unchecked (the default setting) prevents this from happening. The **Allow VT_EMPTY canonical type for OPC DA2 / DA3** options allow the DataHub instance to send `VT_EMPTY` canonical data types for OPC DA2 clients, OPC DA3 clients, or both. By default the DataHub instance does not send data with a canonical type of `VT_EMPTY` because many OPC DA2 clients will not accept that data type.

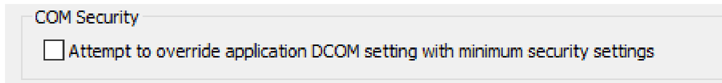
The **Automatically create unknown items requested by the client** option is provided to allow the DataHub instance to dynamically add items as clients request them. To be OPC compliant, the DataHub program would normally return an error if a client requests an item that does not currently exist. The primary purpose of this option is to eliminate a start-up race condition where a client using a data item starts before the data item is available from its source. The DataHub instance will create the item with a null value and bad quality, and return it to the client. Later, when the item's source becomes available, the DataHub instance will be able to update the client with the correct value. If the OPC client requests an item ID without a colon character (`:`) to denote a domain, the DataHub instance will assign the domain `dynamic`, inserting a point called `dynamic:`*`pointname`*, and return success.

The **Serve only one data domain option** configures the DataHub OPC DA server to serve the data in just one DataHub data domain. Specify the domain name in the drop-down list. Setting this option enables the **Exclude domain name from item IDs** option, which when checked exposes the OPC items without the DataHub-assigned *`domainname`*`:` prefix. For data points originating from some OPC servers, this will mean that the DataHub item names match the OPC server's item names.

Do not send uninitialized points tells the DataHub OPC DA server not to send asynchronous updates for points that have been created but not given a value. This can happen when a client application requests information for a point that does not exist, and the DataHub instance creates the point in an uninitialized state to satisfy that request. This is common in start-up scenarios when a data user connects to the DataHub instance before the source of that data is connected. This only affects asynchronous Advise and Refresh transactions. If a client calls `Read` to read an uninitialized point from the DataHub instance, it will respond with a zero value, bad quality and zero timestamp.

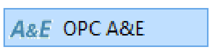
COM Security

If you need to connect a DataHub instance over a network and for some reason you can't use tunnelling, here is an option to facilitate COM configuration



Check the box **Attempt to override application DCOM setting with minimum security settings** to relax COM security. This setting will override the COM permission settings for the application, but will not override the system's global COM restrictions. It is common for OPC DA servers to operate at minimal DCOM security settings, since high security interferes with connectivity and most control systems do not operate in hostile network environments. If in doubt, consult your system administrator.

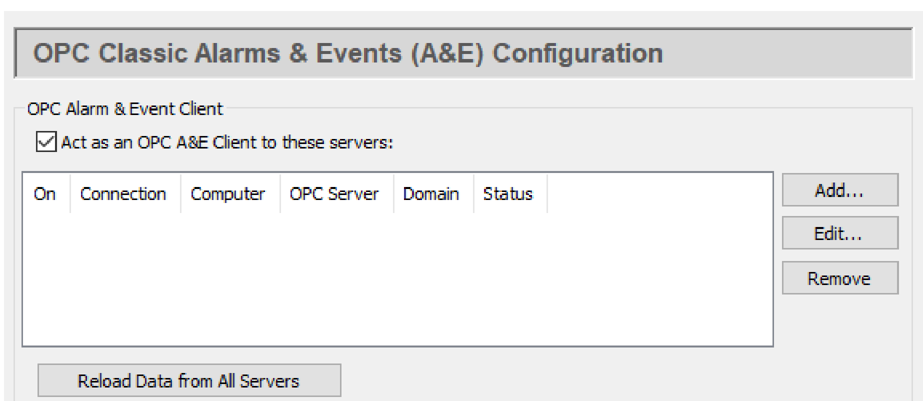
OPC A&E



The OPC A&E option lets you configure the DataHub program to act as an OPC A&E client, an OPC A&E server, or both simultaneously. To also configure the DataHub program as a source for alarms and events, please see Notifications.

OPC A&E Client to Server

The DataHub program can act as a client to one or more OPC A&E servers.



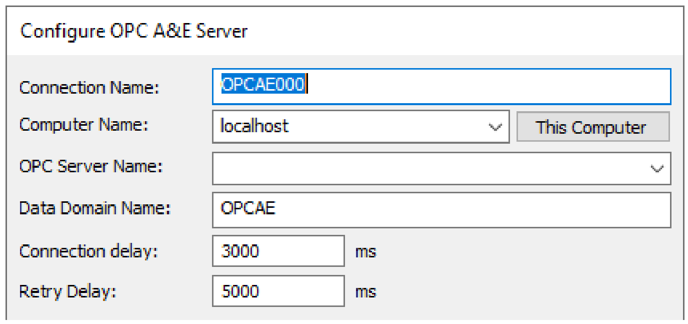
Check the **Act as an OPC A&E Client** box for OPC A&E client functionality. Since a DataHub instance can be a client to more than one OPC A&E server, you need to specify server information for each OPC A&E client connection. Once you have a server listed, you can activate or deactivate the connection using its **On** check box.

To add a server, press the **Add** button to open the **Configure OPC A&E Server** window described below. To edit a server, double-click it or select it and press the **Edit** button to open that window. To remove a server, highlight it and click the **Remove** button.

Pressing the **Reload Data from All Servers** button causes the DataHub instance to disconnect from the A&E servers and then re-establish the connection and re-query the alarm and event information from each of them, just like a new connection

The Configure A&E Server Window

To define or redefine an OPC A&E server connection, click the **Add** or **Edit** button to open the **Define OPC A&E Server** Window:



Connection Name

A name used by the DataHub instance to identify the connection. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other connection names.

Computer Name

The name or IP address of the computer running the OPC A&E server you want to connect to. Select it from the drop-down list, or type it in.

OPC Server Name

The name of the OPC A&E server that you are connecting to, selected from the list of available servers.

Data Domain Name

The name of the DataHub domain in which the data points are received.

Connection Delay

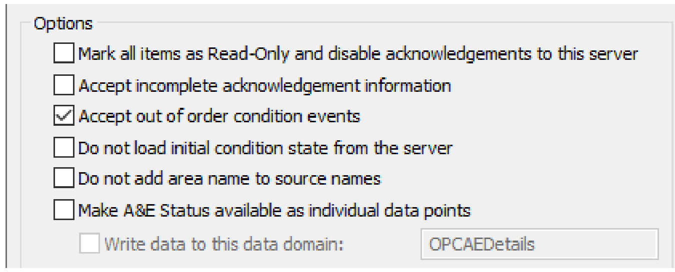
The number of milliseconds to delay the initial connection.

Retry Delay

The number of milliseconds to wait before retrying a failed connection.

Options

You have several additional options:



Mark all items as Read-Only and disable acknowledgements to this server

This option will protect items on the DataHub instance from being changed by the client.

Accept incomplete acknowledgement information

This allows connections to OPC A&E clients which are not configured for acknowledgements or that don't support this part of the OPC A&E specification.

Accept out of order condition events

In OPC A&E the time stamp of an event should always be newer than the time stamp of the previous event for any condition. If, perhaps due to differing clock times on connected DataHub machines, you get errors indicating that events have arrived with out-of-order time stamps, then you can select this option to eliminate the warnings and accept the events.

Do not load initial condition state from the server

When the DataHub instance connects to an A&E server it queries the server for the current state of all alarm conditions. Some servers report all conditions, whether they are active or not. Other servers only report the state of active conditions. Other servers do not report their initial state at all, and simply let the client learn about condition states as they change.

Selecting this option tells the DataHub instance to wait for an event before identifying conditions (and sources). That means that it won't call `GetQualifiedSourceName`, and therefore will always present the source as seen in `szSource`. It also means that an A&E client will not be able to browse the complete condition tree from the DataHub instance, as it will start with no condition information and will only discover it as events arrive.

Do not add area name to source names

When constructing a source name from the initial condition state, the DataHub instance builds the source name by appending the source's area path followed by the unqualified source name from the server. This option disables this behaviour and uses only the unqualified name as the source name.

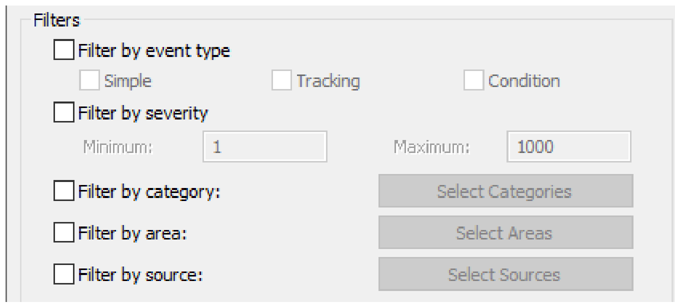
If you are using an A&E server that provides only a partial list of conditions when reading the initial condition state then this allows you to adjust for the behaviour of the server when discovering new conditions as events occur. Specifically, some servers provide an unqualified source name when requesting the initial condition state, but a qualified source name in subsequent events. This option allows you to produce source names that are consistent regardless of whether the source was determined during initialization or discovered later.

Make A&E Status available as individual data points

This option gives you a way to maintain and access the values of A&E status variables in DataHub data points.

Filters

There are several options for filtering alarms and events:

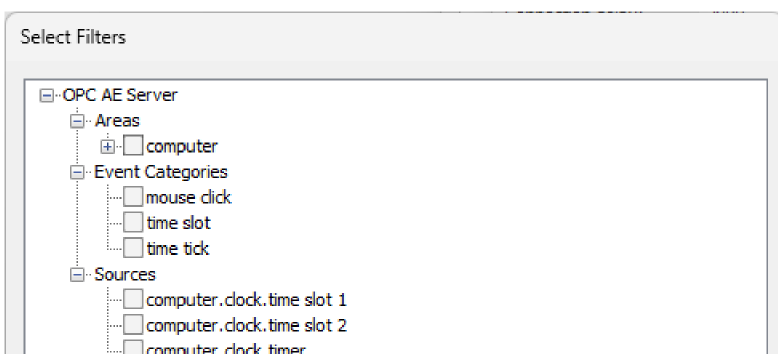


Filter by event type

There are three options available:

- **Simple** events are not related to an alarm, and cannot be tracked.
- **Tracking** events originate outside the process being monitored, for example, an operator intervention.
- **Condition** events indicate that an alarm has been triggered. These events can be activated or deactivated, and they have an acknowledgement mechanism.

The following filters use the **Select Filters** dialog.



Filter by severity

Severity, or priority, indicates the urgency of a condition for an alarm. A low value, such as `1`, corresponds to a low urgency event, for example an informational message. A high value, such as `1000` represents an extreme emergency condition.

Filter by category:

This filter lets you select alarms or events according to the type of event, or event *category*.

Filter by area:

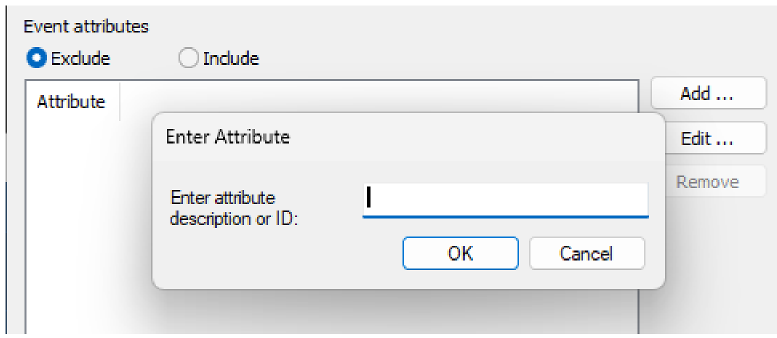
This filter lets you select alarms or events based on the *area*, which is typically a location in a plant, or a specific machine.

Filter by source:

This filter lets you select alarms or events based on the specific OPC A&E tag for the point.

Filter attributes:

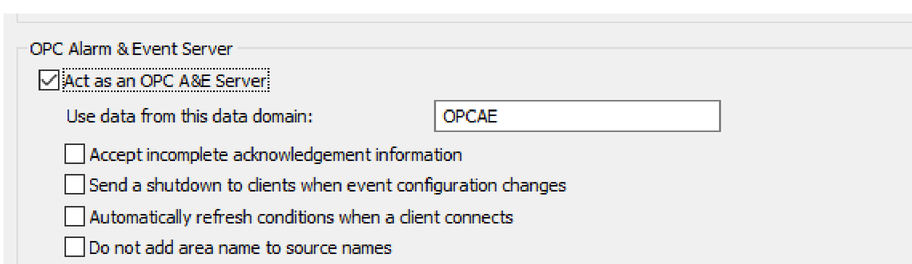
This filter lets you exclude or include event attributes. Filtering attributes can yield significant improvements in memory usage. Enter the attribute description (also referred to as name or ID) for each attribute you specifically want to exclude or include.



OPC A&E Server for Clients

The DataHub program can act as an OPC A&E server to any number of OPC A&E clients. To configure it to act as a source for generating alarms and events, please see Notifications. If your DataHub instance is connecting to an external A&E server as an A&E client (see above), then this A&E server configuration will allow you to pass along A&E values. This is useful for:

- Tunnelling OPC A&E data.
- Converting OPC A&E data to OPC DA data.
- Allowing OPC DA clients to interact with and display data from OPC A&E servers.



Check the **Act as an OPC A&E Server** box to have the DataHub instance function as an OPC A&E server, and choose a data domain. There are four optional settings:

Accept incomplete acknowledgement information

Allows for the receipt of incomplete acknowledgements.

Send a shutdown to clients when event configuration changes

This option may allow a client to reload events after they have been modified, and/or add new events.

Automatically refresh conditions when a client connects

Causes the DataHub instance to re-transmit current condition information to all A&E clients whenever any client connects. This should only be used when a client requires current condition information but does not request current condition information during its initialization. Normally this should not be necessary.

Do not add area name to source names

Tells the DataHub instance to use the source name without qualifying it with the area path. You should not normally need this option. By default the DataHub instance constructs fully qualified source names by prepending the area path to the source name. In most cases this is useful, as it guarantees uniqueness among condition sources, which is required for correct operation. For cases where the unqualified source name is unique in the server, this option provides a way to avoid adding the area path to the source name.

When you connect to multiple A&E servers, the fully qualified source and condition names must be unique across all connected servers. If two servers produce identical source names or identical condition names then the DataHub instance cannot differentiate them. It will not modify the source and condition names to make them unique. The A&E servers must be configured to produce source and condition names that are unique.

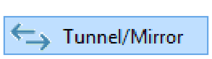
A&E / A&C Connection Status Point

For monitoring OPC A&E or A&C connections, the DataHub engine adds a special connection status point to the A&E domain specified above. This is particularly useful for the Redundancy feature, as it can be used to trigger a switchover.

The point is named `Connected.`*`label`* where *`label`* is the label that was assigned for the A&E or A&C connection. For each successful connection to the A&E or A&C server the point will appear, with a quality of `Good` and a value of `1`. When the server stops or is disconnected, the point quality changes to `Not Connected` and the value changes to `0`.

Note: For OPC UA, the point functions even if a server does not support A&C, because it monitors the status of the connection to the server, not the presence of alarm configuration.

Tunnel/Mirror



The Tunnel/Mirror option lets you configure the DataHub program to act as a master or slave for *tunnelling/mirroring*. Tunnelling/Mirroring allows you to send any data in a DataHub instance across a network robustly and securely. Tunnelling is done using DHTP over TCP, which provides connectivity across a network or over the Internet.

For information about tunnelling OPC DA, please refer to *Tunnel/Mirror Connections*.

Tunnelling and Mirroring

The DataHub tunnelling connection is sometimes referred to as a *mirroring* connection. Mirroring means that the data and any updates to that data on one DataHub instance are exactly mirrored across the network onto the other DataHub instance, and vice-versa. For all practical purposes, tunnelling and mirroring are identical.

Direct TCP connections

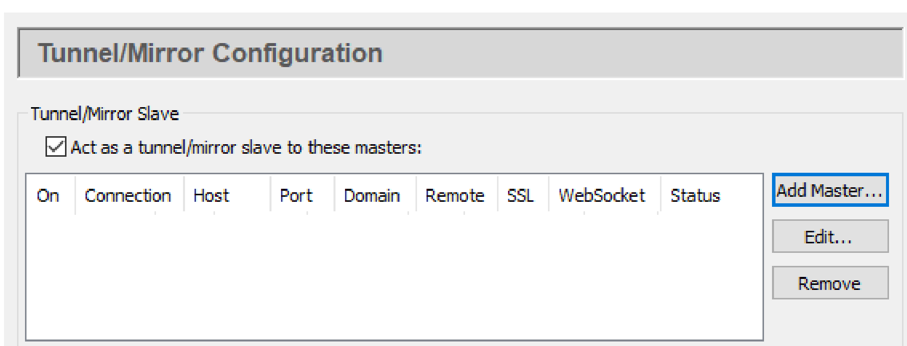
In addition to tunnelling, the DataHub program can accept direct DHTP connections from any TCP client using the DataHub APIs for C++, Java, and .NET, such as DataSim or other, custom applications.

Master and Slave

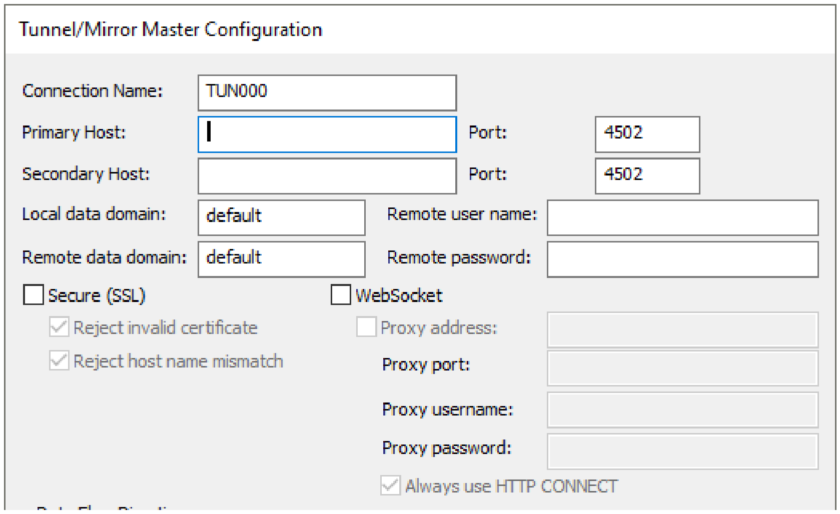
We identify the two tunnelling/mirroring DataHub instances as *master* and *slave*. The only difference between the master DataHub instance and slave DataHub instance is that the slave initiates the connection. Once the connection is established, they function exactly the same. It is possible for a DataHub instance to be both tunnelling/mirroring slave and master simultaneously—acting as a slave to one or more DataHub instances and a master to one or more others. For slave mode you need to specify each master.

Tunnel/Mirror Slave

Check the **Act as a tunnelling/mirror slave to these masters** box to have the DataHub instance act as a slave.



To add a master for this mode, click the **Add Master...** button. To edit a master, double-click it, or select it and press the **Edit...** button. Either button opens the **Tunnel/Mirror Master** window:



Type in the following information:

Connection Name

A name used by the DataHub instance to identify the tunnel. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other tunnel names.

Primary/Secondary Host

The name or IP address of the host computer. This slave DataHub instance will alternate attempts to connect first on the primary host, then on the secondary host, back and forth until a connection is made. The secondary host is optional, and if not entered, all attempts to reconnect will be on the primary host. If the connection is interrupted, the DataHub instance will again alternate attempts at reconnection on the primary and secondary hosts.

This feature is not recommended for redundancy because it only checks for a TCP disconnect. The DataHub Redundancy feature, on the other hand, provides full-time TCP connections to both data sources, for instantaneous switchover when one source fails for any reason. There is no need to start up the OPC server and wait for it to configure its data set. You can also specify a preferred source, and automatically switch back to that data source whenever it becomes available. By contrast, the primary and secondary host in the tunnel can act as a primitive form of redundancy, but will only switch on a connection failure at the TCP level, which is only one sort of failure that a real redundancy pair must consider.

Port

The port number or service name as entered in the **Master service/port** entry box of the master on the remote computer.

Local data domain

The local DataHub data domain for this slave. It is common, but not necessary, to create or use an existing local data domain that has the same name as the remote data domain.

Remote data domain

The name of the remote DataHub data domain, which is the tunnelling master. Point names will be mapped from that data domain into the local data domain, and vice versa.

Remote user name

The user name for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.

Remote password

The password for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.

Secure (SSL)

You can establish a secure connection using SSL tunnelling as long as the tunnelling master DataHub instance you are attempting to connect to has been configured for secure connections. (See below.)

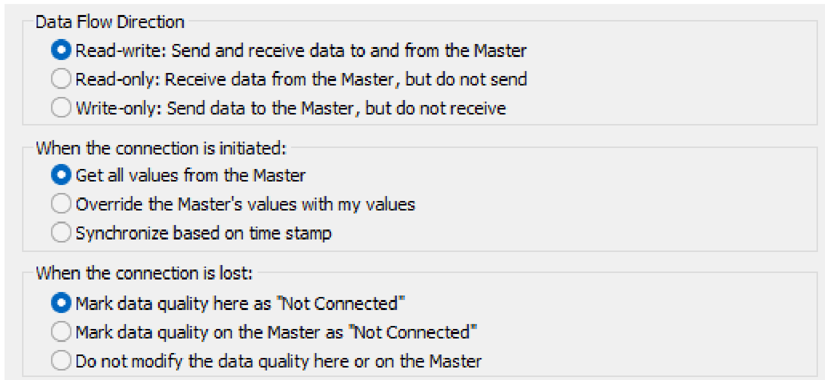
Selecting **Reject invalid certificate** causes the DataHub instance to check that the certificate date is valid, and the certificate chain is trusted. Selecting **Reject host name mismatch** will have the DataHub instance check that the certificate subject matches the host name. If you select neither of these two boxes then any certificate will be accepted. This is not recommended because it is not good security, but it can be useful to test the SSL connection. For more about SSL, please refer to SSL Encryption.

WebSocket

You can connect via WebSocket. This option is applied for both primary and secondary hosts, and allows you to enter a **Proxy address**, and a **Proxy port** number, **username**, and **password** as needed. When tunnelling through a proxy, HTTP uses normal HTTP proxy, and HTTPS uses HTTP CONNECT proxy. You can select the **Always use HTTP CONNECT** to use it for HTTP as well as HTTPS.

> The WebSocket protocol requires a web server to act as an intermediary. So, for this option you will need to use the DataHub Web Server on the tunnelling master DataHub instance (as explained below).

There are several options for the mirrored connection.



1. **Data Flow Direction** lets you determine which way the data flows. The default is read-only data flow from master to slave, but you can set up a read-write or write-only connection by choosing those options.

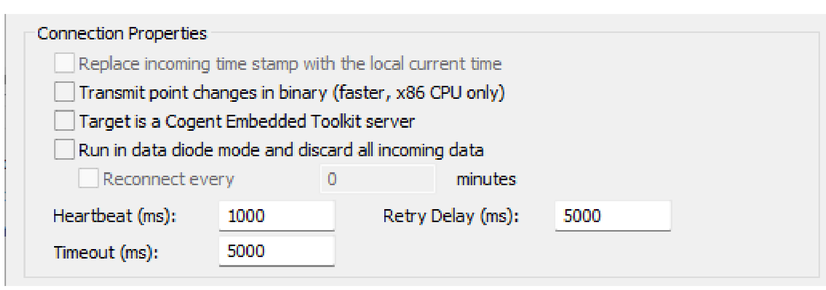
   To optimize throughput, check the **Read-only: Receive data from the Master, but do not send** option. Only do this if you actually want a read-only connection. If you do not require read-write access, a read-only tunnel will be faster.

2. **When the connection is initiated** determines how the values from the points are assigned when the slave first connects to the master. There three possibilities: the slave gets all values from the master (the default), the slave sends all its values to the master, or the data from master and slave gets synchronized. The availability of these options depends on the data flow direction selected above.

3. **When the connection is lost** determines where to display the data quality as "Not Connected", on the master, on the slave, or neither.

   If you have configured **When the connection is initiated** as **Synchronize based on time stamp** (see above), then this option must be set to **Do not modify the data quality here or on the Master** to get correct data synchronization.

4. **Connection Properties** gives you these options:



- **Replace incoming timestamp...** lets you use local time on timestamps. This is useful if the source of the data either does not generate time stamps, or you do not trust the clock on the data source.
- **Transmit point changes in binary** gives users of x86 CPUs a way to speed up the

data transfer rate. Selecting this option can improve maximum throughput by up to 50%, depending on the type of data being transmitted. This option uses a more efficient message encoding scheme than the default ASCII encoding, but it will only work if both sides of the tunnel are running on an x86 architecture CPU. This would be typical of Windows communicating with Linux or QNX, or with another Windows computer. Numeric data benefits most from this option.

- **Target is an Embedded Toolkit server** allows this slave to connect to an Embedded Toolkit server rather than to another DataHub instance.
- **Run in data diode mode and discard all incoming data** Data diode mode configures the DataHub tunnel slave to immediately discard all incoming data from the tunnel master with zero processing. This mode also allows tunnels to pass through any hardware data diode that supports TCP emulation. The **Reconnect every** option periodically disconnects and reconnects the tunnel through the data diode, according to the number of **minutes** specified. This is for data diodes that do not inform the inside connection that the outside connection has closed. Communication will be lost during the disconnect, or the data hierarchy will be missing, until the reconnection occurs.

  This mode is used for outbound slave connections and outbound data flow.

  If you are using a Forwarding Strategy in the External Historian, you will need to check the **Do not require acknowledgments** box in the **Transfer** options of that configuration when using this option. Otherwise, no data will get through, because each acknowledgement needs to be written back to the source of the data.

  If both the tunnel master and tunnel slave DataHub instances are version 11.0.3 or higher, the data diode connection will suppress all responses from the receiver back to the sender instead of relying only on the sender or the hardware data diode to discard responses.

  When the data diode option is checked, other Tunnel/Mirror slave options change as follows:

  - **Secure (SSL)** gets unchecked because it is not fully supported. When using this mode for normal tunnel/mirror connections, SSL can still be specified to enhance the level of security for the outgoing data. The SSL handshake requires bi-directional data flow, but at a level below the application data level. When tunnelling through data diode hardware, SSL is disabled because SSL cannot be passed through a physical data diode.
  - **WebSocket** gets unchecked because a WebSocket negotiation requires bi-directional application-level data and cannot be used in data diode mode.
  - Settings for **Data Flow Direction**, **When the connection is initiated** and **When the connection is lost** get changed to the logical options.

   - The **Heartbeat**, **Retry**, and **Timeout** become uni-directional. The tunnelling slave will send heartbeats, and the tunnelling master will monitor them, timing out if it does not receive data within the timeout period. Heartbeats are ignored by the slave, so disconnection timeouts do not apply to that side of the tunnel.
- **Heartbeat** sends a heartbeat message to the master every number of milliseconds specified here, to verify that the connection is up. Setting this value to `0` stops the heartbeat from being transmitted.
- **Timeout** specifies the timeout period for the heartbeat. If the slave DataHub instance doesn't receive a response from the master within this timeout, it drops the connection. You must set the timeout time to at least twice the heartbeat time. Setting this value to `0` will cause the DataHub instance to rely on the TCP implementation for detecting a broken connection. This can be useful when your network connection is very slow. Please refer to Tunnel/Mirror (TCP) Heartbeat and Timeout for details.
- **Retry** specifies a number of milliseconds to wait before attempting to reconnect a broken connection.

Testing the Client Connection

There is a DataHub instance running on a Skkynet cloud server that you can connect to for testing. Here are the parameters you will need to enter for it:

- **Primary Host** `demo.skkynet.com`
- **Port** Will be set automatically by the system, `80` for **WebSocket** and `443` for **Secure (SSL)**.
- **Local data domain** `cloud`
- **Remote data domain** `DataPid`
- **Remote user name** `demo/guest`
- **Remote password** `guest`
- **WebSocket** Must be selected.
- **Secure (SSL)** Optional.

License verification timeout

The DataHub program gives a TCP connection 30 seconds to verify a license. If your network is too slow this might cause a licensing error. You can increase the timeout to up to 60 seconds by editing this registry entry:

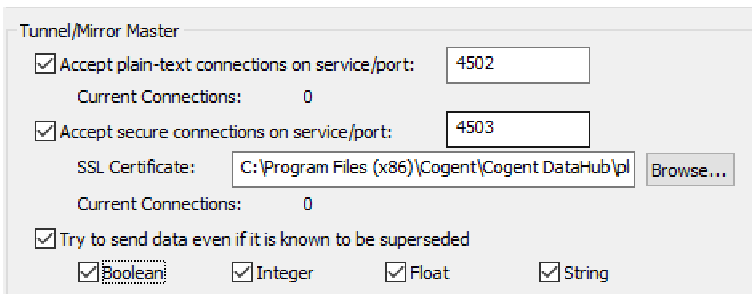
```
HKEY_LOCAL_MACHINE\SOFTWARE\Cogent\Cogent DataHub\TCPLicenseTimeoutSecs
```

See also Tunnelling Security - Best Practices.

Tunnel/Mirror Master

You can configure your DataHub instance to act as a master for plain-text or secure (SSL) tunnelling, or both. Additionally, the DataHub program offers WebSocket support for tunnelling, as explained below.

You must allow Remote Connections in Security for any incoming connections over the network.



Accept plain text connections on service/port

This option enables plain text connections.

For this and the next option, if you enter a name for the **service/port** instead of a number, that name must be listed in the Windows `services` file. Please refer to The Windows Services file Appendix for details.

Accept secure connections on service/port

The DataHub instance installs an **SSL Certificate** for you. If you wish to move it or use a different one, you can change the directory path here. The SSL implementation uses the default SSL-3 encryption cipher: DHE-RSA-AES256-SHA. This is a 256-bit encryption. The server and client negotiate the best encryption based on what both can support. The DataHub instance does not validate the SSL certificate with any outside certificate authority. It uses the SSL connection for encryption only, not authentication.

Try to send data even if it is known to be superseded

You can also configure the master to attempt to send "old" data (superseded by more recent data). Check any or all of **Boolean**, **Integer**, **Float**, or **String** that apply to the kind of superseded data that you wish to have sent.

To optimize throughput using this option, please refer to Tunnel/Mirror.

WebSocket Connections

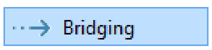
The WebSocket protocol supports real-time bi-directonal data transfer over TCP, by maintaining a constant connection over which messages can be passed, in plain text or

SSL. The DataHub implementation of WebSocket enables secure connections through network proxies without opening any firewall ports.

The WebSocket protocol requires a web server to act as an intermediary for the connection. So, to support incoming WebSocket connections from DataHub tunnelling clients, you will need to configure the tunnelling master DataHub Web Server. For WebSocket connections, we recommend using SSL, on port 443. A plain text connection is also possible, but is less secure and less likely to pass through a proxy.

See also Tunnelling Security - Best Practices.

Bridging



The Bridging option lets you configure the DataHub program for data bridging. Bridging means connecting points from two different connected programs, typically OPC servers, so that when a point changes on one, its value gets written to the bridged point on the other.

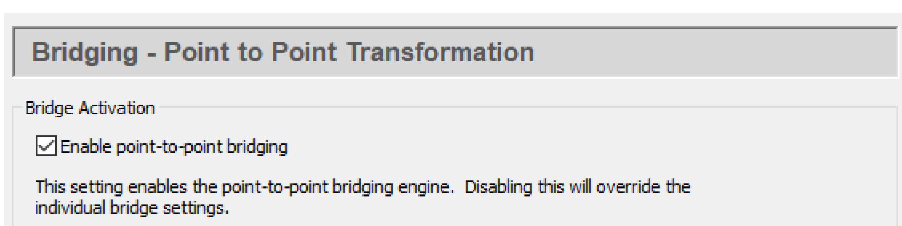
For general and how-to information about bridging, please refer to *Bridging*.

Click here to watch a video.

You can configure the bridge to be one-way in either direction, or bidirectional. In addition, you can transform the data as it passes through the DataHub program using linear transformations.

Bridge Activation

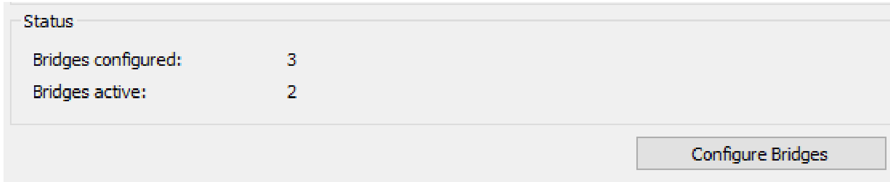
This setting enables and disables bridging globally for the whole DataHub instance.



Ensure the box is checked to enable bridging. Uncheck the box to disable bridging.

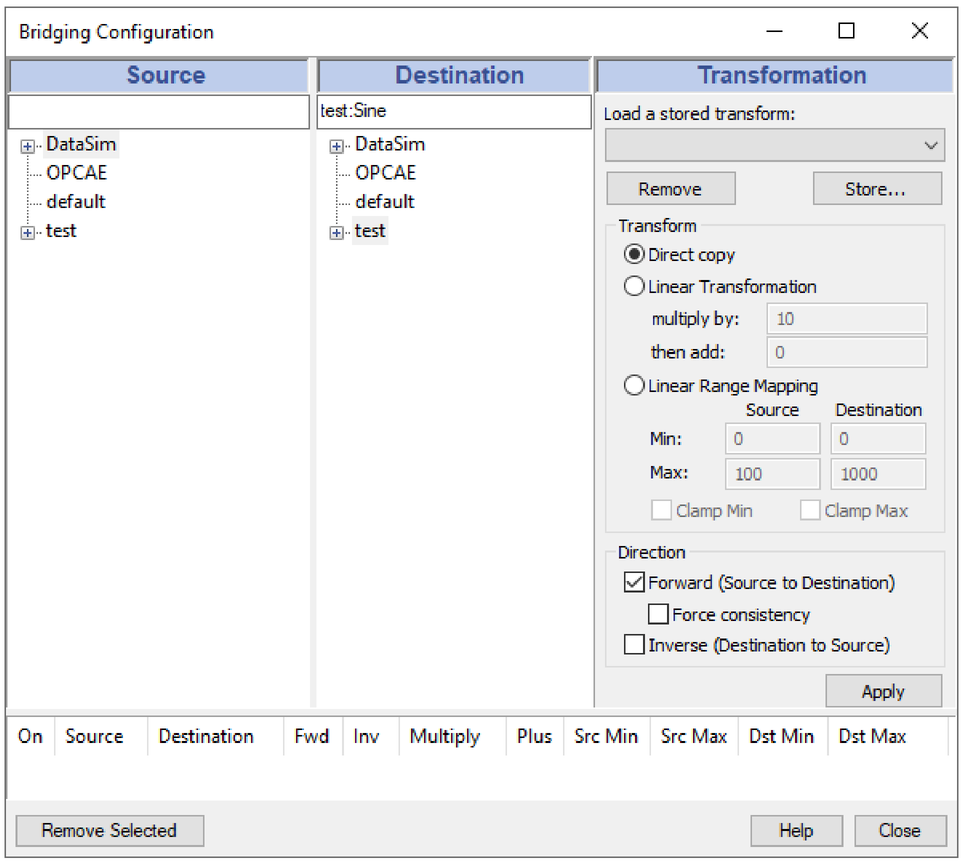
Status

This shows the total number of bridges that have been configured, and how many of them are currently active.



Configure Bridges

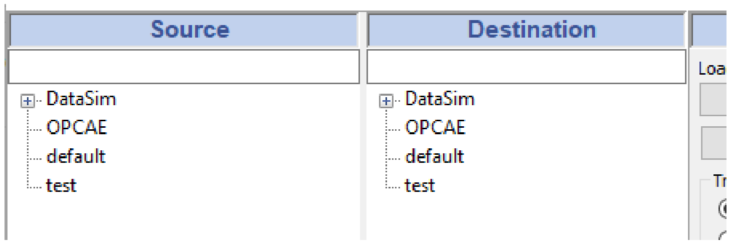
Click the **Configure Bridges** button to open the **Bridge Configuration** window:



The following sections give an overview of bridge configuration. For step-by-step instructions, please refer to the section called "Configuring Bridges".

Point Selection

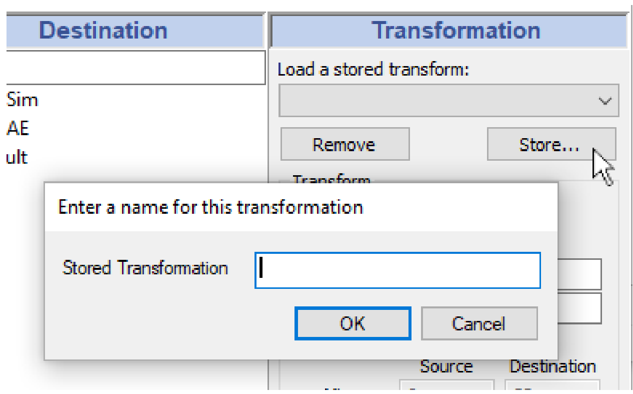
This is where you select the points to be bridged—a source point and a destination point.



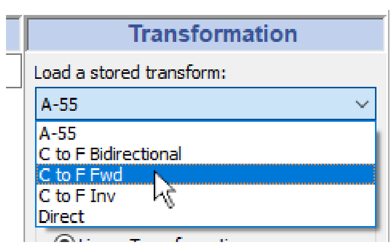
You can click on the point you need, or enter the name in the data-entry box at the top of the column.

Storing Transformations

You can store transformations and retrieve them by name later on.



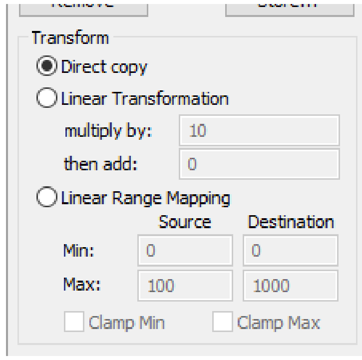
To save a transformation, click the **Store...** button and enter a name in the pop-up box. Once stored, the transformation will become available by name in the drop-down list.



To load a transformation, simply select its name from the list.

Transform

Specify the type of transformation by clicking **Direct copy**, **Linear Transformation**, or **Linear Range Mapping**.



- **Direct copy** makes no transformations. It just copies the point.
- **Linear Transformation** lets you multiply by one value and add another value, such as in the equation `y = mx + b` where the destination point is `y`, the source point is `x`, the **multiply by** value is `m`, and the **then add** value is `b`. For example to transform a Celsius source point to a Fahrenheit destination point, you would multiply by `1.8` and add `32`, or

```
Fahrenheit = (1.8 X Celsius) + 32
```

  If you have selected the **Inverse** direction for a transformation, you will get the inverse of the transformation. In this example, you would get a conversion from Fahrenheit to Celsius, or the results of this equation:

```
Celsius = (Fahrenheit - 32) / 1.8
```

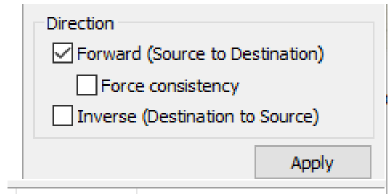
  As an alternative to entering transformation values, the DataHub instance can be configured using **Linear Range Mapping**.

- **Linear Range Mapping** lets you enter a range for the source and destination, and the DataHub instance automatically calculates the corresponding linear transformation. For example, to create the same Fahrenheit to Celsius transformation, you could use the defaults of `0` and `100` for the **Min** and **Max** of the source point. Then you would enter `32` and `212` for the **Min** and **Max** of the destination point. As soon as you make these entries, the correct values get entered automatically in the **Linear Transformation**.

  When you use linear range mapping, you can limit the transformed value to the maximum and minimum by checking the **Clamp** boxes. The clamps get applied to the point being changed, i.e.. to the destination point for forward direction, to the source point for inverse direction, and to both points for bidirectional bridges.

Direction

Decide which direction you want the bridge to apply.



- Select **Forward** to change the destination point when the source point changes, but not change the source when the destination changes. If you select **Force consistency** with this option, and if the destination point gets changed for some reason, then the DataHub instance will attempt to force its value to be consistent with the source point value.
- Select **Inverse** to change the source point if the destination point changes, but not vice-versa.

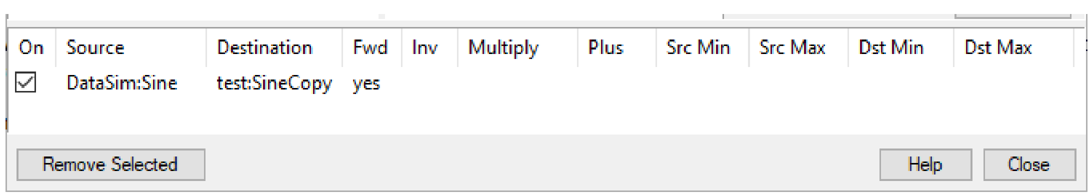
  Selecting **Inverse** will apply the inverse of the transformation, as explained above.

- Select *both* **Forward** and **Inverse** for a bidirectional bridge, where either point changes whenever the other point changes. This combination will deselect **Force consistency** to eliminate the possibility of conflicting behavior.

Click the **Apply** button to create and activate the bridge. The DataHub instance will create the bridge and update the bridged points immediately.

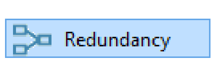
Point Display

Here you can see all the bridges that exist in the system, and the significant information about them.



If you click on a transformation, the source point, destination point, and transform information get displayed in their respective panels. Use the check box at the front of each bridge to activate or deactivate that particular bridge.

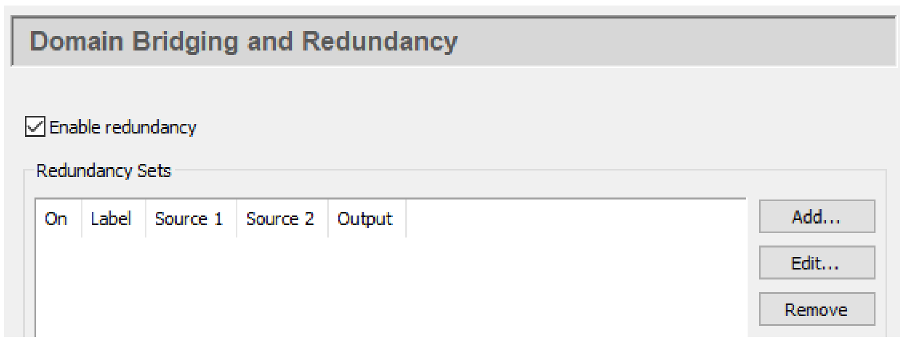
Redundancy



The Redundancy option lets you configure redundant connections to the DataHub program. Please see Using Redundancy for more information on how this feature is used.

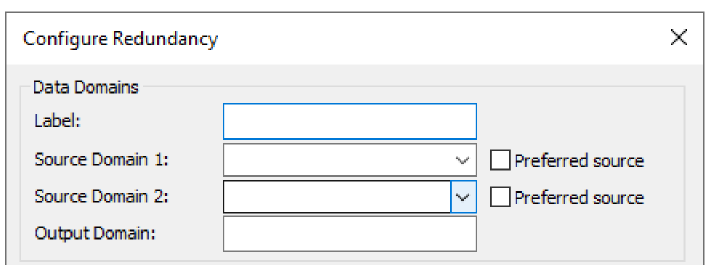
The purpose of redundancy is to collect data from two data sources and present to the client program a single output data set. The DataHub program will determine which source will be presented to the client program, and switch between the two sources without affecting the client. The client will only read data from the output data set.

The two input and one output data sets are maintained as separate data domains in the DataHub program. The sources do not need to be the same protocol, so redundancy can be applied to two sources, for example where one is a direct OPC connection and the other is a tunnel.



Check the **Enable redundancy** box to activate this feature. Redundant connections are created and stored in sets. You can create multiple redundant sets, and activate or deactivate each set using its corresponding **On** check box in the list. To edit a redundancy set, double-click it here, or select it and press the **Edit** button to open the **Configure Redundancy** window (see below). To remove a set, highlight it and click the **Remove** button.

To create a redundancy set, press the **Add** button, which opens the **Configure Redundancy** window:



Data Domains

Label:

A name used by the DataHub instance to identify the redundancy set. There should be no spaces in the label. It doesn't matter what label is chosen, but it should be unique to other labels.

Source Domain 1:

The DataHub data domain for the first data source. If this is the preferred source, check the **Preferred source** button.

If a preferred data source has been specified then the DataHub instance will use that source whenever possible, even if the other source is also available. This is useful if the two data sources have different characteristics. For example, the preferred source may offer a higher bandwidth than the other source. If neither data source is selected as preferred, the DataHub instance will maintain whichever data source is currently being used until it meets any invalid criteria (see below).

Source Domain 2:

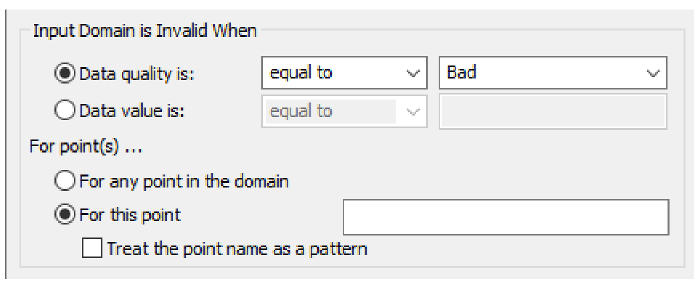
The DataHub data domain for the second data source. If this is the preferred source, check the **Preferred source** button.

Output Domain:

A name for a DataHub data domain which will be the output of the redundant connection, to which the client will connect. If the output domain does not exist, the DataHub instance will create it.

Input Domain is Invalid When

Entries in this section determine when the DataHub instance should switch from one redundant data source to the other.



Data quality is:

Gives you the option of switching data sources based on a change in data quality for the point(s) you have selected (below). You can set the criteria of equal to or not equal to a list of available qualities, such as:

Bad	**EGU Exceeded**	**Last Usable**	**Sensor Calibration**
Comm Failure	**Good**	**Local Override**	**Sensor Failure**
Config Error	**Initializing**	**Not Connected**	**Sub Normal**
Device Failure	**Last Known**	**Out of Service**	**Uncertain**

Generally speaking, all of the above qualities are considered not good except for **Good** and **Local Override**. To ensure that you are getting good quality data from your OPC server, you can switch when **Data quality is**

not equal to Good.

Data value is:

Gives you the option of switching data sources based on a change in the value of the data point(s) you have selected (below).

For point(s)

Allows you to select which points you want to monitor for quality or value (see above).

For any point in the domain

Lets you monitor all points in the domain and switch when any one of them meets the criteria.

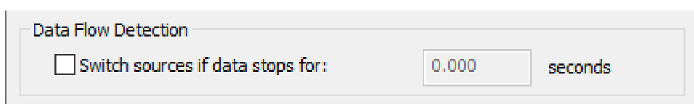
For this point

Lets you specify an individual point name. The point name can be applied to a single point, or to a group of points whose names match the pattern.

For more information please see Configure the Switch in the Using Redundancy chapter.

Data Flow Detection

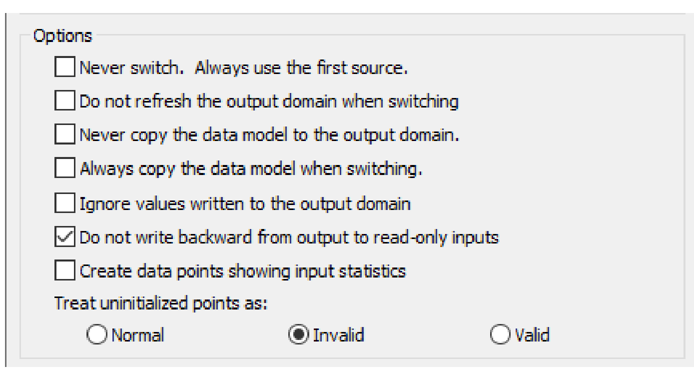
For data that changes regularly, **Data Flow Detection** lets you switch data sources whenever a gap in the data flow is detected. This option will watch for any change in any data point from an input domain. If no point in the input domain changes within the specified time, the entire input domain is assumed to be invalid. A subsequent data change must pass the validity checks above for the input to be considered valid.



Switch sources if data stops for:

The number of seconds that the data flow from the domain must stop before the DataHub instance will switch to the redundant data domain.

Options



Never switch. Always use the first source.

If you never switch, you never use a second source domain. Thus, this allows you to effectively create a copy of a domain, by copying **Source Domain 1** into the **Output Domain**. To have the output domain function as a read-only copy of the source domain, select the **Ignore values written to the output domain.** option, as explained below.

Do not refresh the output domain when switching.

Keeps the existing data in the output domain during a switch, and only updates with values from the new domain when a change occurs. Choosing this option may cause a mismatch between input and output domains for an indeterminate length of time.

Normally during a switchover the DataHub instance copies all values from the new source domain into the output domain. This copying activity might cause delays in updating the output domain for extremely large numbers of points. If that is your situation, and you know that your two servers are synchronized in all meaningful ways, you may wish to select this option. However, you need to keep in mind that values in the input and output domains may not match for an undetermined period of time.

Never copy the data model to the output domain.

Preserves the data model of the output domain, or if there is no data model, flattens the data model from the input domain. In either case, the data point names are maintained. This can be helpful if targeting a system with limited system resources, such as an embedded system, or if you have an existing data model on the output domain and do not want it overridden by the data model on the input domains.

Always copy the data model when switching.

Normally the output domain tracks changes in the data model, and when a switch occurs, if the data model has changed, it gets rewritten. This option forces the output domain to copy the data model, whether it has changed or not.

Ignore values written to the output domain.

Normally, data written to the output domain propagates back to the input domains. This option prevents that from happening. Data written to the output domain will not be written to the input domain. Used with **Never switch. Always use the first source.** (above), this will make the output domain function as a read-only copy of the input domain.

Do not write backward from output to read-only inputs.

This option is similar to **Ignore values written to the output domain.** (above), but prevents writes to points in the input domain only for those points marked as read-only. Data written to writable points in the output domain will be written to the input domain.

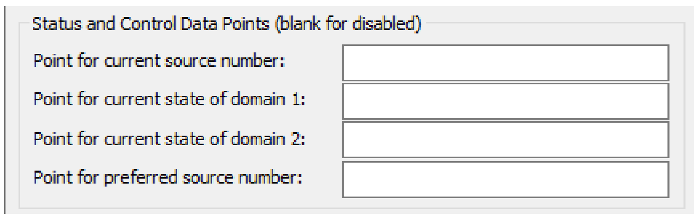
Create data points showing input statistics

Used for debugging, this option creates extra points in the root of the output domain that indicate how many points are considered valid, invalid and uninitialized for each input domain.

The radio buttons under **Treat uninitialized points as:** let you choose whether a point in an input domain that has never been assigned a value (`BAD` quality, `0` timestamp, and `0` value) should be treated as:

- **Normal**: The validity rules apply normally to it.
- **Invalid**: The domain will never be used as an input until all data points have a value assigned to them.
- **Valid**: Any uninitialized points are ignored when determining whether the input domain is valid.

Status and Control Data Points (blank for disabled)



Point for current source number:

The name of a DataHub point that will indicate which source is in use.

Point for current state of domain 1:

The name of a DataHub point that will indicate the state of Domain 1.

Point for current state of domain 2:

The name of a DataHub point that will indicate the state of Domain 2.

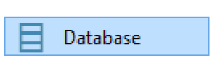
Point for preferred source number:

The name of a DataHub point that will indicate which data source is your preferred source.

Click the **OK** button to submit your entries.

For more information please see Troubleshooting in the Using Redundancy chapter.

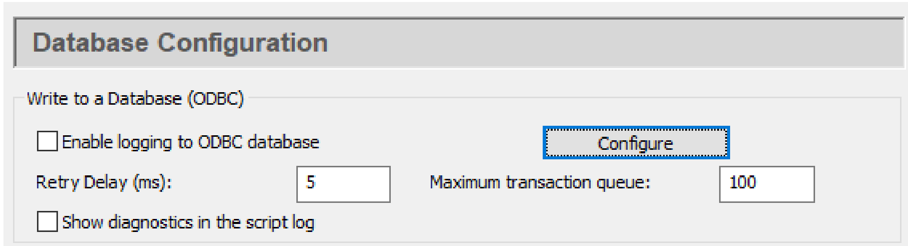
Database



The Database option lets you configure the DataHub program for writing data or making queries to any ODBC compliant database.

For more information about data logging, please refer to *Write to a Database*, and to learn more about making database queries, please refer to *Query a Database*.

Click here to watch a video.



Write to a Database (ODBC)

Enable logging to ODBC database

Globally enables or disables all ODBC logging activity.

Reconnection delay (s):

Specifies the number of seconds before a reconnect is attempted if the ODBC connection is broken.

Maximum transaction queue

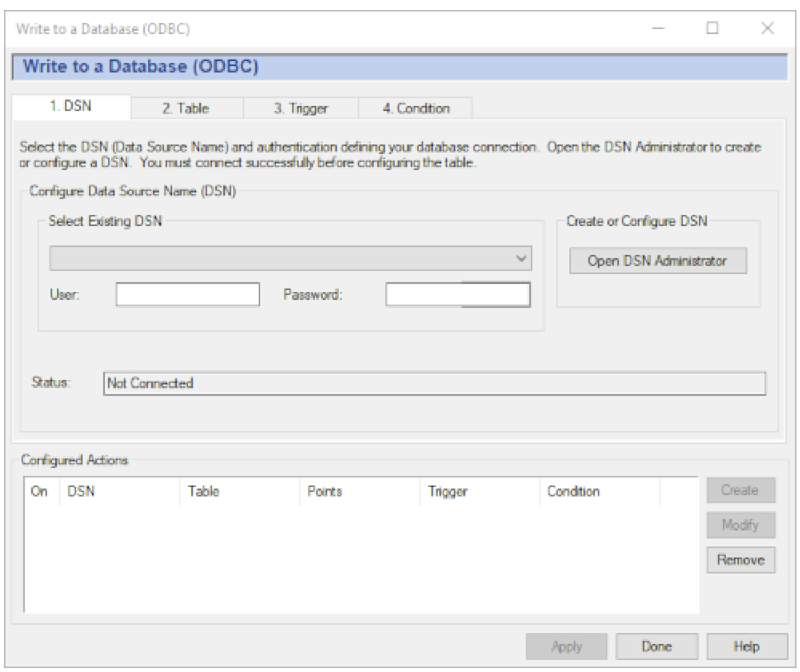
The DataHub instance maintains an in-memory queue of pending operations. This queue helps to avoid writing to disk during busy periods or during short database or network outages. You can modify the depth of this queue to reduce the chance of involving the disk during busy periods. The queue depth for logging defaults to 100 messages.

Show diagnostics in the Script Log

Puts diagnostic messages about the connection in the Script Log.

Configure button

The **Configure** button opens the ODBC Data Logging Window.

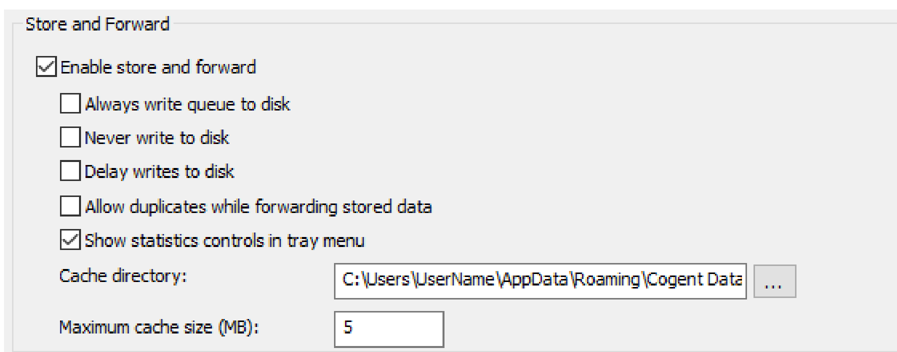


For detailed instructions on using this interface, please refer to *Write to a Database*.

Store and Forward

The term *store and forward* refers to a type of database connection where the data is stored locally to disk and then later forwarded to the database. The DataHub program performs an advanced form of store and forward that only writes to disk if the database is not connected, or has been paused. If the database is available, the data will be transmitted directly to the database. This means that there is no penalty for using store and forward during normal operation. The DataHub store and forward mechanism uses two levels of disk caching to ensure that all data gets logged, and nothing is lost.

When the database first becomes available after an outage, the DataHub instance starts writing cached values to the database, and continues writing new values to the cache. In this way, the values are inserted into the database in the order in which they are generated by the system. Once the cache is cleared, the DataHub instance then starts writing new values directly to the database.



Enable store and forward
Activates the store and forwarding feature.

Always write queue to disk
Data in the transaction queue will be written to disk cache first, and from there to the database. The safest protection against a crash is to check this box, and uncheck **Delay writes to disk** (below).

Never write queue to disk
The data in the transaction queue will be only stored in memory, and never written to disk.

Delay writes to disk
Data in the transaction queue will be written to disk at the most opportune times. The safest protection against a crash is to uncheck this box, and check **Always write queue to disk** (above).

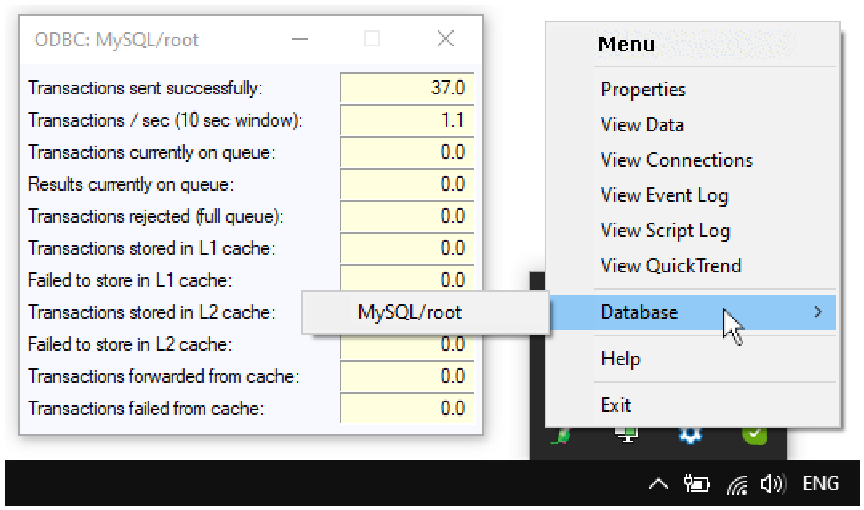
Allow duplicates while forwarding stored data
If the network breaks while transmitting data from a cache, the DataHub instance needs to know how to handle any already-sent data when it reconnects. Leaving

this box unchecked will require the DataHub instance to track its cache position at all times, and modify that information each time a value is sent. This will impact the speed of every transmission, but it will ensure that no values get transmitted twice.

Checking this box will cause the DataHub instance to simply start from the beginning of the queue or cache on each reconnect, and retransmit some data. This significantly reduces data-handling complexity and decreases transmission rates. This option is particularly useful if network breaks are frequent and some duplication of logged data is acceptable.

Show statistics in tray menu

Adds a **Data Logging** entry to the DataHub instance's system tray menu, which lets you open a statistics window:



Transactions sent successfully:

The number of transactions that were sent, either directly to the database, or to the disk cache.

Transactions / sec (10 sec window):

The sending rate for transactions, calculated over the past 10 seconds.

Transactions currently on queue:

The number of transactions in the queue.

Results currently on queue:

Not yet documented.

Transactions rejected (full queue)

The number of transactions that were rejected from the queue because it was full.

Transactions stored in L1 cache

The number of transactions taken off the queue and put into the first-level cache. An internal algorithm determines which of the two caches is most appropriate for storing a given transaction.

Failed to store in L1 cache

The number of transactions that were not able to be stored in the first-level cache.

Transactions stored in L2 cache

The number of transactions taken off the queue and put into the second-level cache. An internal algorithm determines which of the two caches is most appropriate for storing a given transaction.

Failed to store in L2 cache

The number of transactions that were not able to be stored in the second-level cache.

Transactions forwarded from cache

The total number of transactions forwarded from both caches. This number should be the sum of L1 and L2, once all transactions have been forwarded, and as long as the DataHub instance was started up with no cache on disk.

Transactions failed from cache

The number of transactions attempted from cache, could not be successfully delivered, and were stored for later transmission. This phenomenon may occur the first time that the DataHub instance learns that the database is not available. For example, you'll see this for every network break if you've checked **Always write queue to disk**.

Cache directory:

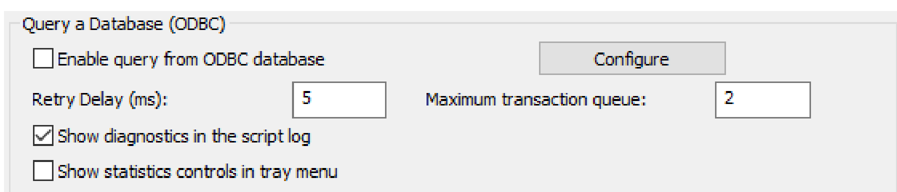
The path and directory name for the cache.

Maximum cache size (MB):

The amount of disk space to allocate for the cache, in megabytes.

Query a Database (ODBC)

In addition to writing data to a database, DataHub program also allows you to query a database and add the resulting values to the DataHub data set.



Enable query from ODBC database

Globally enables or disables all ODBC query activity.

Reconnection delay (s):

Specifies the number of seconds before a reconnect is attempted if the ODBC connection is broken.

Maximum transaction queue

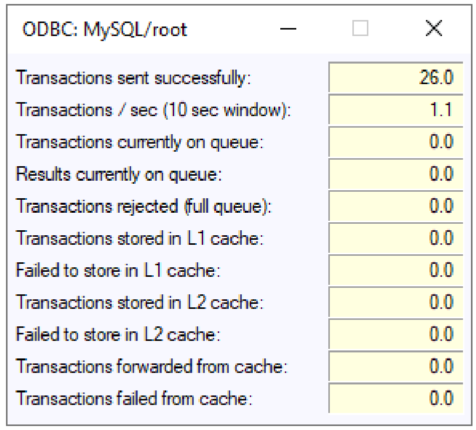
The DataHub instance maintains an in-memory queue of pending operations. This queue helps to avoid writing to disk during busy periods or during short database or network outages. You can modify the depth of this queue to reduce the chance of involving the disk during busy periods. The queue depth for queries defaults to 2 messages.

Show diagnostics in the Script Log

Puts diagnostic messages about the connection in the Script Log.

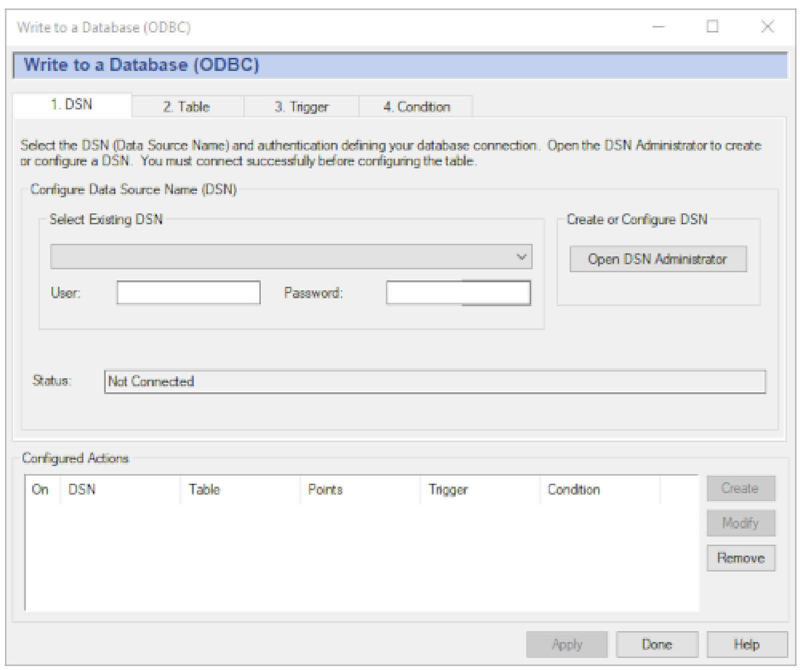
Show statistics controls in tray menu.

Creates a new entry in the DataHub system tray menu that lets you open a statistics control window.



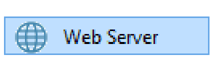
Configure button

The **Configure** button opens the ODBC Data Logging Window.



For detailed instructions on using this interface, please refer to *Query a Database*.

Web Server



The Web Server option lets you configure the DataHub program to run as a lightweight http server capable of serving HTML documents, Java applets, and many kinds of binary files. It features password-protected access and server-side scripting, and supports DataHub WebView.

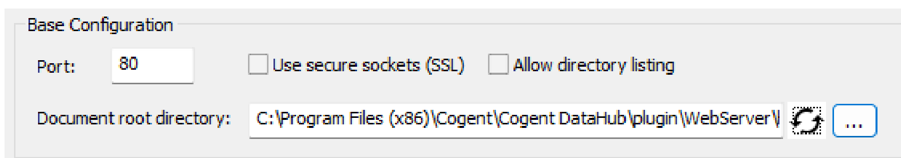
For information about using the Web Server, please refer to *Using the Web Server*.

Web Server

The web server can be turned on and off while the DataHub instance is running.

Ensure the **Act as web server** box is checked to enable the web server. Uncheck the box to disable it.

Base Configuration



Port

The number of the port used to make TCP connections to the web server. The DataHub Web Server is preconfigured to run on port number 80, but you might need to change that setting.

Windows allows multiple users on a single TCP port, and never refuses a connection. However, this can cause irregular behavior. It is essential that the DataHub Web Server be the exclusive user of a port. Please refer to step 4 in the section called "Configuring the DataHub Web Server" for more details.

Use secure sockets (SSL)

Checking this box will cause the web server to run in secure mode.

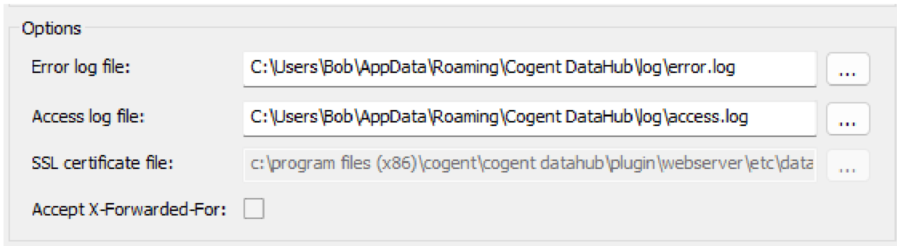
Allow directory listing

Checking this box allows users to browse the directory on your server.

Document root directory

The root directory for your documents. The recycle button resets the entry to the default setting.

Options



Error log file:

The path and name of the file where errors are logged.

Access log file:

The path and name of the file where access attempts, successes, and failures are logged.

SSL certificate file:

The path and name of the certificate file used for secure sockets (SSL). Please see SSL Certificates for more information about SSL certificates in the DataHub program.

Accept X-Forwarded-For:

Check this box to use X-Forwarded-For (XFF) headers in proxy requests, which will apply permissions based on the original client's address. Otherwise, permissions will be associated with a proxy's address, and will apply to any connection being made through the proxy. This option applies to both web requests and tunnels being made via a WebSocket.

A malicious client could add an XFF header to a web request and thereby masquerade as a different IP address. For example, the client could know the IP address of the DataHub machine, and add that IP address as an XFF header. That would cause the DataHub instance to believe that the connection is coming from the local host, which could then give the malicious client more permissions than would otherwise be allowed. This connection would not need to be via a proxy. The malicious client could make a direct connection and still add the X-Forwarded-For header.

Additionally, HTTP requests are allowed to repeat headers. When a proxy receives an incoming request, it can add its own XFF header to the message. If a malicious client sends an XFF header, then the proxy will add a second one. DataHub software will take the last instance of any header as the only applicable one, so if the proxy adds its XFF header to the end of the message's header block then the DataHub instance will ignore the malicious header and only process the proxy's header.

Consequently, you should *not enable* this option unless both of these two conditions apply:

- You know all non-localhost connections to this DataHub instance will be via proxy.
- Each proxy is configured to strip incoming XFF headers, or is guaranteed to add its own X-Forward-For header to the end of the header block in all requests.

WebView users

- If there is any public way to connect to the DataHub instance without a proxy, then XFF *must be disabled*. If there is also a way to connect through a proxy then that proxy *must not* be accessible by untrusted clients.
- If the only public way to connect to the DataHub instance is through a proxy, then XFF *must be enabled*.
- If there is a public way to connect to the DataHub instance without a proxy, and also a public way to connect to it through a proxy, then *neither setting for XFF is secure*.
- **Also:** Attacks require the attacker to acquire the victim's session ID. This is substantially harder if the connection is over SSL, so long as it uses a valid certificate. We make the session ID visible in WebView, so in theory an attacker could social engineer the attack by asking the user to provide it.

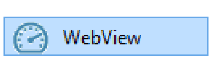
Explanation: WebView creates and authenticates a session over HTTP, then clones it so the data connection also has a separate authenticated session that is related to the first one. We do this because we cannot necessarily re-authenticate if the TOTP code has expired. It means that anybody connecting from the HTTP session's IP address who has the session ID can open a socket and attempt to clone the session to acquire the session's credentials. The session ID is not a secret.

If a proxy is being used, and XFF is ignored, then all connections appear to come from the proxy's address. In that case, somebody who has the session ID can issue commands through the proxy and appear to be the original user.

If a proxy is not being used, and XFF is processed, then somebody who has the session ID could add XFF to the headers and masquerade as the original user.

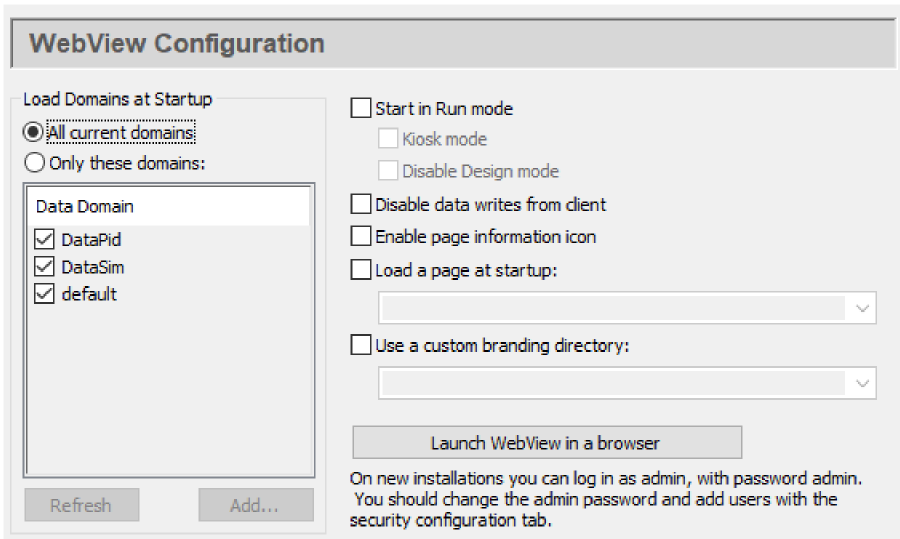
There is no way for the DataHub instance to tell if a proxy is being used other than from the headers, which can always be spoofed if there is no proxy in use.

DataHub WebView



DataHub WebView is a real-time data visualization tool.

This section covers configuration parameters for the WebView application. For information about WebView and how to use it, please refer to the DataHub WebView manual.



All current domains

This option initializes all DataHub data domains when the WebView application starts. This is helpful in Design mode for selecting data points to bind to controls, by using auto-fill-in.

Only these domains

This option initializes all points in the selected domains when the WebView application starts. Data points in the unchecked domains will be loaded only when requested by a WebView client. Unchecking domains that contain large numbers of points can significantly improve page load times for users during Run mode.

Start in Run mode

Allows you to start in Run mode, rather than Design mode, with these options:

Kiosk mode

Presents just the working screen of the web browser, with no border, menus, URL entry field, etc. To escape from Kiosk mode (and close the browser), press **Alt** + **F4**.

Disable Design mode

Prohibits any switch from Run mode to Design mode, whether running in Kiosk mode or normally.

Disable data writes from client

Prevents the web client from accessing DataHub point values.

Show page information icon

Shows or hides the page information icon.

Load a page at startup

Allows you to specify a page that will automatically load when the WebView application starts.

Use a custom branding folder

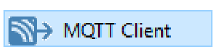
Allows you to specify a folder for holding custom branding information. For details, please refer to Customizing.

Launch WebView in a browser

Provides a convenient way to start the WebView application to check this configuration.

The WebView application requires the DataHub instance to be configured as a tunnelling master. Please refer to Tunnel/Mirror Master in the Cogent DataHub manual for details.

MQTT Client



The MQTT Client option lets you configure the DataHub program as an MQTT client to any number of MQTT brokers, with pre-configured connections for Azure IoT Hub, Google IoT, and AWS IoT Core.

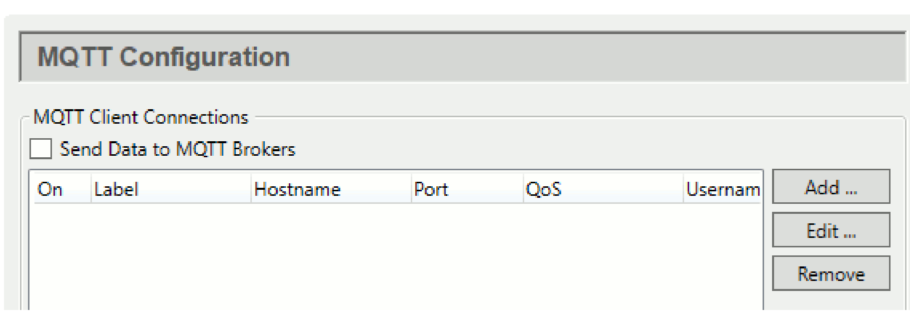
The DataHub program implements bi-directional data transfer between the MQTT broker and standard industrial protocols. It provides some configurability of the MQTT message format, allowing you to convert directly between MQTT messages and data points. In effect the DataHub program can act as an industrial MQTT gateway.

For a how-to guide for configuring an MQTT client connection, please see Making MQTT Client Connections.

Make the Connection

MQTT Client Connections

The DataHub program can act as a client to one or more MQTT brokers.

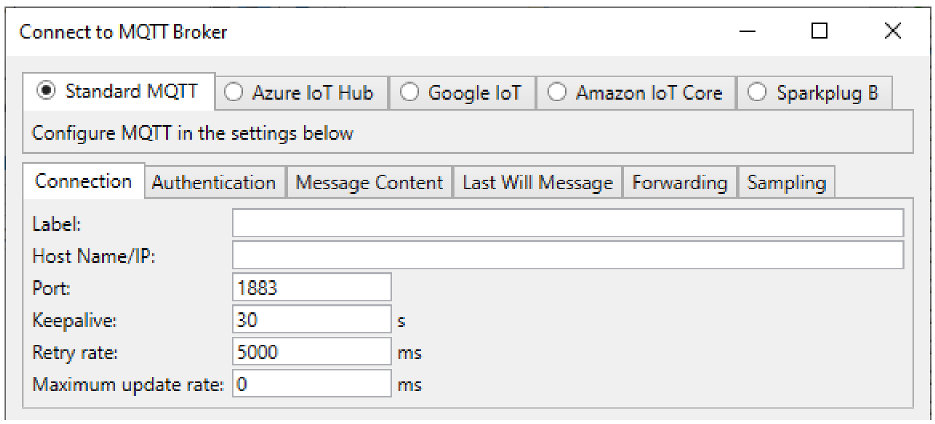


Check the **Send Data to MQTT Brokers** box to enable MQTT client functionality. Since a DataHub instance can be a client to more than one MQTT broker, you need to specify broker information for each MQTT client connection. Once you have a broker listed, you can activate or deactivate the connection using its **On** check box.

To add a broker, press the **Add** button to open the **Connect to MQTT Broker** window described below. To edit a broker connection, double-click it or select it and press the **Edit** button to open that window. To remove a broker, highlight it and click the **Remove** button.

The Connect to MQTT Broker window

To define or edit an MQTT broker connection, click the **Add** or **Edit** button to open the **Connect to MQTT Broker** window:



Here you have four initial options: configure a standard MQTT connection, or choose one of Azure IoT Hub, Google IoT, or AWS IoT Core. Each of these three broker-specific tabs provides entry fields unique to that connection which assist in filling in the configuration explained below.

Connection

To configure a standard MQTT connection, click the **Standard MQTT** tab and enter the following information:

Label
: A name used by the DataHub instance to identify the connection. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other connection names.

Host Name/IP
: The name or IP address of the computer running the MQTT broker you want to connect to.

Port
: The number of the open port on the MQTT broker that will receive your connection

request. The default, 1883, is the port typically used for MQTT.

Keepalive

The number of seconds between MQTT keepalive messages, which are transmitted between the broker and client to help them detect a network failure or lost connection. The default is 30. Lower numbers will detect network failures more quickly, but will also slightly increase message traffic and may result in false failure detections on slow networks.

Retry rate

The number of milliseconds to wait before retrying a failed connection.

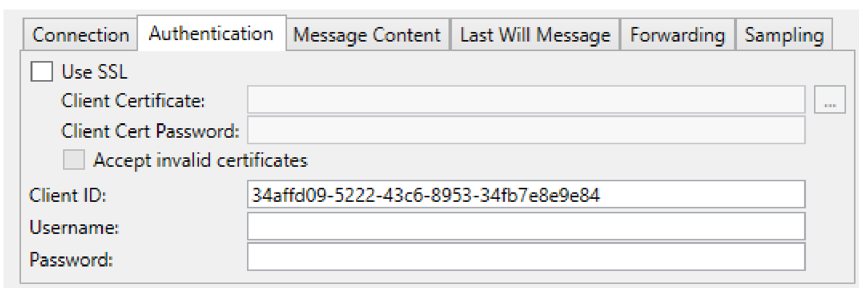
Maximum update rate

A limit on how often the DataHub instance sends packets to the MQTT broker. The default, 0, sets no limit. Setting this to a positive number will cause the DataHub client to accumulate those changes for that number of milliseconds, and then attempt to send them all at once. If the receiving application does not expect batched messages then there is no advantage to setting this option. Please see Broker Limits for more information.

This can be useful when sending JSON messages (see below) that contain multiple point names and values, for better efficiency.

Authentication

Enter your MQTT broker authentication information, as applicable.



Use SSL

MQTT over SSL requires the broker to have a server certificate, either self-signed or certified by an official certificate authority (CA). Checking the **Accept invalid certificates** box will allow the DataHub MQTT client to establish an SSL connection to the broker if the server certificate is invalid or self-signed. Otherwise the broker's certificate must be issued by a recognized and trusted CA.

In addition, the DataHub MQTT client can optionally provide a client certificate that the broker will use to identify and authenticate the connection. If the client certificate is password-protected, you must also supply the client certificate password. For authentication you may provide a client certificate, a username/password pair, or both, depending on the broker's requirements.

Client ID

An ID that the broker is expecting for this MQTT connection.

Username

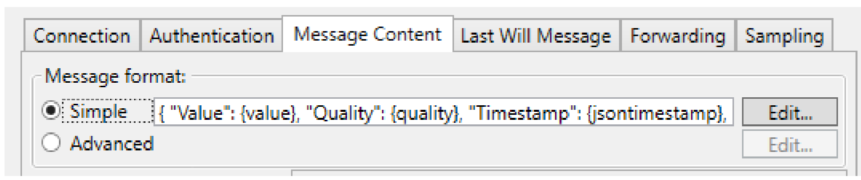
The user name for this ID.

Password

The password for this username.

Message Content

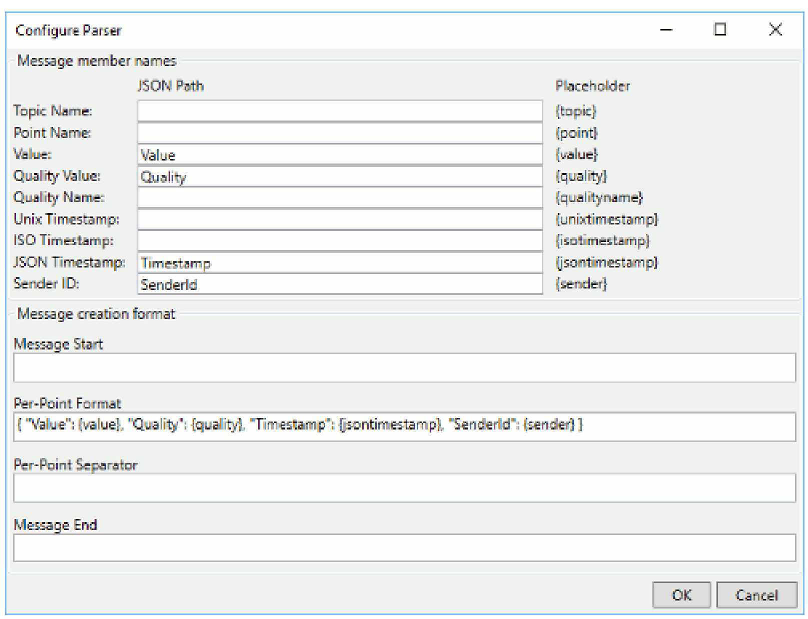
MQTT does not have a set format for message content; different MQTT brokers often require different formats. You need to know the format used by the broker you are connecting to.



Configuring **Simple** message formats is explained below. For **Advanced** message formats, please see MQTT Advanced Parser in Using MQTT.

Message format

The **Simple** option lets you edit the format of your message to match to the format of the broker you are connecting to. Click the **Edit** button to open the Configure Parser window:



The JSON Path fields at the top show your current entry. To make changes, edit the **Message Start**, **Per-Point Format**, **Per-Point Separator**, **and the Message End** fields. When you press the **OK** button your changes will be registered. To make a new entry, such as `"PointName"`, enter a string and the placeholder (like `{point}` in this example) using the same syntax as the other entries in the **Per-Point Format** entry field.

- The simplest way to pass an MQTT message is with unparsed values. To configure this in the DataHub instance, the **Per-Point Format** must be simply:

  ```
  {value}
  ```

  with no entries in the other fields.

- The default **Per-Point Format** can be used for single DataHub points:

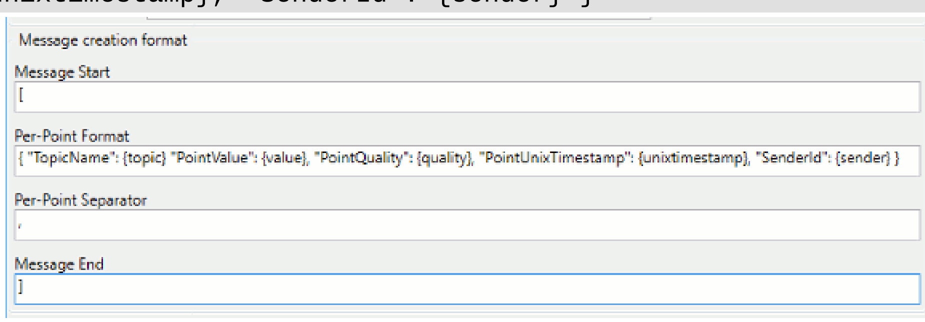
  ```
  { "Value": {value}, "Quality": {quality},
  "Timestamp": {jsontimestamp}, "SenderId": {sender} }
  ```

  with no entries in the other fields.

- To collect the data from multiple points and send it as a single message, you can do the following:

  1. In the Connection settings, change the **Maximum update rate** to a non-zero number to allow the DataHub instance to batch values by time.
  2. In the **Push data point to the MQTT broker** settings, check the box **Send all messages to this topic:**, and enter a topic name.
  3. In the **Message Content**, **Message format** settings, use open and closed square brackets (`[` and `]`) for the **Message Start** and **Message End** entries, and a comma (`,`) for the **Per-Point Separator**. Then make the following entry for the **Per-Point Format**:

     ```
     { "TopicName": {topic} "PointValue": {value},
     "PointQuality": {quality}, "PointUnixTimestamp":
     {unixtimestamp}, "SenderId": {sender} }
     ```

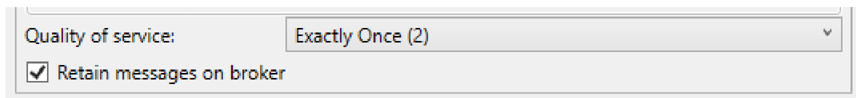
     - White space does not matter.
     - The order of the properties does not matter.
     - Capitalization in property names *does* matter.
     - If topics are encoded in each element of the array (as above), the destination topic to which the client sends this message does not matter. The destination topic must still be well-formed, it just will not get written to.

These settings will tell the DataHub instance to collect values for the amount of time specified in the **Maximum update rate**, and will send all point values as a batch to the specified topic.

When pulling data from the broker, the broker's payload format may not map directly to DataHub points. Please see Message Payload Formats for information on how to handle this case.

Quality of service

MQTT supports 3 levels of quality of service.



- **At Most Once (0)** Every message will be delivered on a best-effort basis, similar to UDP. If the message is lost in transit for whatever reason, it is abandoned—the receiver never receives it, and the sender does not know that it was lost.
- **At Least Once (1)** Every message will be delivered to a receiver, though sometimes the same message will be delivered two or more times. The receiver may be able to distinguish the duplicates, but perhaps not. The sender is not aware that the receiver received multiple copies of the message.
- **Exactly Once (2)** Every message will be delivered exactly once to the receiver, and the sender will be aware that it was received. Some MQTT brokers and services, such as Azure IoT Hub, Google IoT, and AWS IoT Core do not support this quality of service, and will simply disconnect when you attempt to send a topic update.

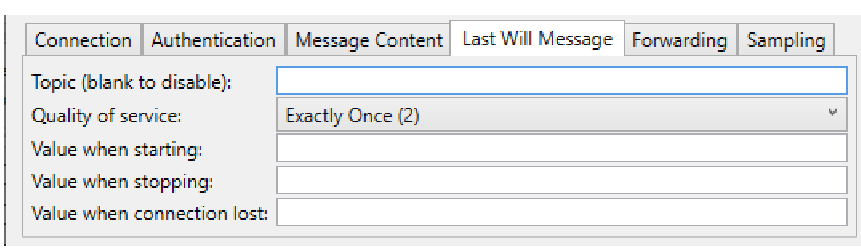
If you are not sure, choose **Exactly Once (2)**, the default.

Retain messages on broker

Normally an MQTT message that has no subscribers is simply discarded by the broker. This option tells the broker to keep the last message on this topic even if there are no subscribers.

Last Will Message

The Last Will and Testament (LWT) feature of MQTT automatically generates a message to all other clients if a client fails unexpectedly. Here you can configure that message, as well as messages for normal startup and shutdown.



Topic

The MQTT topic for the message. Leaving this blank will disable the sending of any message.

Quality of service

Choose the MQTT quality of service. Please refer to **Quality of service** (above) for more information.

Value when starting

The message you want this client to send on start-up.

Value when stopping

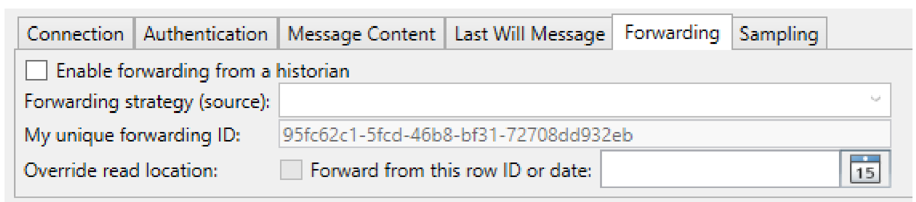
The message you want this client to send on normal shut-down.

Value when connection lost

The message you want this client to send on any kind of unexpected shut-down or disconnect.

Forwarding

The **Forwarding** feature of MQTT lets you access data collected in an external historian and forward it to an MQTT broker. Currently only InfluxDB is supported.



Enable forwarding from a historian

The checkbox activates data forwarding. When data forwarding is active, the MQTT client connection will disable transmission of live data. This is done to ensure that data values are not transmitted multiple times, once from the historian and once from the live data set, and avoids the out-of-order transmission that would otherwise occur.

Forwarding strategy (source)

Select the label for the configured InfluxDB database containing the data that you want to forward.

My unique forwarding ID

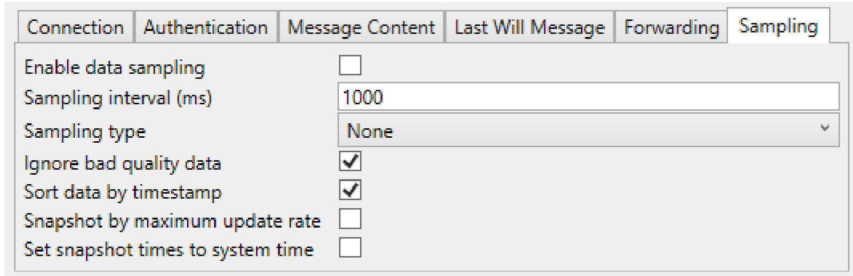
A string that uniquely identifies this connection as a forwarder. Each connection that acts as a forwarder from a specific database must be uniquely distinguished from all others. The forwarding mechanism uses this ID to keep track of which values have been transmitted to each forwarder. You may enter any string, or keep the automatically generated ID.

Override read location

Sets the specified row ID or date as the starting point for reads from the historian.

Sampling

The **Sampling** feature lets you send samples of the data for specified time intervals, rather than the full data set.



Enable data sampling

Activates the data sampling feature.

Sampling interval (ms)

The length of time for which each sample will be taken, in milliseconds. For example, a sample interval of `1000` will produce a sample every second. Choosing this option will result in zero or more values being sent to the server based on the presence of data changes and the **Sampling type**.

Sampling type

Choose the criteria for the sample. This setting determines which values will be transmitted for each sampling interval. If there is no data (or no Good quality data) for a point within a sampling interval then no value will be transmitted. The following criteria are available:

None - no sampling is done and all values are transmitted.
First - the first value in the sampling interval is transmitted.
Last - the last value in the sampling interval is transmitted.
Mean - the average of all (good) values in sampling interval are transmitted.
Min - the minimum value within the sampling interval is transmitted.
Max - the maximum value of the sampling interval is transmitted.
MinMax - the minimum and maximum values of the sampling interval are transmitted, in time order.

Ignore bad quality data

If the data quality for that time interval is not Good then that data change will be ignored. Other samples within the time interval that have Good quality will still be processed normally.

Sort data by timestamp

Sorts the sampled values in time order when constructing the message body using the document definition. Since sampling is done on a per-point basis, the resulting collection of values may not be in time order. For example, the maximum value of `point2` might have occurred before the maximum value of `point1`. This option sorts the resulting combined set of values.

Snapshot by accumulation time

Specifies that a complete snapshot of all configured data points will be periodically sent as a batch to the broker. Please refer to the **Maximum update rate** in the

Connection settings configuration. The snapshot period will be this update rate, not the sampling interval. Each data point will be transmitted with its source timestamp and current value.

Set snapshot times to system time

When saving data using a snapshot, replace the source timestamp of every point value with the current system time. This applies to all points, whether or not they have changed within this accumulation interval.

Once you have configured the Connection, Authentication, Message Content, Last Will Message, Forwarding, and Sampling options, we recommend testing the connection by clicking the **OK** button. This will close the **Connect to MQTT Broker** dialog and display your entries in the list of configured brokers. The **Status** should eventually change to `Running`.

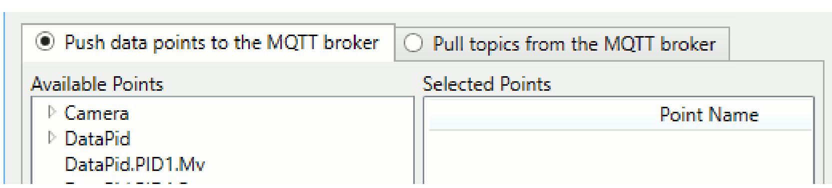
When the connection is tested and working, you are ready to exchange data.

Exchange Data

Once your connection is configured, you can create topics on the MQTT broker using points from the DataHub instance, and/or request topics from the MQTT broker to create corresponding DataHub points.

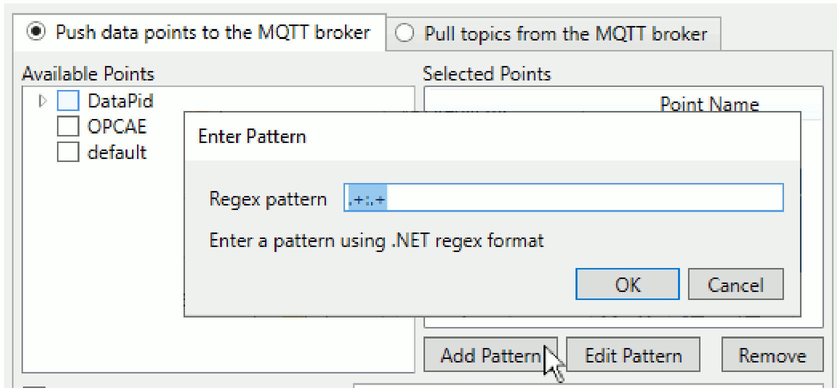
Push data point to the MQTT broker

This mode allows you to select points from the DataHub data set and to transmit them to the MQTT broker. Normally you should select **Convert dot to slash** to allow the DataHub instance to convert point names to valid topic names. You may also choose **Also subscribe to changes in the broker**. This will cause the DataHub instance to listen for changes in the topics and write the results back to DataHub points. Not all brokers support subscriptions.

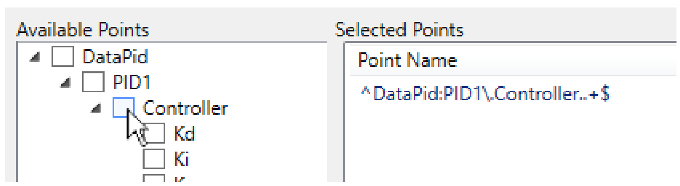


Choose the points from the **Available Points** list and they will appear in the **Selected Points** list. Use the **Remove** button to remove a selection.

You can select groups of points or even a whole domain by using a pattern based on a regular expression. Click the **Add Pattern** button to enter a regular expression. Use the **Edit Pattern** button to edit an existing expression. Every point matching the regular expression will be sent to the MQTT broker, and if more matching points are dynamically added to the domain, they will be sent as well.



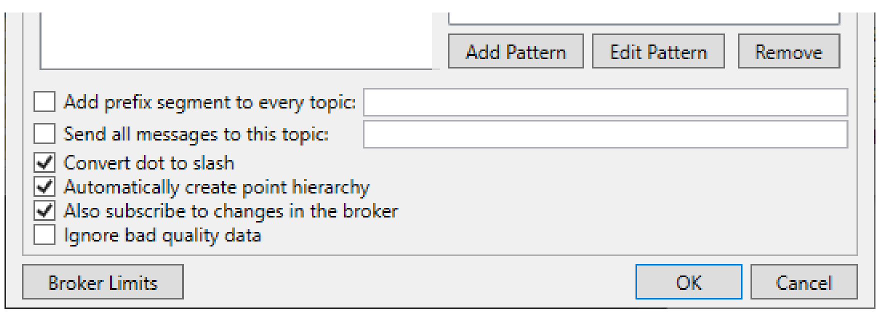
The domain portion of the point name can be a regular expression, to match more than one data domain. For example, the expression `.+:.+` matches all points in all domains. A pattern MUST include exactly one colon (`:`) character that separates the data domain from the data point name. It must be un-escaped and not part of a capture group. If no colon character exists in the pattern then the matching results will be indeterminate.



To add a regular expression based on a branch or point, hold down the **Ctrl** key while clicking on the checkbox.

Regular expressions are a way that programmers use place-holders and wild cards in a variable name so that it can refer to multiple names at one time. The DataHub program uses .NET Regular Expressions, whose use and syntax can be [found here].

The following options apply to all points selected:



Add prefix segment to every topic

A string gets inserted at the beginning of the DataHub point name, before the domain name. This is useful for creating a single tree for points from different domains. For example, an entry of `MyTree` here would change a point named `DataPid:PID1.Mv` to `MyTree:DataPid.PID1.Mv`. A point named `DataSim:Ramp` would become `MyTree:DataSim.Ramp`. If the **Convert slash to dot** option (see below) is checked, these points would be represented on the MQTT broker as `MyTree/DataPid/PID1/Mv` and `MyTree/DataSim/Ramp`.

Send all messages to this topic

If the broker you are connecting to does not expect a topic for each point, you can specify one destination topic for all points here.

Convert slash to dot

The MQTT topics use a slash (`/`) character in hierarchical names, while OPC and other industrial protocols typically use a dot (`.`). Keep this option checked to have the DataHub instance convert DataHub points into MQTT topics.

Automatically create point hierarchy

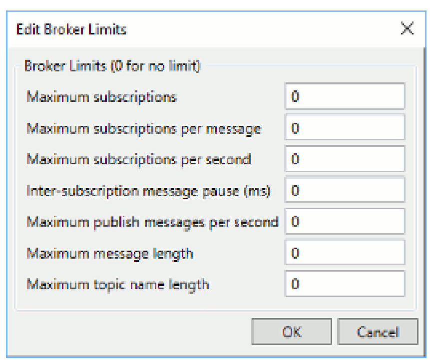
The MQTT protocol supports hierarchical names. Checking this option preserves the hierarchy within the DataHub instance.

Also subscribe to changes in the broker

Allow the broker to write back to these points in the DataHub instance.

Broker Limits

Some brokers impose certain limits on client connections. For example, cloud services like AWS and Azure limit transmission rates, message sizes and subscriptions, to avoid abuse. If you specify broker limits here, the DataHub instance will construct messages to comply with them, and will throttle subscription and publication messages to stay within those limits.

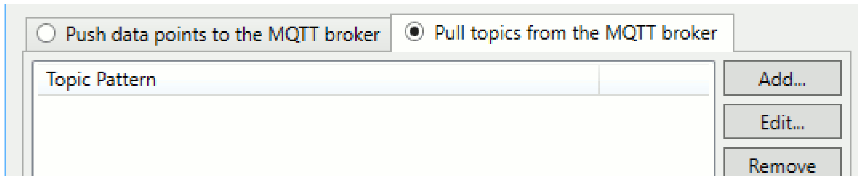


If the rate of incoming data exceeds these limits for outgoing data transmissions, the DataHub instance will buffer outgoing data for a short time, and then begin removing stale buffered data to keep the transmitted data as current as possible. See also **Maximum update rate**.

Click the **OK** button to save your changes, or **Cancel** to cancel them.

Pull topics from the MQTT broker

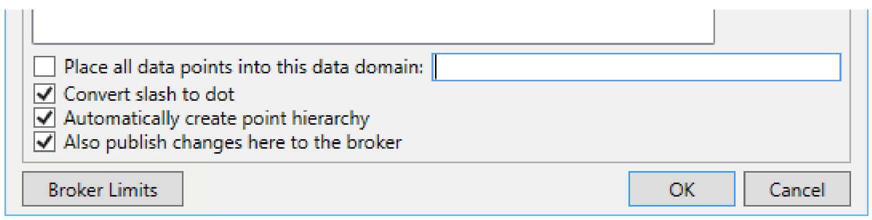
This mode allows you to specify topics in the broker that the DataHub instance should subscribe to. This will cause values in the broker to be written to DataHub points. You may also choose **Also publish changes here to the broker**. This will cause the DataHub instance to write values for the selected points back to the broker, if the broker supports this.



Click the **Add** button to enter a point in a pop-up dialog. It will appear in the **Selected Points** list. Use the **Edit** button to make changes, and the **Remove** button to remove a selection. The topics should be supplied in MQTT syntax, like this: `plant1/mixer/motor/speed`. You may specify MQTT topics with the wild cards plus (+) and hash (#).

- The + character is an internal wild card that matches any string between / delimiters. For example, you can use `plant1/+/motor/speed` to subscribe to all motor speeds in plant1. The topic name cannot start or end with a +.
- The # character is a terminal wild card that can only appear at the end of the topic, such as `plant1/mixer/#` to subscribe to all topics related to plant1/mixer. You may specify a topic that is just a single # to subscribe to all topics in the broker.

The following options apply to all topics:



Place all data points into this data domain

This is a convenient way to organize your incoming MQTT connections. Choose any existing DataHub domain, or enter a new name and a new domain will get created in the DataHub instance.

Convert slash to dot

The MQTT protocol typically uses a slash (`/`) character in hierarchical names, while OPC and other industrial protocols often use a dot (`.`). Checking this option lets you convert MQTT-style names.

Automatically create point hierarchy

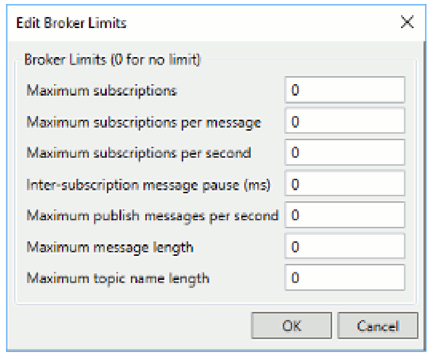
The MQTT protocol supports hierarchical names. Checking this option preserves that hierarchy within the DataHub instance.

Also publish changes here to the broker

Allows the DataHub instance to write values to these points in the broker.

Broker Limits

If your broker has limits on subscriptions, messages, or topic names, you can enter them here.



Click the **OK** button to save your changes, or **Cancel** to cancel them.

Pre-Configured Connections

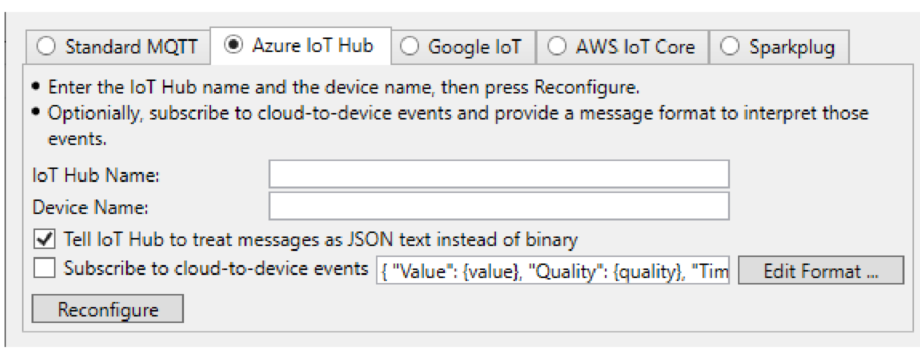
Because MQTT is a messaging protocol, not a data communications protocol, it does not specify a particular format for making a connection or the data payload. Thus, each MQTT implementation can be different with its own, unique connection characteristics.

Our **Standard MQTT** option provides a generic way to configure a connection to any MQTT broker. In addition, we offer the following pre-configured options to facilitate connecting to Azure, Google, or AWS MQTT brokers.

Azure IoT Hub

To make a connection to Azure IoT Hub you will need to follow some extra steps. Authentication can be done by certificate or by using a password, but not both. The password must be generated by a separate tool as described below.

Once you have a password, click the **Azure IoT Hub** radio button and enter the following information:



IoT Hub Name

The IoT Hub Name provided by Azure.

Device Name

A name for the device that you want to connect.

Tell IoT Hub to treat messages as JSON text instead of binary.

By default Azure IoT Hub treats an MQTT payload as binary data. Selecting this option (the default) will inform IoT Hub that the payload is JSON text, typical of a DataHub MQTT client connection. This may affect how other downstream Azure services process the MQTT messages.

Subscribe to cloud-to-device events

Optionally, you can enter the MQTT message format to receive data and event updates from the IoT Hub.

After making your entries, press the **Reconfigure** button to add that configuration to the list, and clear the fields for another entry. You will see the necessary information entered in the **Connection**, **Authentication**, and **Message Content** tabs. You can optionally configure a **Last Will Message**, if desired.

The **Reconfigure** button also sets the DataHub instance's **Broker Limits** configuration to the default values for this cloud service's broker. If any broker limits are non-zero, (such as if they were previously configured), they will not be reset. To reset them, first manually change them to zero and then click this button again.

When you are finished, you can configure your Exchange Data options.

Azure IoT Hub does not allow a client application to subscribe to a topic. That is the way Azure is designed. It was never intended to be a general-purpose MQTT broker. The only way to get data from Azure via MQTT is through a mechanism called “Cloud-to-device events”. There is a setting in the DataHub configuration for that. You need to generate the events from the Azure portal. The Azure documentation can provide more information: https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-devguide-messaging.

Using CA Certificates

DataHub software supports CA certificates for SSL, in either PEM or PFX format. To use a CA certificate you need to do the following in your Azure IoT Hub configuration :

1. Go to **Certificates** and add your CA certificate.
2. Create your device and set the **Authentication type** to authenticate by Certificate.

Then, in the DataHub MQTT Client Azure IoT Hub **Authentication** tab:

1. Check the **Use SSL** box.
2. Add your CA signed client certificate in the **Client Certificate** field.

Using Azure IoT Password Creation

As an alternative to a CA certificate, you can use a password. The Azure IoT password is an SAS token. To generate the SAS token:

1. Open your IoT Hub in the Azure portal.
2. On the left menu under **Settings** find the **Shared Access Policies**, and click on the policy name you want to use.

   On the right you will see the **Shared Access Keys**.
3. Find and make a copy of the **Connection-String Primary**. You will need this in the Azure IoT Explorer.
4. Download the current release of the Azure IoT Explorer from:

   https://github.com/Azure/azure-iot-explorer/releases
5. Install it and run the application.
6. Paste in the copy you made of the IoT Hub **Connection String Primary**, and click **Connect**.

   This will list your IoT Devices.
7. Click your device.
8. Find the **Connection string with SAS Token** section.
9. Set **Symmetric Key** to **Primary Key**.
10. Set the keys expiration time in minutes.
11. Click **Generate**. The result will look like this:

    ```
    HostName=SWTBOPCUAHub.azure-devices.net;DeviceId=TestDevice2;
    SharedAccessSignature=SharedAccessSignature sr=SWTBOPCUAHub.az
    ure-devices.net%2Fdevices%2FTestDevice2&sig=FLwubhFB4V%2F7j6pZ
    S3KXEomL4%2F2uCaBSipyKiIZCWuw%3D&se=1592419771
    ```

    (But all one string, no carriage returns.)
12. Azure only requires the part of this string starting from "`SharedAccessSignature=`". You can copy the entire string, or only the portion starting from "`SharedAccessSignature=`" to the end of the string. If you plan to share this configuration with older versions of the DataHub program then you should copy only that portion. The result should be a single string, similar to this:

    ```
    SharedAccessSignature sr=SWTBOPCUAHub.azure-devices.net%2Fdevi
    ces%2FTestDevice2&sig=FLwubhFB4V%2F7j6pZS3KXEomL4%2F2uBaCSipyK
    iIZCWuw%3D&se=1592419771
    ```

    (All one string, no carriage returns.)

This is the SAS token, which you can paste verbatim into the DataHub configuration **Password** field.

Google IoT

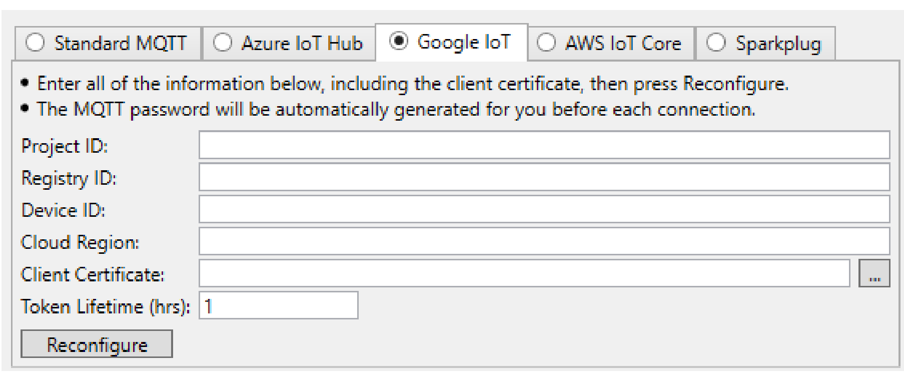
Google no longer offers an IoT service, but ClearBlade offers a complete migration path that you may want to use instead. The DataHub interface and this documentation will continue to use "Google" terminology to stay consistent.

Before configuring a DataHub MQTT connection to Google IoT, you need to create a device in the Google IoT portal. Here's how:

1. Open the Google IoT console.
2. Select **IoT Core** from the left-hand menu.
3. Select **Create Registry**.
   a. Set the **Registry ID** and **Region**.
   b. Create the registry.
4. Select **Devices** from the left-hand menu.
5. Select **Create a Device**.
6. Enter a name and click **Create**.
7. Create a key using OpenSSL in a terminal, as follows:
   a. Run this command in a shell prompt that has openssl installed:
   ```
   openssl req -x509 -newkey rsa:2048 -keyout rsa_private.pem
   -nodes -out rsa_cert.pem -subj "/CN=unused"
   ```
   This will create 2 files, named `rsa_cert.pem` and `rsa_private.pem`
   b. Convert the `rsa_cert.pem` and `rsa_private.pem` to PFX in your local machine:
   ```
   openssl pkcs12 -inkey rsa_private.pem -in rsa_cert.pem -export
   -out rsa_cert.pfx
   ```
8. Select the device, select its **Authentication** tab, and click **Add Public Key**.
9. Select **RS256_X509** for the Public key format and click **Add**.
10. Copy the text of `rsa_cert.pem` into the dialog box.
11. Download the Google CA root certificate.

Now you can configure the DataHub instance.

1. Click the **Google IoT** tab and enter the following information as provided by Google:



Project ID

The ID for your project.

Registry ID

Your Registry ID.

Device ID

The Device ID for this device.

Cloud Region

The name of the Google cloud server region.

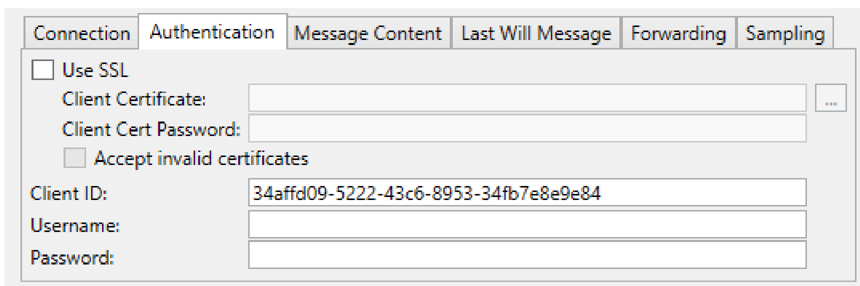
Client Certificate

A path to `rsa_cert.pfx` that you created in the previous steps.

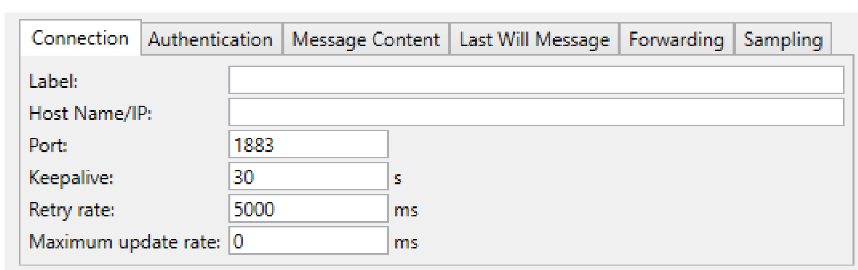
Token Lifetime

Google IoT and ClearBlade (Google IoT work-alike) drop an MQTT client connection when the connection token lifetime expires. Here you can set the token lifetime from .005 to 24 hours. The default is 1 hour.

2. Press the **Reconfigure** button to add that configuration to the list.
3. Select the **Authentication** tab in the second row of tabs.



4. In the **CA Certificate** field, enter a path to the Google CA root certificate file that you downloaded previously. If the certificate is in PEM format, you can use it without modification even if the DataHub instance requests a CER or CRT format file.
5. Open the **Connection** tab.

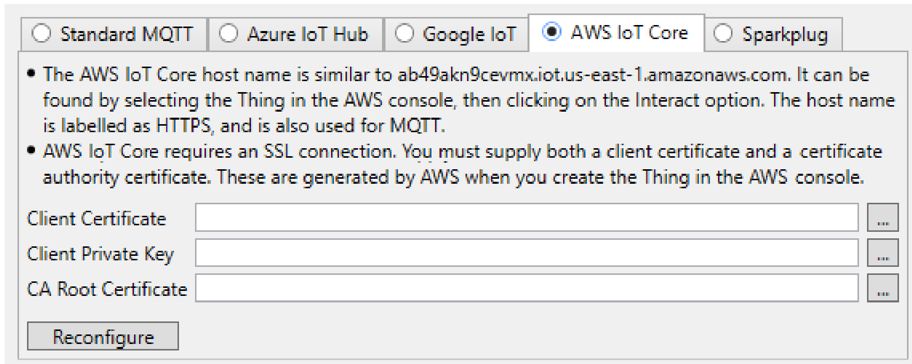


6. Enter a **Label** to identify the connection. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other connection names.

You are now ready to configure your Exchange Data options.

AWS IoT Core

Click the **AWS IoT Core** tab and follow the instructions given in the interface:



Client Certificate, **Client Private Key**, and **CA Root Certificate** entries correspond to files that AWS provides. After entering the correct information for all three fields, press **Reconfigure** and the DataHub instance will automatically create a certificate file and fill in the members of the **Authentication** and **Message Content** tabs.

The **Reconfigure** button also sets the DataHub instance's **Broker Limits** configuration to the default values for this cloud service's broker. If any broker limits are non-zero, (such as if they were previously configured), they will not be reset. To reset them, first manually change them to zero and then click this button again.

If you need to change any auto-generated settings, please keep in mind that AWS IoT Core does not accept connections with quality of service 2, or with message retention, and only allows the following settings in the **Message Content** tab:

- **Retain messages on broker** = not checked
- **Quality of service** = **At Most Once** or **At Least Once**

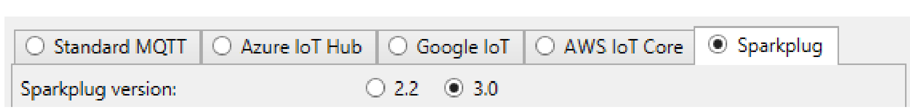
When you are finished, you can configure your Exchange Data options.

Sparkplug

The DataHub program can be configured as a Sparkplug 3.0 or 2.2 client. It supports EoN device or application types for version 3.0, and EoN device, primary application or non-primary application types for version 2.2.

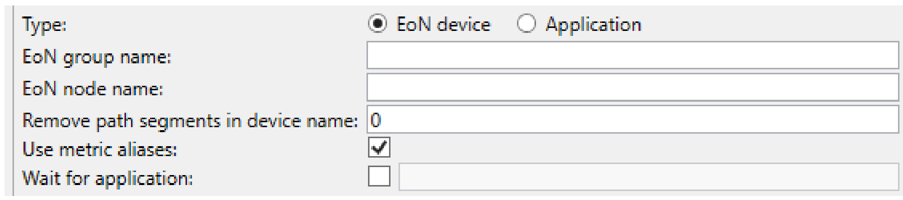
Sparkplug version

Choose version 2.2 or 3.0.



EoN device

This setting allows a DataHub instance to function as an Edge of Network (EoN) device. In this mode the DataHub instance acts as a data source, effectively acting as a gateway between any supported protocol and Sparkplug.



EoN group name

An identifier that can be shared among EoN devices. This is commonly used to group similar devices.

The combination of **EoN group name** and **EoN node name** (below) identify each EoN device, and must be unique among all Sparkplug clients connected to the same broker.

Sparkplug identifier strings can contain any valid UTF-8 alphanumeric characters except for the plus sign (+), forward slash (/), and number sign (#).

EoN node name

An identifier that uniquely identifies this device within its group.

Remove path segments in device name

When the DataHub MQTT client is publishing a data hierarchy as a Sparkplug Edge of Network device, it will use the first branch name in the data point name as the Sparkplug "device" name. The child branches and leaves of this branch will be published as device metrics. In some cases you may have a hierarchy that contains one or more additional branch levels above the branch that is best used as a device name. This option allows you to specify how many branch levels in the data point hierarchy to skip to arrive at a branch in the hierarchy that represents the EoN device name. To use the point name without modification, set this value to zero.

Use metric aliases

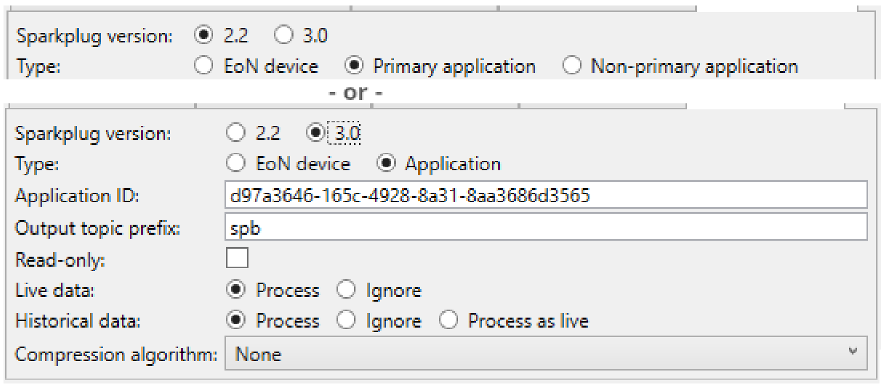
Sparkplug metrics can use numeric aliases to reduce network bandwidth by substituting a number for the metric name, which is typically longer. Some applications do not correctly handle aliases. Disabling this option will cause DataHub EoN connections to send the metric name with each message instead of using aliases.

Wait for application

Selecting this option and providing an application name causes the DataHub Sparkplug EoN client to wait until the specified application has announced that it is online before the client emits its birth message and begins transmitting data.

Application / Primary application

This setting allows the DataHub instance to function as version 3.0 application or a version 2.2 primary application. This will inform other Sparkplug clients about its current connection status.



The **Application** and **Primary application** type settings for versions 3.0 and 2.2 respectively are identical.

There should be at most one primary application connected to a Sparkplug 2.2 broker at any given time.

Application ID

An identifier for this client connection that must be unique among all connections to the MQTT broker.

Sparkplug identifier strings can contain any valid UTF-8 alphanumeric characters except for the plus sign (+), forward slash (/), and number sign (#).

Output topic prefix

An identifier string that will be added to the name of each data point, after the DataHub domain name (if any), and before the group or node name. In addition to the normal Sparkplug identifier character restrictions, this identifier cannot contain the colon (:) character.

Read-only

Checking this box will prevent this application from writing values back to EoN devices and clients.

Live data

Choose whether to process or ignore live data, which is any Sparkplug metric values that are not flagged as historical. The choices are:

- **Process:** Convert the metric names to DataHub point names and update the point values.
- **Ignore:** Do not convert the metrics to DataHub points. The Sparkplug message will still be transmitted to other Sparkplug clients, but they will not appear as DataHub points.

Historical data

Choose whether to process or ignore historical data, or to process it as live data. Historical data is any data that is explicitly flagged as historical. The choices are:

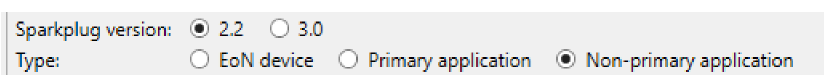
- **Process:** Convert the metric names to DataHub point names, and send the values to all External Historian connections that are monitoring those point names. The live DataHub points will not be changed.
- **Ignore:** Do not convert the metrics to DataHub points, and do not update External Historian connections. Do not update the live DataHub points. The Sparkplug message will still be transmitted to other Sparkplug clients.
- **Process as live:** Treat the metrics as if they were not flagged as historical, and instead process them using the **Process** algorithm for live data (see above).

Compression algorithm

Optionally choose a **Gzip** or **Deflate** compression algorithm for this connection. The default is **None**.

Non-primary application

The non-primary application type is only available for Sparkplug 2.2.

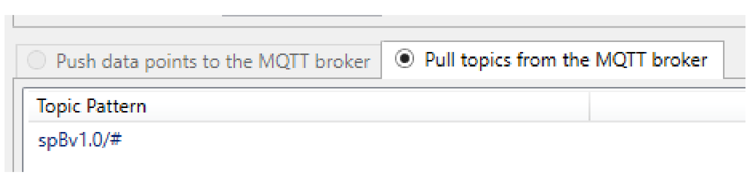


This setting allows the DataHub instance to function as a non-primary application. A non-primary application will not inform other Sparkplug clients about its current connection status. There can be any number of non-primary applications connected to a broker.

The non-primary application type is configured the same as a primary application type except that it has no application ID.

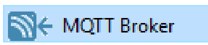
Topic Pattern

The topic pattern for pulling topics from the MQTT broker should always be set to `spBv1.0/#`.



When you are finished, you can configure your MQTT Exchange Data options as documented here.

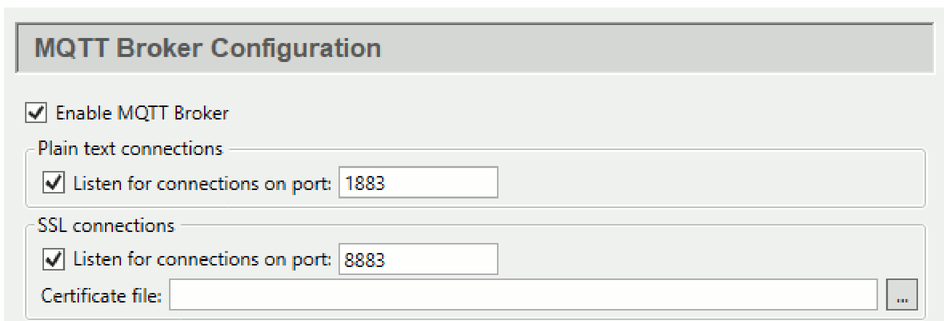
MQTT Broker



The MQTT Broker option lets you configure the DataHub program as an aggregation and distribution point for MQTT messages from devices and MQTT clients. It can operate as a standard MQTT broker, or as a gateway broker to the DataHub program's data set.

You must allow Remote Connections in Security for any incoming connections over the network.

These are the configurable options for the MQTT Broker:



Enable MQTT Broker
This box enables or disables all MQTT Broker functionality.

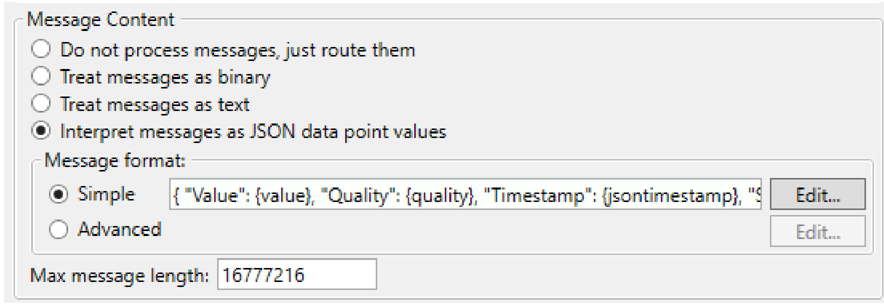
Plain text connections
Check the box to enable plain text connections, and specify a port. Port 1883 is the MQTT default for plain text.

SSL connections
Check the box to enable SSL connections, and specify a port. Port 8883 is the MQTT default for SSL. If you are using a certificate for SSL connections, you can enter it here. Please see SSL Certificates for more information about SSL certificates in the DataHub program.

Message Content

Here you can set a DataHub instance to act as a standard MQTT broker or a gateway broker.

1. **Standard MQTT broker** In this mode the DataHub instance does not interpret MQTT messages and simply distributes them to its clients according to standard MQTT protocol. To select this mode, enable the option **Do not process messages, just route them**.



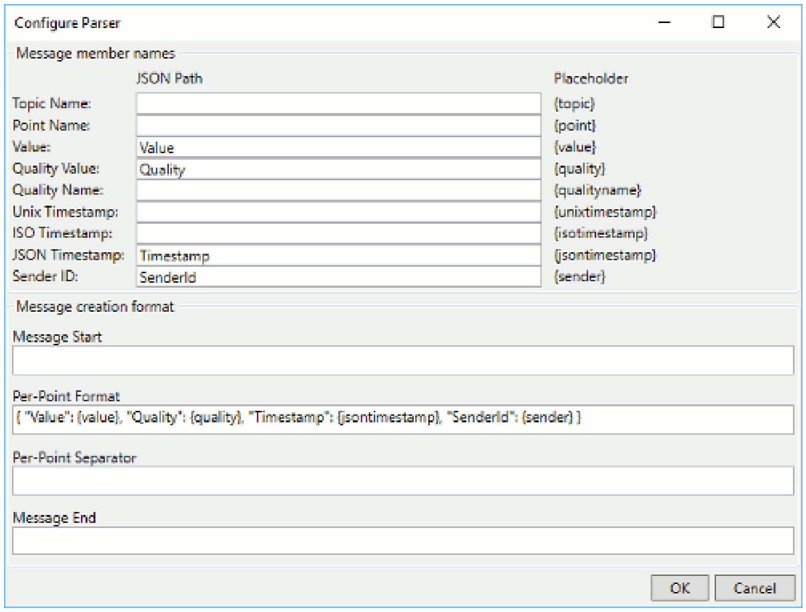
2. **Gateway broker** In this mode the DataHub instance still performs the role of a standard MQTT broker, while at the same time it interprets the incoming messages, mapping them to DataHub points. Messages from clients produce data changes in all configured DataHub protocols. Changes to data in the DataHub instance result in messages to MQTT subscribers. MQTT clients can participate in control systems as peers with OPC, DDE and DHTP clients and server.

   Messages can be interpreted in three ways:

   - **Treat messages as binary** Messages are Base-64 encoded and stored in the DataHub instance as strings. They are not processed beyond that. Use this mode if you want the DataHub instance to put the values into data points based on the MQTT topic name. For example, you could use this mode when the MQTT data is an image.
   - **Treat messages as text** Messages are interpreted as UTF-8 text and added to the DataHub instance as point values. No further interpretation is done. Use this mode when the MQTT messages are free-form text or you do not want them to be interpreted further.

     You can use this option to discover the client message format. It will cause the JSON parser to be bypassed, and the client messages to be written as text into the destination topic.

   - **Interpret messages as JSON data point values** Messages are expected to be text in JSON format. The DataHub instance can interpret the messages according to a message format you specify. To edit the message format, click the **Edit** button, which opens the Configure Parser window:

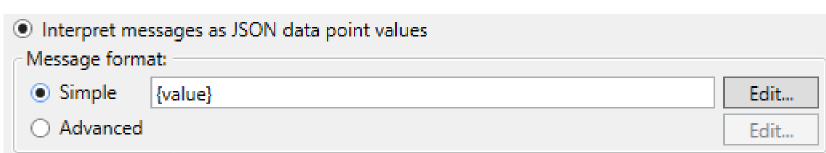


The JSON Path fields at the top show your current entry. To make changes, edit the **Message Start**, **Per-Point Format**, **Per-Point Separator**, **and the Message End** fields. When you press the **OK** button your changes will be registered. To make a new entry, such as `"PointName"`, enter a string and the placeholder (like `{point}` in this example), using the same syntax as the other entries in the **Per-Point Format** entry field.

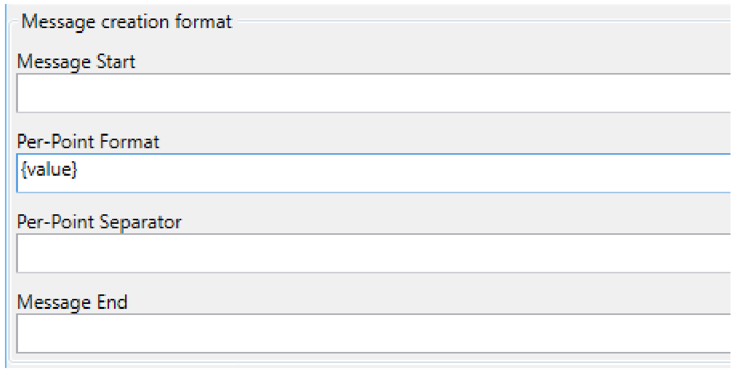
The **Max message length** field allows you to set a maximum number of bytes that the broker will send in an individual message. This setting is only relevant when the broker is interpreting messages, and the message format would allow for multiple point values to be combined into a single MQTT message. This setting will limit the number of point values that will be packed into each message. Do not set this value to be smaller than the expected length of a message containing only one point value.

Unparsed Values

The simplest way to pass an MQTT message is with unparsed values. To configure this in the DataHub instance, the message format must be simply `{value}`.



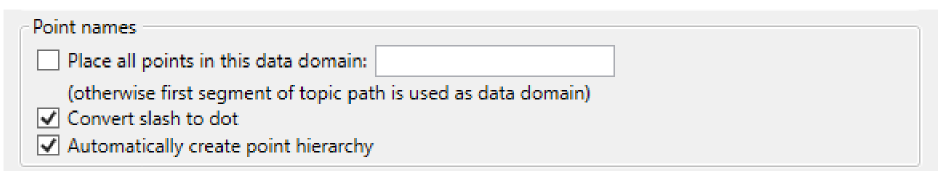
For a **Simple** format, click the **Edit button** to open the Configure Parser dialog, and ensure that the entry for **Per-Point Format** is only the string `{value}` with no extra characters. Also, there should be no entries in the **Message Start**, **Per-Point Separator**, and **Message End** fields.



To see how the `{value}` message format can be used to connect an MQTT client whose message format you do not know, please refer to the section called “Connecting Incoming MQTT Clients”.

For **Advanced** message formats, please see MQTT Advanced Parser in Using MQTT.

Point Names



Place all points in this data domain

You can specify a DataHub domain in which all points related to MQTT topics will be collected.

Convert slash to dot

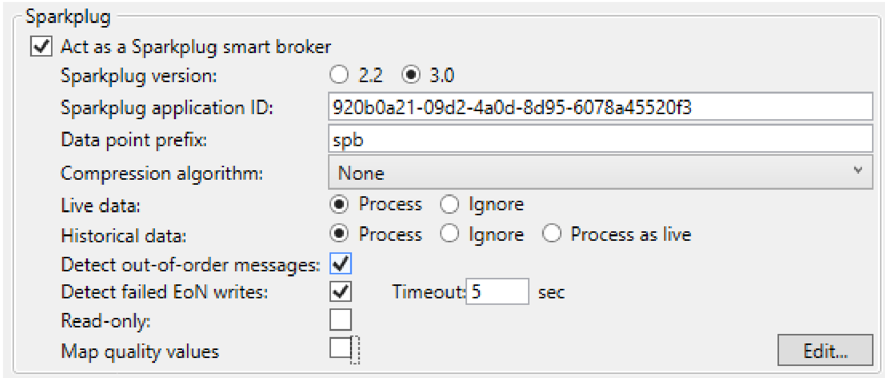
The MQTT protocol typically uses a slash (`/`) character in hierarchical names, while OPC and other industrial protocols often use a dot (`.`). This option will convert MQTT-style names.

Automatically create point hierarchy

The MQTT protocol supports hierarchical names. This option preserves the hierarchy within the DataHub instance.

Sparkplug

Check the **Act as a Sparkplug smart broker** box to have the DataHub MQTT broker function as a Sparkplug broker. The broker will interpret Sparkplug messages and may do additional processing as explained below. The broker will continue to act normally for MQTT messages, as configured in the Message Content settings.



The additional processing for Sparkplug includes:

- Acts as a Sparkplug 3.0 application, or a Sparkplug 2.2 primary or non-primary application. This will collect all information from EoN devices and expose them as DataHub points. If the smart broker is not set to **Read-only** then changes to those data points will be transmitted back to the EoN devices.
- Monitors the connection status of all EoN devices and changes the associated data point qualities to Not Connected when an EoN device disconnects.
- When configured for Sparkplug 2.2, synthesizes a Sparkplug BIRTH message for all currently connected EoN devices whenever a primary or non-primary application connects. This ensures that applications will always be informed of EoN devices, regardless of connection order.
- Monitors message sequence numbers from EoN devices. If an out-of-sequence message arrives the smart broker will force the EoN device to disconnect. This will cause the EoN device to reconnect and resynchronize its data.
- Monitors writes to the EoN devices. If a write to a device occurs, and no subsequent data arrives from the device for that metric within 5 seconds, the smart broker will force the EoN device to disconnect. This will cause the EoN device to reconnect and resynchronize its data.

Sparkplug version

Choose the version of Sparkplug you are using, 2.2 or 3.0. Configuration is similar for these, with a few differences as mentioned below.

Type

For Sparkplug 2.2, if you already have a primary application in your system, choose **Non-primary application** here. Otherwise, choose **Primary application**. Sparkplug 3.0 does not make this distinction, so this option is not needed.

Sparkplug application ID

This is a string that uniquely identifies an application. It is used by Sparkplug EoN clients and monitoring applications to distinguish the on-line state of an application. Normally the application ID should be unique on the broker. Sparkplug 2.2 non-primary applications do not have an application ID.

Sparkplug identifier strings can contain any valid UTF-8 alphanumeric characters except for the plus sign (+), forward slash (/), and number sign (#).

Data point prefix

An identifier string that will be added to the name of each data point, after the DataHub domain name (if any), and before the group or node name. If the data domain name (specified by **Place all points in this data domain**) is blank, or the point prefix specified here ends with a colon (:) character, then this value will be used as the data domain name for data points derived from Sparkplug data. Sparkplug STATE points are not affected by this option, and will be processed as plain-text MQTT messages.

Compression algorithm

Optionally choose a **Gzip** or **Deflate** compression algorithm for client connections. The default is **None**.

Live data

Choose whether to process or ignore live data. See the description of Live data in the MQTT Client Sparkplug Application section for more information.

Historical data

Choose whether to process or ignore historical data, or to process it as live data. See the description of Historical data in the MQTT Client Sparkplug Application section for more information.

Detect out-of-order messages

This will allow the DataHub instance to identify out of order or lost messages from an EoN (Edge of Network) device. Should this occur, the DataHub instance will disconnect the device and allow it to reconnect, causing it to re-send its BIRTH (startup) message, and thereby resynchronize all the receiving applications.

Detect failed EoN writes

When a write to an EoN (Edge of Network) device fails, the device will not necessarily retransmit its correct current value. Connected applications will thus not know that the write failed and will reflect an incorrect value. Choosing this option uses a timer to identify that a write request was transmitted, but no subsequent DATA message was received from the EoN device. If so, the DataHub instance will force the EoN device to disconnect, causing it to retransmit its BIRTH message and thereby resynchronize any applications.

Emit EoN BIRTH messages

This feature is only needed for Sparkplug 2.2. It allows the DataHub instance to synthesize a BIRTH message on behalf of an EoN (Edge of Network) device when a new application connects. This causes the newly connected application to synchronize correctly and subsequently receive and process DATA messages from the EoN device. This option works even for non-primary applications that otherwise are unable to synchronize with EoN devices.

Read-only

Checking this box will prevent the smart broker from writing values back to EoN devices and clients.

Map quality values

The Sparkplug specification defines a specific set of quality values:

`0` = Bad
`192` = Good
`500` = Stale

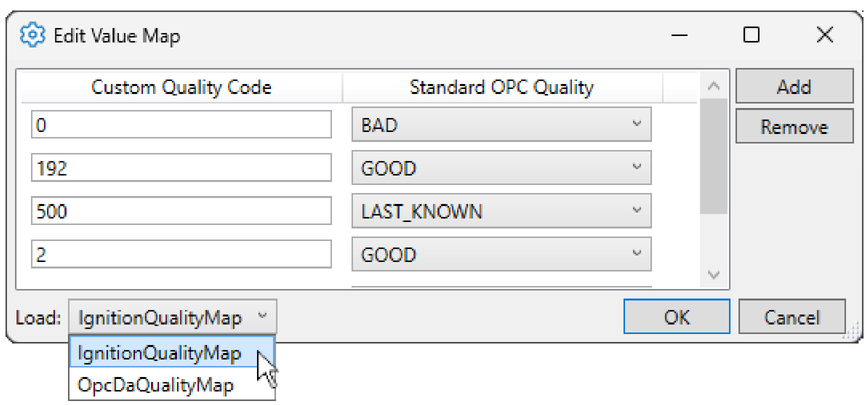
Normally, a DataHub instance will map these to the standard OPC DA quality values as:

`0` = Bad
`192` = Good
`500` = Bad - Last Known

Some Sparkplug clients, like Ignition, produce non-standard quality codes. A DataHub instance needs to know how to map those codes to the OPC DA qualities that it uses internally. Sparkplug quality values are 32-bit signed integers.

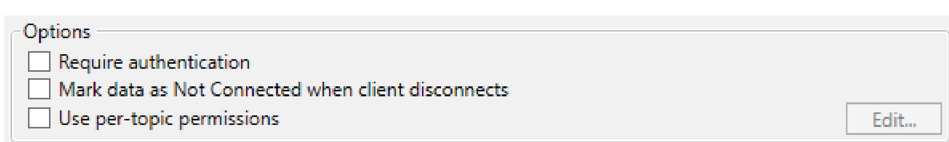
You can create your own custom quality mapping by entering the numeric quality values from the Sparkplug client and assigning them to the corresponding OPC DA qualities. This mapping is many-to-one. That is, you can have more than one custom quality code map to the same OPC standard quality.

To create a quality map, click the **Edit** button to open the **Edit Value Map** dialog.



You can load a predefined quality code map using the **Load** combo box. Once loaded, you can modify it as necessary to meet your application requirements. You can re-order lines in the mapping table by dragging and dropping.

Options



Require authentication

Forces all client connections to the MQTT Broker's to supply a username and password. Anonymous connections will be rejected. The usernames and passwords for this are created in the DataHub Security option, following the Common Scenario recommendations for TCP or tunnel/mirror connections. The MQTT Broker applies the user's **Read** permission when the connection attempts to subscribe to a topic, and applies the user's **Write** permission when the connection attempts to write to a topic. All other data permissions are ignored by the MQTT Broker.

If this option is not checked, clients can still supply a username and password and read/write permissions will be enforced. Anonymous connections will receive both read and write permissions.

Cogent DataHub users: When the broker is running from a single domain, permissions are applied to the whole broker domain. When the broker is exposing all domains, permissions are applied on a per-domain basis.

Mark data as Not Connected when client disconnects

When the DataHub Broker is running in gateway mode it writes the values of MQTT messages into DataHub data points, with `Good` quality. If an MQTT client disconnects from the broker then this option will cause the broker to change the qualities of every point originating from that client to `Not Connected`, indicating that the client is no longer connected and the value of the data point is not necessarily up to date. This option applies only to those points whose values were updated by the client during the time it was connected.

Use per-topic permissions

See MQTT per-topic permissions in the Security chapter for an example showing how to use this option.

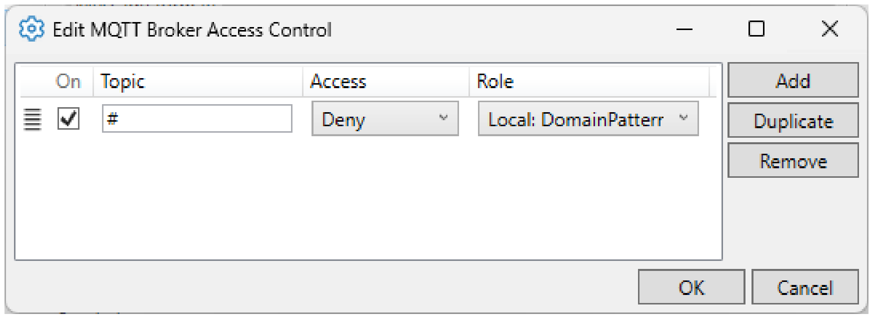
This option applies DataHub Security features to configure granular access control on portions of the MQTT topic space. It specifies an ordered collection of rules, where each rule specifies the permissions for a role on a per-topic or per-topic-pattern basis. Every principal that is a member of that role receives the configured permissions. Permissions are applied in the order they appear in the list, with the exception of user and client name patterns, which are always applied after topic names and topic patterns. The first matching rule will determine the permissions for any PUBLISH (write) or SUBSCRIBE (read) requests made on a connection.

Topics may contain wildcards following the MQTT topic syntax. A + character in the topic path matches a specific segment in the topic, and a # character matches all topics that start with the segments preceding the # character. See the MQTT specification for more details.

In addition, you can supply user and client name patterns. The string **%u** will be replaced with the username supplied for this connection. The string **%c** will be replaced with the MQTT client ID for this connection. Rules that include the **%u** and **%c** patterns will be evaluated after all other topic patterns, in the order that they appear in the list.

If no rule matches a request, the request is denied.

To use the **Edit MQTT Broker Access Control** dialog, click the **Add** button to add a new rule, **Duplicate** to duplicate an existing rule, or **Remove** to remove a rule. You can change the order of rules in the list by dragging and dropping using the menu icon ( ) on the left edge of each rule. Also see the example in the MQTT per-topic permissions section of the Security chapter.



Topic

The MQTT topic to which these permissions will be applied. Topics may contain + and # wildcard characters, and %u and %c string replacement placeholders.

Access

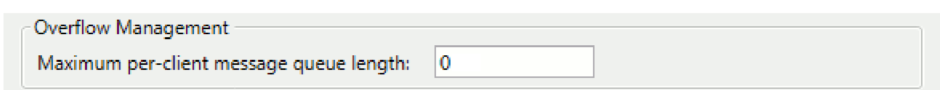
Choose between **Deny**, **Read**, **Write**, or **ReadWrite** for the type of permission required.

Role

The applicable role as defined in the DataHub Security configuration.

Overflow Management

When the broker receives messages more quickly than clients can accept them, it stores the messages in queues, one per client. Here you can manage overflows in those queues.

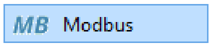


Maximum per-client message queue length

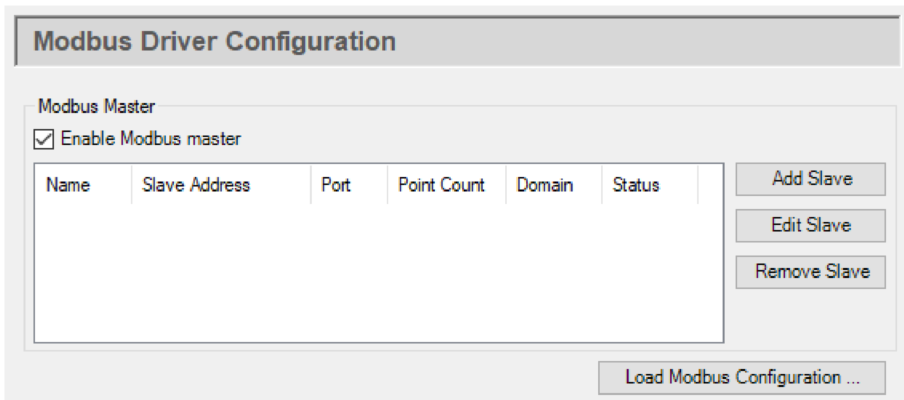
Set a limit for the maximum number of outstanding messages that are queued per client. The default queue length is zero, no limit. This causes the Broker to use its own smart queue management based on the recipient's data ingestion rate.

In DataHub v10, the MQTT broker would always send all QoS 0 retained messages in response to a subscription, regardless of this setting. In DataHub v11 and higher, the Broker respects the queue length setting. This may result in unexpected loss of retained topic information when the client initially connects. To restore the behaviour of v10, set the **Maximum per-client message queue length** to zero.

Modbus



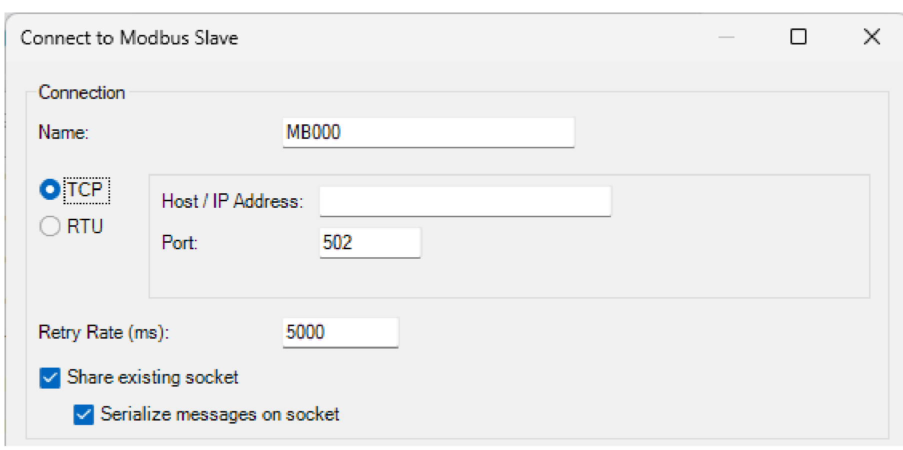
The Modbus option provides Modbus master support for Modbus/ TCP. Using this with the OPC DA option enables the DataHub program to function as a Modbus OPC server.



The **Add Slave**, **Edit Slave**, and **Remove Slave** buttons allow you to add, edit, or remove a slave connection, as described below. The **Load Modbus Configuration** button allows you to load an XML file to configure the DataHub program. For an example of the XML code, you can refer to the plugin_Modbus.cfg file located with the configuration files.

Clicking **Add Slave** or **Edit Slave** will open the Connect to Modbus Slave dialog with the following options:

Connection



Name

A unique name for this connection. The system auto-generates the name `MB`*nnn* where *nnn* is an incrementing number starting at `000`.

TCP or **RTU**

The **TCP** configuration options are given here. See below for **RTU** configuration.

Host / IP Address

The name or IP address of the Modbus slave.

Port

The port number used to connect to the Modbus slave. The default port is `502`.

Retry Rate (ms)

A value in milliseconds of how often the DataHub instance should attempt to retry the connection to the Modbus slave, in case of failure to connect.

Share existing socket

When more than one connection is made to the same IP address and port number there is an opportunity for the DataHub Modbus driver to share the same socket for all such slave connections. If you select this option, the Modbus driver will find any other slave connections to the same IP address and port, and combine them into a single socket connection. If you do not select this option then the connection to the slave will occur on a distinct socket from other slaves on the same IP address and port. This selection is on a per-slave basis. There can be at most one shared socket to any IP address and port, and any number of non-shared sockets.

Serialize messages on a socket

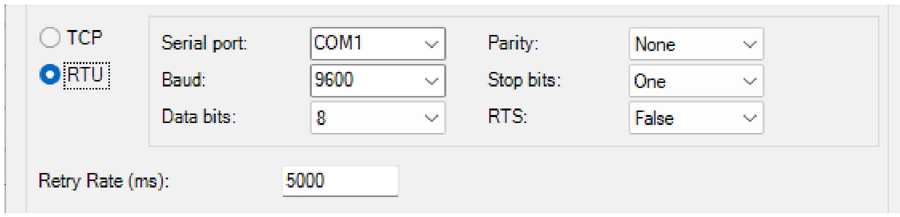
If a socket is being shared, setting this option tells the DataHub Modbus driver to serialize the communication with the devices. That is, not send a message until the previous message has produced a response. This is necessary for some devices that expect the Modbus master to transmit a single message and then wait for either a response or a timeout. For this type of device, if the master transmits more than one message at a time, only the first message is processed and the others are lost.

If none of the connected devices require serialized messages, you should not set this option. It is more efficient to transmit requests to all of the slave devices at once, and then to wait asynchronously for the responses to come back. That way, if a particular slave is off-line or is very slow, it will not affect the timing of the communication with the other slave devices, since the results of the query can arrive in any order and independently of one another. You can think of this kind of communication as parallel multiplexing of the shared socket, instead of serialized messages.

Serializing messages will, in general, produce longer latencies when communicating with more than one slave device, and will introduce significant delays for all slaves when any slave is slow to respond. Effectively, this will couple the slave device polling timing. Thus, you should not set this option unless your target slave device requires it.

If you have configured more than one slave connection to share a socket, then setting this option on any of those slave connections will cause all slave connections sharing the same socket to also be serialized.

RTU



Serial port

The COM port used to connect to the Modbus slave.

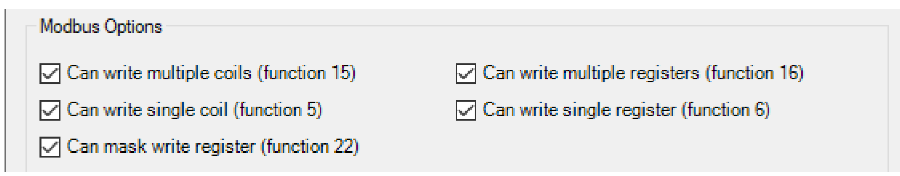
Baud, **Data bits**, **Parity**, **Stop bits**, and **RTS**

Match all these options with the configuration of the Modbus Slave.

Retry Rate (ms)

A value in milliseconds of how often the DataHub instance should attempt to retry the connection to the Modbus slave, in case of failure to connect.

Modbus Options



The DataHub program supports nine of the most commonly used Modbus read and write functions, as illustrated in the following two tables:

Table 1. Supported Modbus Read Functions

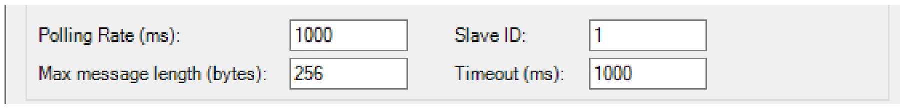
Code	Function Type	Function Name
1	Internal Bits or Physical Coils	Read Coils
2	Physical Discrete Inputs	Read Discrete Inputs
3	Int/Physical Output Registers	Read Holding Registers
4	Physical Input Registers	Read Input Registers

Table 2. Supported Modbus Write Functions - Optional

Code	Function Type	Function Name
5	Internal Bits or Physical Coils	Write Single Coil
6	Int/Physical Output Registers	Write Single Register
15	Internal Bits or Physical Coils	Write Multiple Coils
16	Int/Physical Output Registers	Write Multiple Registers

Code	Function Type	Function Name
22	Int/Physical Output Registers	Mask Write Register

The Modbus driver can write all of the value types that it can read. You may select which Modbus functions will be available for writing during configuration of the slave connection. If no function is enabled that would allow the driver to write a particular value then that value will not be written to the Modbus slave. The slave device must support Masked Write Register (function 22) in order to write to a bit field within a register.



Polling Rate (ms)

A value in milliseconds of how often the DataHub instance should poll the connection to the Modbus slave for data updates.

Max message length (bytes)

The maximum message length that the slave device can support. The Modbus specifications set this length to 256, but some devices may vary from that. Check your device documentation, and set this value accordingly.

Slave ID

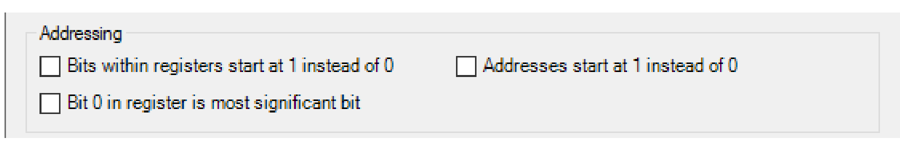
A value in the range of `0 - 256`. This setting is useful for TCP Modbus when the connection goes via a serial gateway to multiple slave devices, and the target slave device needs to be identified. Setting this value to `0` means a non-specific broadcast to all devices.

Timeout (ms)

A value in milliseconds for the response timeout.

Addressing

These options are provided to facilitate configuration, allowing the selected addresses to match the documentation of the slave device.



Bits within registers start at 1 instead of 0

If you are accessing bit fields within a register, this option lets you choose which bit to start with.

Bit 0 in register is most significant bit

If you are accessing bit fields within a register, this option tells the driver whether to treat the lowest order or highest order bit as the first bit.

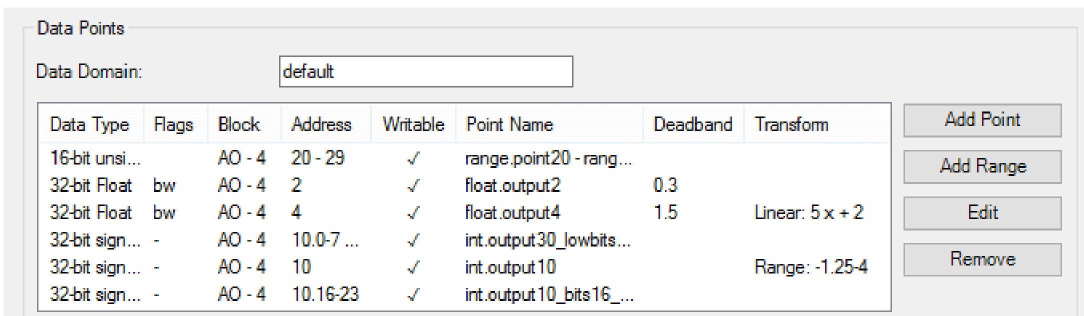
When packing digital values into an integer (see below), the order of the digital bits will be determined by this setting. If checked the highest address in the field will be packed into integer bit `0`. If not, the digital bit in the lowest address in the field will be packed into integer bit `0`.

Addresses start at 1 instead of 0

A convenience option allowing you to start your address numbering at `1` instead of `0`.

Data Points

Here you configure the points in the DataHub instance that correspond to register addresses in the Modbus slave. Detailed information about the configured points for this slave gets displayed in the list.



Choose **Add Point** to add a single point, or **Add Range** to add a range of points.

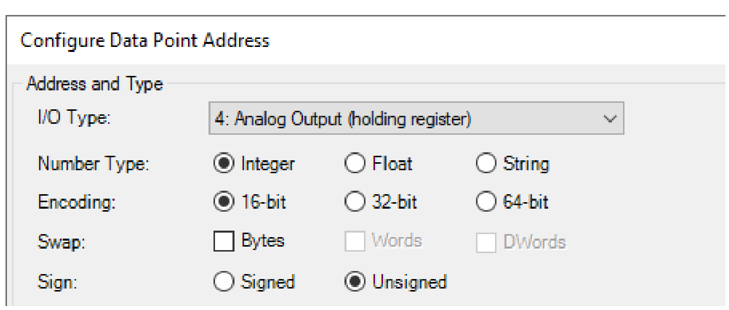
If you select an existing, configured point from this list, when you click the **Add Point** button the system will make a copy of that point, incrementing the address and highlighting the DataHub point name.

Data Domain

The data domain in the DataHub instance for all of the data points for this slave connection.

Address and Type

The **Add Point**, **Add Range** and **Edit** buttons in the Connect to a Modbus Slave window (above) all open the Configure Data Point Address dialog:



I/O Type

A pick list of the four supported I/O types:

0: Digital Output (coil)
1: Digital Input (discreet)
3: Analog Input (input register)
4: Analog Output (holding register)

When one of these is chosen, the following selections are given default values.

Number Type

Available for analog inputs and outputs only, the options are **Integer**, **Float**, and **String**.

Encoding

Encoding for integers can be 16, 32, or 64 bit; for floats 32 or 64 bit.

Strings are stored as groups of contiguous registers. The bytes of each register in the string are ordered according to the byte order selection (see Swap, below) and then converted to a character string using one of the following encoding methods:

- **ASCII** Each byte is interpreted as an 8-bit ASCII character. Two characters are stored in each register. If the configured number of registers is insufficient to store the entire string then the string will be truncated.
- **UTF-8** Each byte in a register is interpreted as a single byte in the UTF-8 stream. If the string contains only 7-bit ASCII characters then UTF-8 is equivalent to ASCII. A single UTF-8 character can require up to 5 bytes (2.5 registers) to store. The number of characters that can be stored in a sequence of registers is therefore variable. If the configured number of registers is insufficient to hold the entire UTF-8 sequence then all bytes beyond the register length will be truncated to the nearest character. This option is displayed in **Flags** in the Connect to Modbus Slave window as "u".
- **UTF-16** Each character is normally stored in a single register. For some characters, a second register may be necessary to store the entire character. If the configured number of registers is insufficient to hold the entire UTF-16 sequence then the sequence will be truncated to the nearest character.

Swap

These options allow you to specify the byte order of the data stored in the Modbus slave device. The natural byte order in Modbus is big-endian, meaning that the most significant byte is stored first. The DataHub Modbus driver assumes that the data in the slave device is big-endian unless you specify otherwise. If you know that your slave device stores its data in a different order, you can use the swap options to specify which bytes, words or dwords are swapped in the slave device relative to the standard big-endian representation.

All possible byte order combinations can be produced by selecting zero or more of the following:

- **Bytes**: each pair of bytes gets swapped. For example, AB would become BA; ABCD would become BADC.
- **Words**: each pair of words gets swapped. This is only applicable when the length

of the value is at least 4 bytes. For example, `ABCD` would become `CDAB`; `ABCDEFGH` would become `CDABGHEF`.

- **DWords**: two dwords get swapped. This is only applicable when the length of the value is 8 bytes. For example, `ABCDEFGH` would become `EFGHABCD`.

These options are displayed in **Flags** in the Connect to Modbus Slave window as "`b`" for Bytes, "`w`" for Words, and "`d`" for DWords.

Other examples:

- Swapping both bytes and words: `ABCD` - `DCBA`
- Swapping both bytes and dwords: `ABCDEFGH` - `FEHGBADC`
- Swapping both words and dwords: `ABCDEFGH` - `GHEFCDAB`
- Swapping bytes, words, and dwords: `ABCDEFGH` - `HGFEDCBA`

Sign

The sign indicates whether a particular integer should be interpreted as signed or unsigned. There is no distinction in the Modbus slave register, so the sign is applied by the Modbus master driver. The **Signed** option is displayed in **Flags** in the Connect to Modbus Slave window as "`-`".

Deadband

An optional means to filter out insignificant value changes.

When the DataHub Modbus driver writes a value from the Modbus slave device to the DataHub instance, it notes that value as significant. Each subsequent incoming value gets compared to that last significant value, and is only written to the DataHub instance when the difference is greater than the amount specified by the deadband. Any new value that gets written then becomes the latest significant value to be used for future deadband comparisons.

An entry of `0` means that no deadband applies, and all value changes will be considered significant.

No deadband is applied when writing values from the DataHub instance to the Modbus slave device. All value changes will be written to the device.

Address

The Modbus register address(es) to link to DataHub point(s).

The information in the table below also pops up when you hover your mouse over this entry field.

Addresses can be specified as individual values, ranges of values, bit fields within a register, and ranges of bits within a register. Here is a guide of the address formats.

	Address Format	Description	Example	Refers to
Digital Points	*address*	A single value.	`12`	The digital value in address 12.
	address-address	A "packed" integer composed of up to 64 consecutive digital bits.	`12-17`	A 6-bit integer created by packing digital values `12-17` into integer bits `0-5`.
	address[*N*]	An array of *N* consecutive values starting from *address*.	`13[5]`	An array of 5 digital values starting at address 13.
Analog Points	*address*	A single value.	`4`	The 16, 32 or 64 bit integer starting at register 4.
	address.bit	A single bit within an integer.	`4.3`	The third bit of the integer starting at register 4.
	address.bit-bit	A range of bits within an integer.	`4.3-27`	Bits 3 through 27 (inclusive) within the integer starting at register 4.
	address[*N*]	An array of *N* consecutive values starting from *address*.	`10[5]`	An array of 5 analog values (16, 32 or 64 bit) starting at address 10.
Strings	*address*[*N*]	A string consuming at most *N* 16-bit registers.	`10[20]`	A string of up to 20 registers, starting at address `10`. This could hold 40 ASCII characters, between 8 and 40 UTF-8 characters, or between 10

	Address Format	Description	Example	Refers to
				and 20 UTF-16 characters.

For Digital and Analog Points

- ***address*** is the Modbus register address corresponding to the data point, starting from `0` (or optionally from `1`), within the I/O block for that register type. I/O blocks can be one of Analog Input, Analog Output, Digital Input and Digital Output. All values of any bit length other than digital values are considered to be analog. All bit fields within a register are also considered to be analog.
- ***bit*** is the bit number, starting from zero (or optionally from `1`) within an integer data type. The bit number cannot be larger than the number of bits in the selected data type. For example, if the data type is a 32-bit integer then *`bit`* can be from `0` to `31` (or `1` to `32`).
- ***endbit*** is the last bit in a multi-bit bit field. This can be any number from *`bit`* `+ 1` to the highest bit number in the selected data type. If *`endbit`* is equal to *`bit`*, it will be treated the same as if *`endbit`* was not specified. The resulting bit field will be converted to signed or unsigned integer of the same size as the selected integer type.

Packing Digital Values

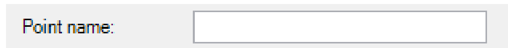
- When packing digital values into an integer, the order of the digital bits will be determined by the setting **Bit 0 in register is most significant bit** (see above). If this is not checked then the digital bit in the lowest address in the field will be packed into integer bit `0`. If this option is checked then the highest address in the field will be packed into integer bit `0`.
- Packed digital values can be up to 64 bits in length. You can use the **Convert to** type option in the Transform section to determine the data point type of the result. You may specify any signed or unsigned integer type, though you should specify a type that is large enough to hold the selected number of bits.

For Strings

- ***N*** is the number of 16-bit registers to use for storing the string. This is the maximum number of registers in the string, not the maximum number of characters. The maximum number of characters will depend on the character encoding selected, and the string to be stored. For example, UTF-8 strings can require up to 5 bytes per character.
- The bytes in a string are packed into the registers such that 8-bit types (ASCII and UTF-8) store 2 characters per register and UTF-16 stores one character per register. The Swap option (see above) determines which of the two bytes is treated as the first character.

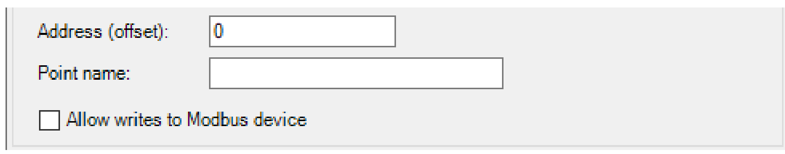
Point name

Any valid DataHub point name, without a domain name. (The domain is specified in the **Connect to Modbus Slave** dialog). A dot (`.`) in the point name will create an assembly or sub-assembly in the domain hierarchy.



Ranges

A range is a labour-saving method for specifying many similar data points at one time. By choosing **Add Range** instead of **Add Point** for adding points, you can specify a point once, and then enter a value in the **Item Count** to repeat that specification for that number of points. The range will automatically create new points with consecutive addresses based on the selected data type.



Point names are numbered consecutively, starting from the **Start Number** that you specify, incrementing by one for each point name in the range. The point name in a range must contain a .NET format specifier that tells the driver how to construct the point name and where to insert this number. The specifier is one of these forms:

`{0}` The current sequence number, with no additional leading zeros.

`{0:D`*n*`}` The current sequence number, prefixed with additional zero characters to pad the number to *n* characters.

The format specifier does not need to be at the end of the point name. For example, the **Point name** entry:

```
mb.tank{0:D2}_level
```

with an **Item Count** of 3 and a **Start Number** of 5 would produce point names like this:

```
mb.tank05_level
mb.tank06_level
mb.tank07_level
```

If you specify a range of bit masks within registers, then these rules apply:

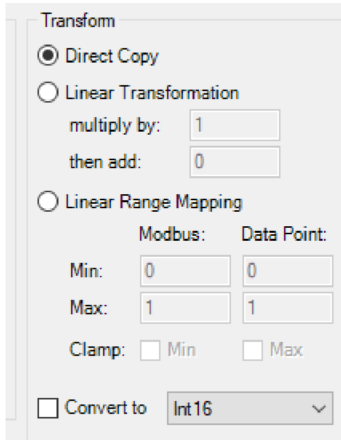
- If the bit field contains exactly one bit then the range will be all consecutive bits within the same register (or 32- or 64-bit integer as specified in the data type).
- If the bit field contains more than one bit then the range will consist of the same bits taken from consecutive registers (or 32- or 64-bit integers as specified in the data type).

Allow writes to Modbus device

Enables or disables writes to the Modbus slave for this point or range.

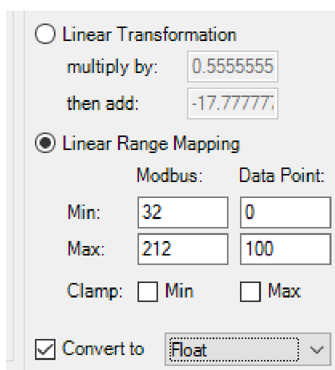
Transform

Specify the type of transformation by clicking **Direct copy**, **Linear Transformation**, or **Linear Range Mapping**.



- **Direct copy** does not apply a transform. It copies the value from the Modbus slave directly to the DataHub point.
- **Linear Transformation** lets you multiply by one value and add another value, such as in the equation `y = mx + b` where the DataHub point is `y`, the Modbus value is `x`, the **multiply by** value is `m`, and the **then add** value is `b`. For example to transform a Celsius value in the Modbus slave to a Fahrenheit value in the DataHub instance, you would multiply by `1.8` and add `32`, or

  ```
  Fahrenheit = (1.8 X Celsius) + 32
  ```
- **Linear Range Mapping** lets you enter a range for the **Modbus** slave and DataHub **Data Point**s, and the DataHub instance automatically calculates the corresponding linear transformation.



For example, the **multiply by** and **then add** entries to convert a Fahrenheit value in the Modbus slave to a Celsius value in the DataHub instance would not be simple round numbers. But you can let the system do the math by using the entries of `32` and `212` for the **Min** and **Max** of the **Modbus** value, and `0` and `100` for the **Min** and **Max** of the **Data Point**. As soon as you make these entries, the correct values get entered automatically in the **Linear Transformation**.

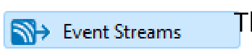
Entries for **Clamp** are applied to all values read into or written out of the DataHub instance for this point. So, the value read from the Modbus slave will never exceed the clamped range. Or, when a value is written to the DataHub point from another source, the clamp is applied before writing the transformed value to the Modbus slave. It is possible for the value in the Modbus slave to be different from the value in the DataHub instance if a value beyond the clamped range is written to the Modbus slave by an external program. In that case, the DataHub point will report the clamp value, even though the value in the Modbus slave is out of range.

- **Convert to** lets you convert an input value from the Modbus slave into a signed or unsigned integer, float, or double for the DataHub point value.

When applying a transformation to a value, the result is frequently a non-integer. Thus, it is a good idea to convert the value to a floating point (float or double) number when using a transform.

You can use this option to determine the data point type of a packed digital value (see above). You may specify any signed or unsigned integer type, though you should specify a type that is large enough to hold the selected number of bits.

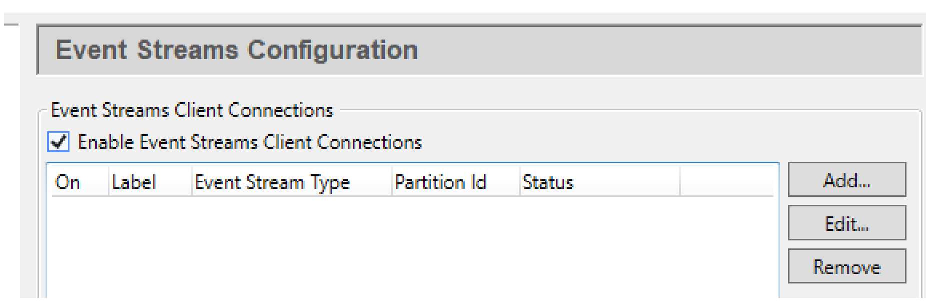
Event Streams



The Event Streams option lets you connect a DataHub instance to event streams from various providers, currently Apache Kafka and Azure Event Hubs.

To write data to Kafka or Event Hubs, you can use the External Historian feature. Please see Apache Kafka or Azure Event Hubs in the External Historian section for more details.

Event stream services support real-time ingestion, distribution, and processing of events or messages from various sources to multiple consumers, facilitating data integration, event-driven architecture, and real-time analytics.



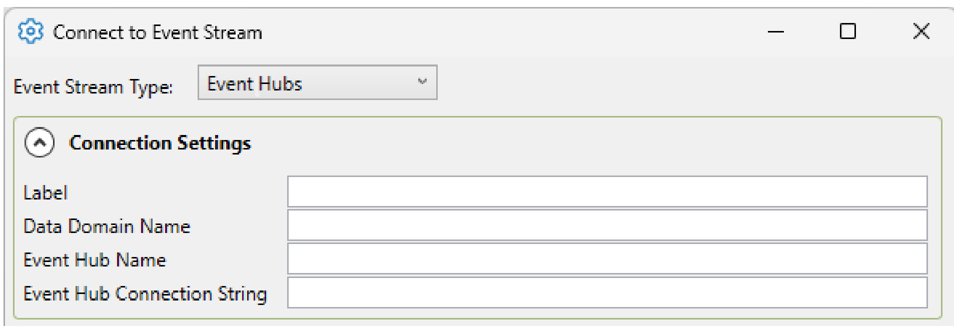
Check the **Enable Event Streams client connections** box for event streams functionality. Since a DataHub instance can connect to more than one event stream, you need to specify information about each one. Once a stream is listed, you can activate or deactivate the connection using its **On** check box.

To add an event stream, press the **Add** button to open the **Connect to Event Stream** window described below. To edit a stream, double-click it or select it and press the **Edit** button to open that window. To remove a stream, highlight it and click the **Remove** button.

Azure Event Hubs

Azure Event Hubs is a cloud-based event streaming service provided by Microsoft Azure, designed for high-throughput and real-time data streaming. As part of the Azure messaging services, it can handle large volumes of events needed for IoT data ingestion.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Data Domain Name

A unique text string specifying a DataHub data domain. All events that will be read from the Event Hub will be stored within this domain.

Event Hub Name

The name of the Event Hub that will be read from.

Event Hub Connection String

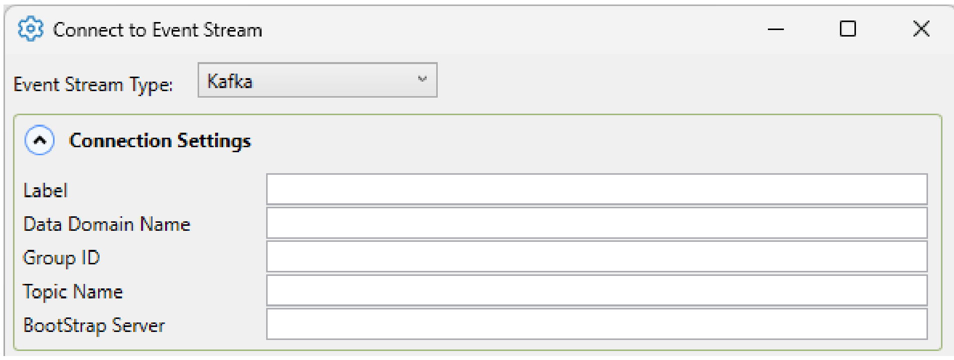
The connection string used to connect to and authenticate the Event Hub connection. This can be found in the Event Hub's Namespace page, under Shared Access Policies.

Please see Common Settings for the rest of the settings.

Apache Kafka

Apache Kafka provides distributed, fault-tolerant, and scalable event streaming capabilities, often used for real-time data integration, event-driven architectures, and building data pipelines.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Data Domain Name

A unique text string specifying a DataHub data domain. All events that will be read from the Kafka topic will be stored within this domain.

Group ID

Assigns the consumer to a specific group. If multiple consumers share the same Group ID reading from the same topic, they will share the load of reading from it.

Topic Name

The name of the topic created when setting up the Apache Kafka cluster. This topic contains all the points that are being read. If using Azure Event Hubs for Kafka, this name will be the Event Hub name.

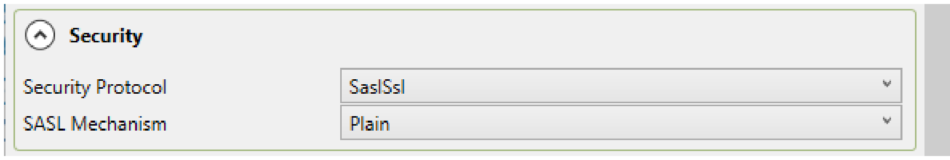
Bootstrap Server

A comma-separated list of host and port pairs that are the addresses of the Kafka brokers in a "bootstrap" Kafka cluster. If using a local Kafka cluster, use: `localhost:9092`.

If using Azure Event Hubs for Kafka, the topic name will be: `*Namespace*.servicebus.windows.net:9093` where *`Namespace`* is replaced with the correct Azure Event Hub Namespace.

Security

The authentication mechanism used to connect to Kafka.



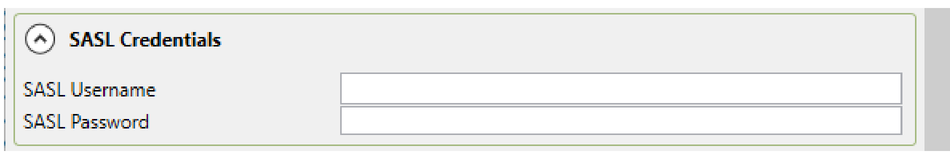
Security Protocol

Select one of the following that the Kafka Cluster is set to accept: **Plaintext**, **Ssl**, **SslPlaintext**, **SaslSsl**. If using Azure Event Hubs for Kafka [link], use **SaslSsl**.

SASL Mechanism

If SaslSsl is selected as the Security Protocol, select one of the following Sasl mechanisms specified by the Kafka Cluster to authenticate your Kafka connection: **Gssapi**, **Plain**, **ScramSha256**, **ScramSha512**, **OAuthBearer**.

SASL Credentials



SASL Username

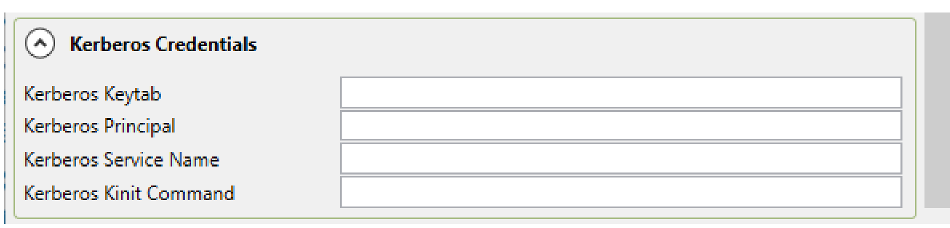
The SASL username. For a connection to an Azure Event Hub, the username will be: `$ConnectionString`.

SASL Password

The corresponding password. For a connection to an Azure Event Hub, the password will be the primary connection string of the Event Hub namespace.

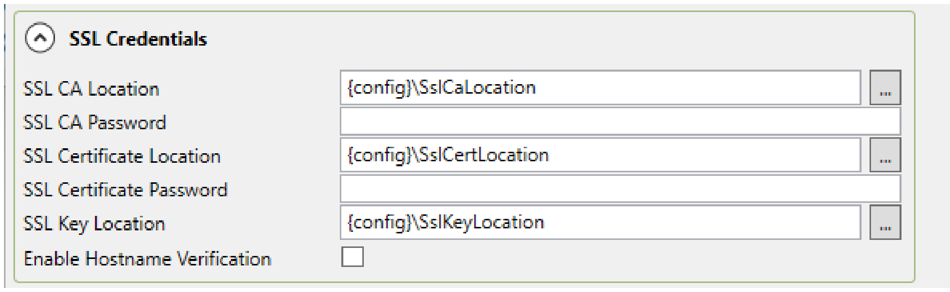
Kerberos Credentials

Credentials for the Kafka Cluster if it uses Kerberos Authentication.



SSL Credentials

Credentials for the Kafka Cluster if it uses SSL Authentication.



SSL CA Location

The location of the SSL CA certificate. Use the button with the three dots to open the file selector.

SSL CA Password

The password for the SSL CA certificate

SSL Certificate Location

The location of the SSL certificate. Use the button with the three dots to open the file selector.

SSL Certificate Password

The password for the SSL certificate

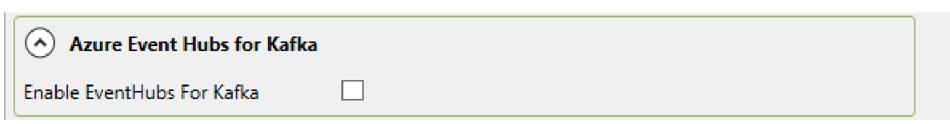
SSL Key Location

The location of the SSL key. Use the button with the three dots to open the file selector.

Enable Hostname Verification

Host name verification checks that the broker host name matches the name in the broker certificate.

Azure Event Hubs for Kafka



Enable Event Hubs for Kafka

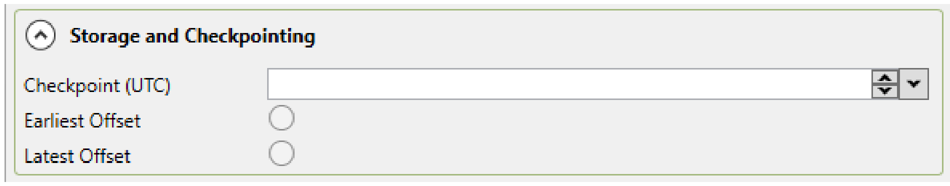
Checking this box enables writes to an Event Hub, using Apache Kafka.

Please see Common Settings for the rest of the settings.

Common Settings

These settings apply to all event streams.

Storage and Checkpointing



Checkpoint (UTC)

The exact timestamp to begin reading from. Events will begin processing at the first Event on or after this timestamp. The timestamp can be selected with the DateTime picker, or typed in manually.

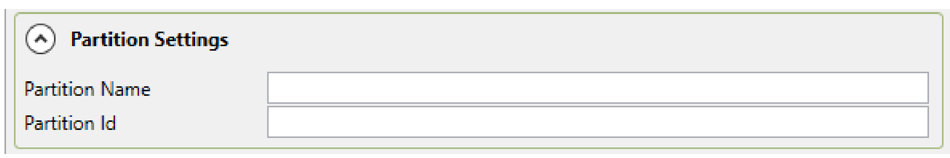
Earliest Offset

Automatically starts the Event Stream reader from the earliest known offset. This is usually the beginning of the Event Hub stream.

Latest Offset

Automatically starts the Event Stream reader from the latest known offset. This is usually the end of the Event Stream.

Partition Settings



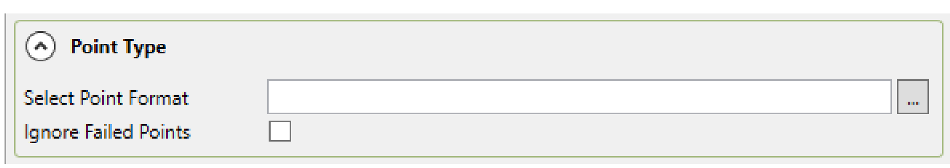
Partition Name

Allows you to name the partition inside the hierarchy for the Data Domain, when specifying a partition. If left blank, the partition name will be what you enter for **Partition ID**.

Partition ID

Enter a specific partition ID if you would like to read from a specific partition only. If you would like to read from all partitions, leave this blank. If you would like to read from multiple specific partitions, create an Event Streams connection for each partition.

Point Type



Select Point Format

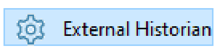
Click on the 3 dots on the right hand side in order to open the Json Advanced Format Dialog. This Dialog is the counterpart of the Document Definition Dialog from the External Historian. Use this Parser to specify what type of JSON message is coming in, how to parse this message, and convert it into DataHub Points. For more information, see ???MQTT Advanced Parser Tutorial

Ignore Failed Points

Checking this box allows the Event Stream reader to continue processing past failed messages, after logging the failed read in the Event Log. This is useful if there are points that you do not want to process at the beginning of the Event Hub Stream, or that do not fit into the Advanced Parser format. Ignoring the failed points will continue processing, skipping all these failed events, until reaching an event that the Advanced Parser is able to parse—the desired Events.

Leaving this box unchecked will stop the Event Hub reader, generate an error message in the Event Log, and retry this same event the next time the Event Hub reader is started.

External Historian



The External Historian option allows you to configure a connection to an external historian such as AVEVA Historian or Insight, InfluxDB, or Amazon Kinesis.

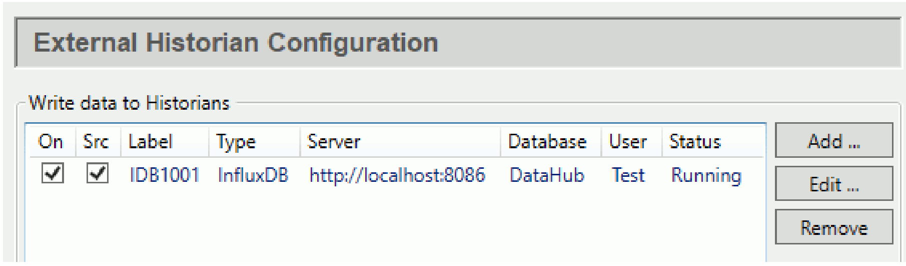
Please see the Using the External Historian chapter for how-to information.

Before configuring the External Historian options, you will need to first ensure that you have configured an external historian. InfluxDB can be installed with the DataHub program, and its configuration is documented here. Amazon Kinesis is a service available through Amazon Web Services (AWS). Its configuration is documented on the AWS website. AVEVA Historian and AVEVA Insight are available from AVEVA.

Need to use InfluxDB and Chronograf? Please see Connecting to InfluxDB to get started.

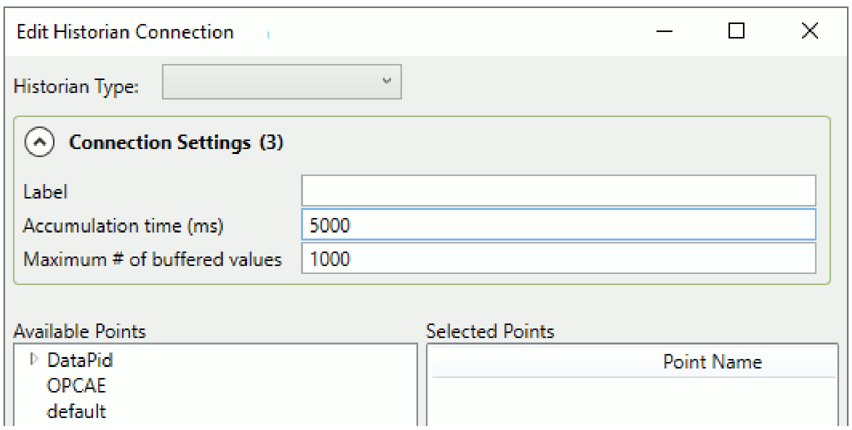
General Configuration

Write data to Historians



Use the **On** checkbox to activate or deactivate a configured historian. The **Src** checkbox allows you to use the selected historian as a data source for DataHub clients, as explained below. The other columns display information about the connection.

Clicking the **Add** or **Edit** button opens the Edit Historian Connection window:



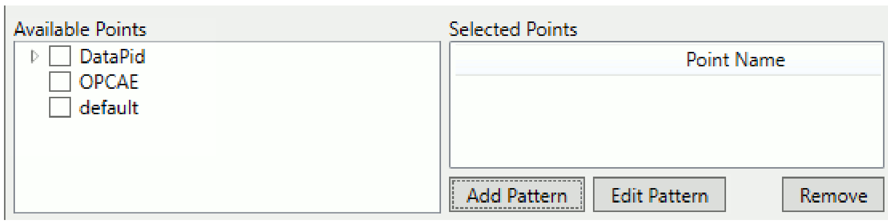
Use the **Historian Type** drop-down list to choose the historian that you want to connect to. The options currently available include:

Amazon Kinesis
Apache Kafka
AVEVA Insight
AVEVA Historian
AVEVA PI
Azure Event Hubs
InfluxDB V1
InfluxDB V2
ODBC
OPC Classic HDA
REST Client
Tunnel (Push)
Tunnel (Pull)

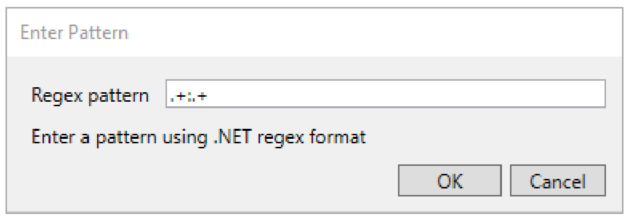
You can now go to the sub-section corresponding to the historian you want to configure, and them return here when finished.

Picking Points

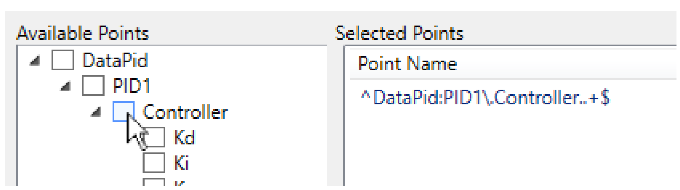
For any external historian that you configure, you can pick the points from the list:



You can pick individual points one by one, or click the **Add Pattern** button to open the Enter Pattern window:



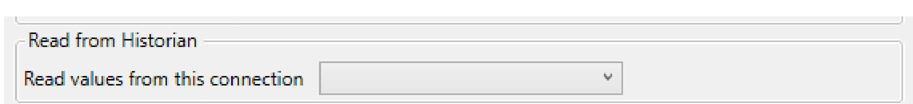
Here you can enter a regular expression, using the .NET regex format (documented here), to select a group of points with common characteristics. For example, the expression: `^DataPid:.*$` would select all of the points in the DataPid domain.



To add a regular expression based on a branch or point, hold down the **Ctrl** key while clicking on the checkbox.

Read from Historian

This option lets you choose which historian a DataHub client will get its historical data from.



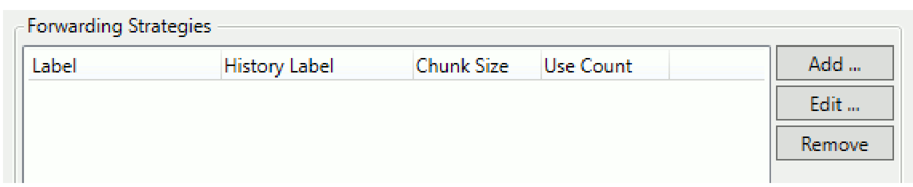
The **Read values from this connection** drop-down list lets you select which historian (DataHub Historian or external) will be used by any DataHub client that consumes historical data, such as WebView, QuickTrend or OPC UA HA (Historical Access). The DataHub instance allows only one historian to be used at any given time. To use an external historian for this purpose, you must check its **Src** checkbox in the **Write data to Historians** list.

Some programs that interact with the DataHub data set are able to consume historical data. WebView, for example, uses historical data from the DataHub program to populate its Trend control. Other programs include QuickTrend, the OPC-UA Historical Data server, and any Gamma scripts that are written to support the External Historian. The default source for this historical data is the DataHub Historian. But you can use this option to configure an external historian to supply that data instead.

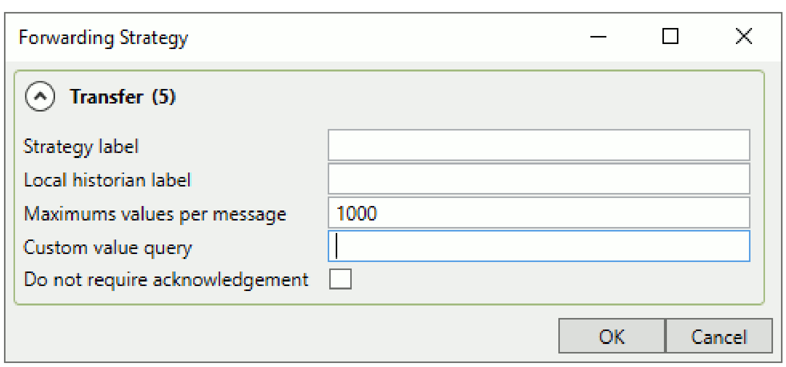
OPC UA HA is an interface to an external data store. It requires a readable External Historian in addition to the OPC UA feature.

Forwarding Strategies

In addition to writing data to a local historian, the External Historian feature can also forward that data to a remote instance of the same historian product. Here you define a forwarding strategy, and when you configure forwarding for an external historian, you can activate it.



Clicking the **Add** or **Edit** button opens the Forwarding Strategy window:



Strategy label

A text string to identify this strategy that consists of only letters, numbers and the underscore (_) character, with no spaces or other characters.

Local historian label

A label assigned to the historian connection, as displayed in the **Write data to**

Historians list, above.

Maximum values per message

Data is forwarded to the remote historian in chunks, with multiple values in a single message. Here you can specify up to how many values get transmitted in each message.

Custom value query

Instead of forwarding all the logged data to the remote historian, you can construct a query on the historian to forward a subset of the data.

Do not require acknowledgement

Check this box if you do not want the remote historian to send acknowledgements for each data message received.

This completes the general options common to all historians. The following sections cover the unique options for each supported historian.

Connection Configuration

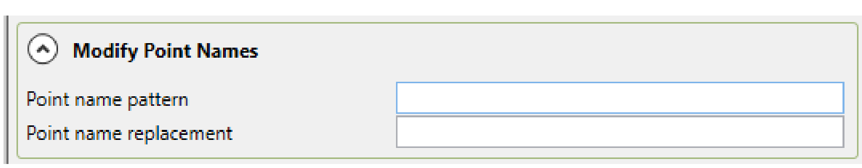
Each of the supported historian connections includes Modify Point Names, Data Sampling, and Forwarding options.

Modify Point Names

This option allows you to specify how point names are represented in the historian. When a DataHub instance writes to the historian or queries data from the historian, it first transforms the point name using a regular expression match and replace. The resulting name is used as the identifier for the point in the historian. If either of these options is blank, or the name pattern does not match the point name, the identifier in the historian will be the fully qualified point name (with the `domain:` prefix) from the DataHub engine.

The pattern and the replacement are a .NET regular expression used to match the point name and a replacement specifier to produce the historian identifier from the pattern match. These options follow .NET Regex.Replace format.

Point names are modified when writing data to the historian and when querying data for specific points from the historian. Historian identifiers are not modified when reading data from the historian for store-and-forward operations. That is, store-and-forward preserves the identifier names as found in the historian.



Point name pattern

A regular expression that matches all or part of the fully qualified point name. This expression may include capture expressions that can be referenced in the replacement string.

Point name replacement

A string that will replace all occurrences of the point name pattern within the fully qualified point name. Capture expressions in the pattern are referenced with a `$` sign followed by a number. The entire matching substring is `$0`, and each capture expression within the match is numbered sequentially from left to right as `$1`, `$2`, etc.

Examples

Remove the first point path segment after the domain name:

- Pattern: `([^:]+):[^.]*\.(.*)`
- Replacement: `$1:$2`
- Input: `DataPid:PID1.Mv`
- Output: `DataPid:Mv`

Remove the domain name:

- Pattern: `[^:]+:(.*)`
- Replacement: `$1`
- Input: `DataPid:PID1.Mv`
- Output: `PID1.Mv`

Remove the domain name (alternate):

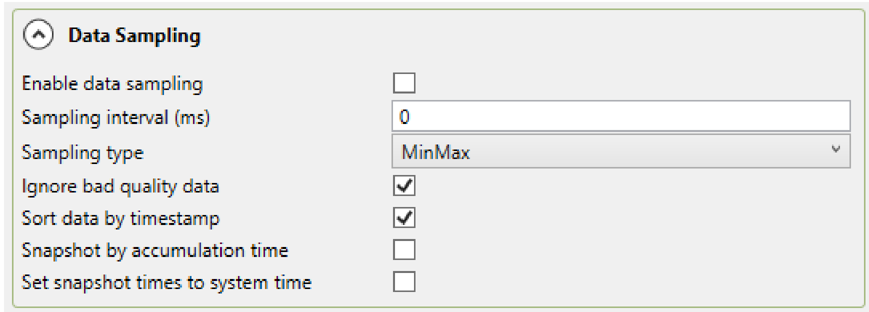
- Pattern: `[^:]+:`
- Replacement: none
- Input: `DataPid:PID1.Mv`
- Output: `PID1.Mv`

Extract the first path segment and place it at the end:

- Pattern: `([^:]+:)([^.]*)\.(.*)`
- Replacement: `$1$3.$2`
- Input: `DataPid:PID1.Mv`
- Output: `DataPid:Mv.PID1`

Data Sampling

You can configure the External Historian feature to send samples of the data for specified time intervals to the supported historian, rather than the full data set.



Enable data sampling

Activates the data sampling feature.

Sampling interval (ms)

The length of time for which each sample will be taken, in milliseconds. For example, a sample interval of `1000` will produce a sample every second. Choosing this option will result in zero or more values being sent to the server based on the presence of data changes and the **Sampling type**.

Sampling type

Choose the criteria for the sample. This setting determines which values will be transmitted for each sampling interval. If there is no data (or no Good quality data) for a point within a sampling interval then no value will be transmitted. The following criteria are available:

None - no sampling is done and all values are transmitted.
First - the first value in the sampling interval is transmitted.
Last - the last value in the sampling interval is transmitted.
Mean - the average of all (good) values in sampling interval are transmitted.
Min - the minimum value within the sampling interval is transmitted.
Max - the maximum value of the sampling interval is transmitted.
MinMax - the minimum and maximum values of the sampling interval are transmitted, in time order.

Ignore bad quality data

If the data quality for that time interval is not Good then that data change will be ignored. Other samples within the time interval that have Good quality will still be processed normally.

Sort data by timestamp

Sorts the sampled values in time order when constructing the message body using the document definition. Since sampling is done on a per-point basis, the resulting collection of values may not be in time order. For example, the maximum value of `point2` might have occurred before the maximum value of `point1`. This option sorts the resulting combined set of values.

Snapshot by accumulation time

Specifies that a complete snapshot of all configured data points will be periodically stored, before being sent as a batch to the historian. Please refer to the

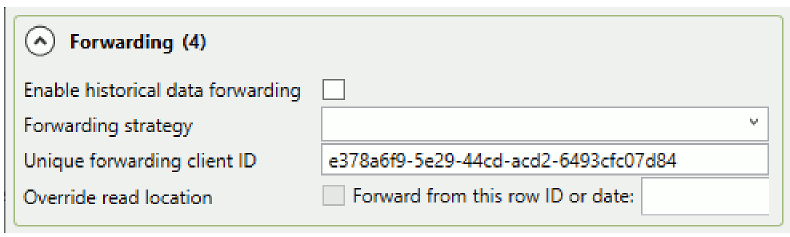
Accumulation time in your **Connection Settings** configuration. The snapshot period will be this accumulation time, not the sampling interval. Each data point will be stored with its source timestamp and current value.

Set snapshot times to system time

When saving data using a snapshot, replace the source timestamp of every point value with the current system time. This applies to all points, whether or not they have changed within this accumulation interval.

Forwarding

In addition to writing data to a supported historian locally, the External Historian feature can also forward that data to a remote instance of the same supported historian product.



Enable historical data forwarding

Activates the data forwarding feature.

Forwarding strategy

Select a forwarding strategy that has been previously defined.

Unique forwarding client ID

A text string unique to this forwarding configuration that allows the historian to identify it. You can use the system-generated string, or enter your own.

Override read location

Allows you to forward a portion of the data set by resetting the start point to a more recent time. The date/time data format is `YYYY-MM-DD HH:MM:SS`, and can be edited as needed. The calendar button allows you to quickly enter the date.

Once you have completed this configuration, you can return to Picking Points in General Configuration to continue.

Supported Historians

The External Historian feature supports these connections.

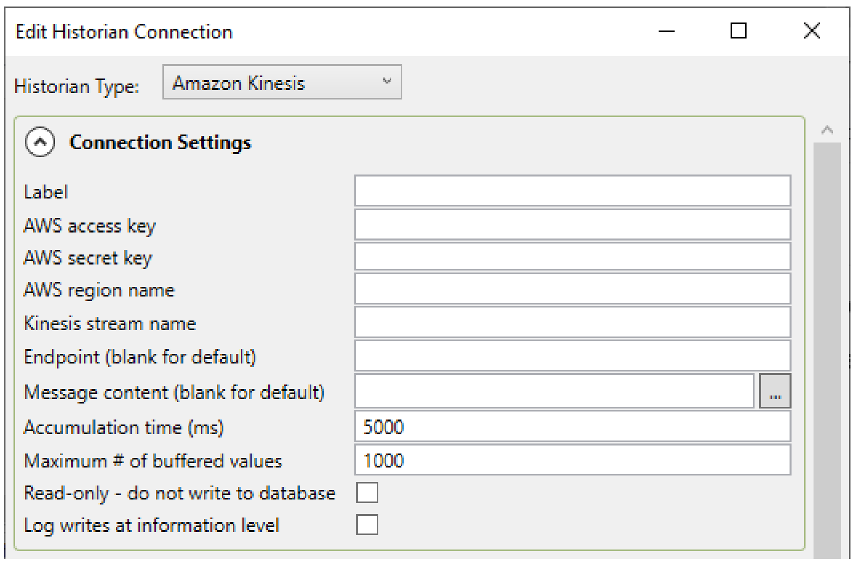
Amazon Kinesis
Apache Kafka
AVEVA Insight
AVEVA Historian
AVEVA PI
Azure Event Hubs
InfluxDB V1

Influx V2
ODBC
OPC Classic HDA
REST Client
Tunnel (Push)
Tunnel (Pull)

Amazon Kinesis

From the Edit Historian Connection window you can select Amazon Kinesis.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

AWS access key

The access key ID for an AWS account user that has permission to write to the Kinesis stream.

AWS secret key

The secret key that AWS has assigned to the above user.

AWS region name

The AWS region code, such as `us-east-1`, that is associated with the data stream.

Kinesis stream name

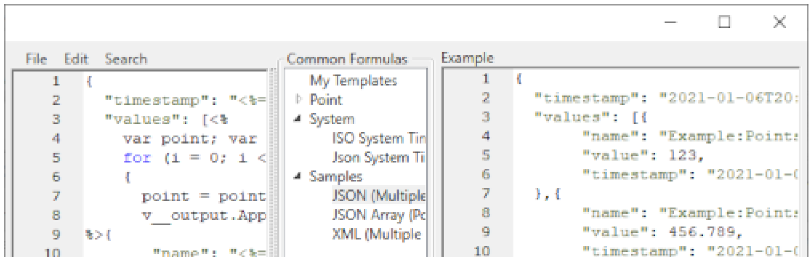
The name that you have chosen for the data stream, as configured in Kinesis.

Endpoint (blank for default)

If you have configured a different endpoint for the data stream on AWS, you can enter it here.

Message content (blank for default)

Specify a document format in ASP, if you need to. The " ..." button opens the script editor with common formulas and examples to help edit a message.



Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to Kinesis. Setting this value to zero means that no accumulation time will be enforced.

Since AWS pricing is based on the number of messages received, this option allows you to reduce your costs by sending messages in batches.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to Kinesis whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to Kinesis. Setting this value to zero means that all values will be sent as soon as possible.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Modify Point Names, Data Sampling and Forwarding

Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

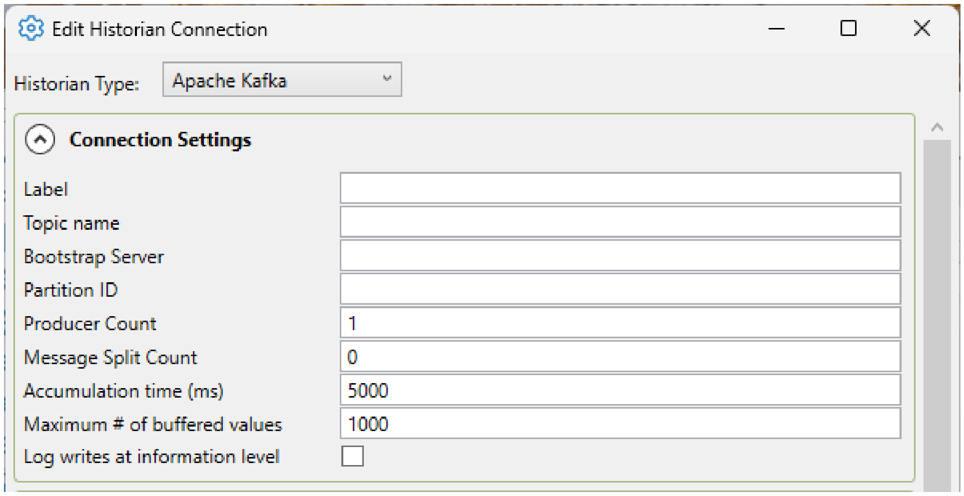
Once you have completed the Amazon Kinesis-specific configuration, you can return to Picking Points in General Options to continue.

Apache Kafka

From the Edit Historian Connection window you can select Apache Kafka.

This option is used for writing data to Kafka. To collect data from a Kafka event stream, please see Event Streams.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Topic name

A unique topic created when setting up the Apache Kafka cluster. This topic will contain all the points that will be written. If using Azure Event Hubs for Kafka (see below), this entry will be the Event Hub name.

Bootstrap Server

A comma-separated list of host and port pairs that are the addresses of the Kafka brokers in a “bootstrap” Kafka cluster. If using a local Kafka cluster, use: `localhost:9092`.

If using Azure Event Hubs for Kafka, the topic name will be: *`Namespace`*`.servicebus.windows.net:9093` where *`Namespace`* is replaced with the correct Azure Event Hub Namespace.

Partition ID

Enter a specific partition ID if you would like to write to a specific partition only. If you would like to write to all partitions, leave this field blank. If you would like to write to multiple specific partitions, create an Apache Kafka connection for each partition.

Producer Count

The number of producers to send items to Apache Kafka. The default is `1`. This ensures that the messages sent maintain the proper time sequence. Using more than one producer increases throughput, but time order of messages is lost.

Message Split Count

The amount of times to split a message batch. For example, if there are 10,000 points, a message split of 5 would split the message into 5 messages of 2000 points each. This is useful to match with the producer count to increase throughput.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to Kafka. Setting this value to zero means that no accumulation time will be enforced.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to Kinesis whenever the first of these two limits is reached.

Maximum # of buffered values

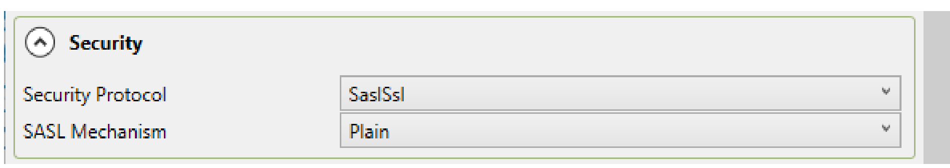
The maximum number of values that the DataHub instance will buffer in memory before transmitting them to Kafka. Setting this value to zero means that all values will be sent as soon as possible.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Security

The authentication mechanism used to connect to Kafka.



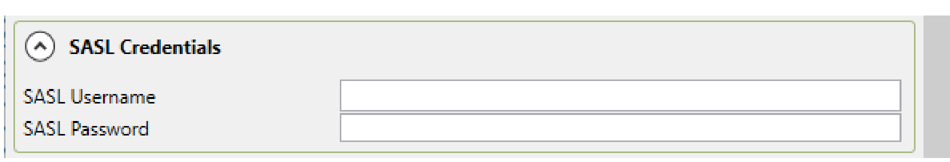
Security Protocol

Select one of the following that the Kafka Cluster is set to accept: **Plaintext**, **Ssl**, **SslPlaintext**, **SaslSsl**. If using Azure Event Hubs for Kafka [link], use **SaslSsl**.

SASL Mechanism

If SaslSsl is selected as the Security Protocol, select one of the following Sasl mechanisms specified by the Kafka Cluster to authenticate your Kafka connection: **Gssapi**, **Plain**, **ScramSha256**, **ScramSha512**, **OAuthBearer**.

SASL Credentials



SASL Username

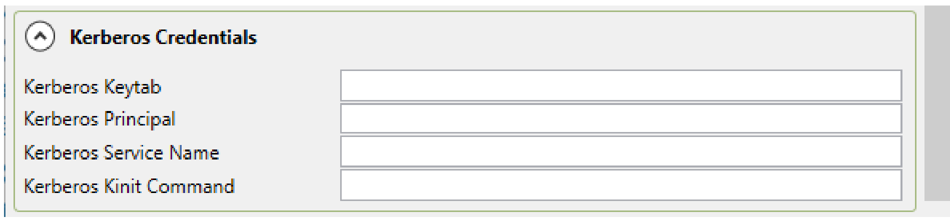
The SASL username. For a connection to an Azure Event Hub, the username will be: `$ConnectionString`.

SASL Password

The corresponding password. For a connection to an Azure Event Hub, the password will be the primary connection string of the Event Hub namespace.

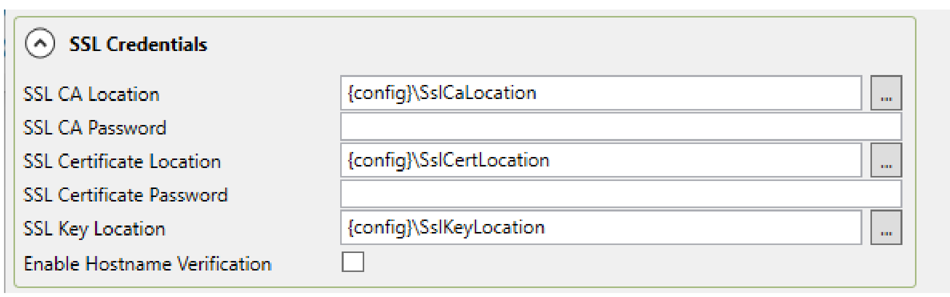
Kerberos Credentials

Credentials for the Kafka Cluster if it uses Kerberos Authentication.



SSL Credentials

Credentials for the Kafka Cluster if it uses SSL Authentication.



SSL CA Location

The location of the SSL CA certificate. Use the button with the three dots ... to open the file selector.

SSL CA Password

The password for the SSL CA certificate

SSL Certificate Location

The location of the SSL certificate. Use the button with the three dots ... to open the file selector.

SSL Certificate Password

The password for the SSL certificate

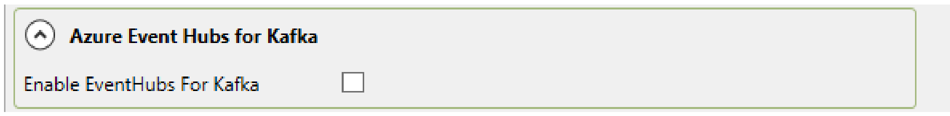
SSL Key Location

The location of the SSL key. Use the button with the three dots ... to open the file selector.

Enable Hostname Verification

Host name verification checks that the broker host name matches the name in the broker certificate.

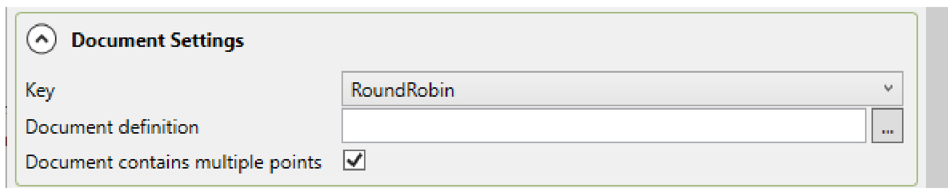
Azure Event Hubs for Kafka



Enable Event Hubs for Kafka

Checking this box enables writes to an Event Hub, using Apache Kafka.

Document Settings



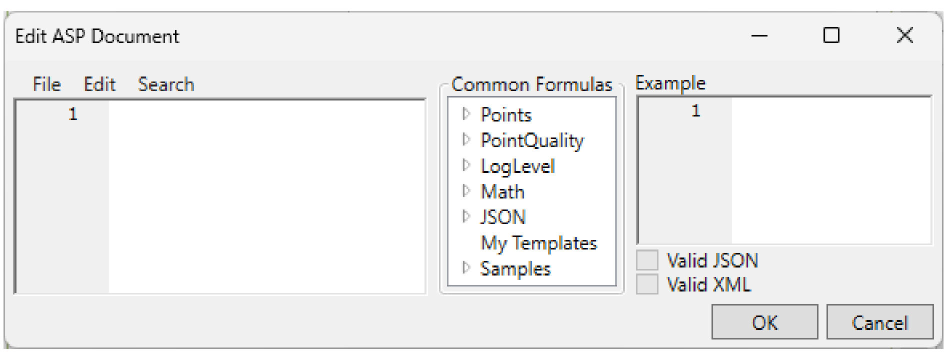
Key

Allows you to specify the key for ordering the messages.

- **RoundRobin** means no key at all, use the default.
- **Timestamp** puts all the messages from one timestamp into the same partition.
- **PointName** puts all the data from a point name in the same partition.

Document definition

Click on the 3 dots on the right hand side to open the Document Definition Dialog.



You can use this editor to construct document definitions. Double-click on any of the items in Common Formulas to put the formula into the editing pane. The Samples list contains a number of sample entries that you can use as-is or as a basis for your own definitions. The syntax and more explanation about ASP documents can be found under ASP Document Definition about 1/2 way down this page. this page.

Document contains multiple points

Specifies whether or not the document definition is processing more than one point.

If accumulation time is being used, this should be selected. If using the provided template, please select this checkbox.

Modify Point Names, Data Sampling and Forwarding

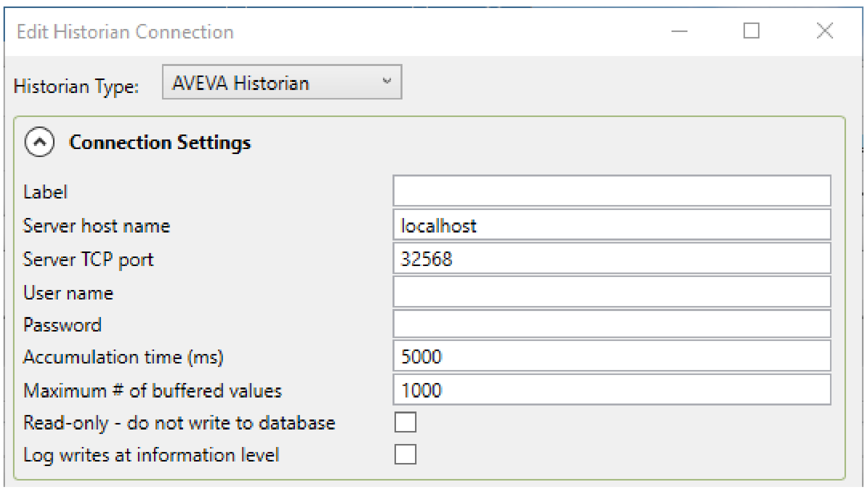
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the Apache Kafka-specific configuration, you can return to **Picking Points** in General Options to continue.

AVEVA Historian

From the Edit Historian Connection window you can select AVEVA Historian.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Server host name

The computer name or IP address for the machine running the AVEVA Historian.

Server TCP port

The TCP port for connecting to the AVEVA Historian.

User name

The user name for the AVEVA Historian account.

Password

The password associated with the **User name**.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to AVEVA Historian. Leaving this field blank means that data will be sent as soon as it is available. Accumulating data before transmission will improve network performance but will add latency.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to AVEVA Historian whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to AVEVA Historian. Setting this value to zero will allow any number of values to be buffered within the accumulation time.

Read-only - do not write to database

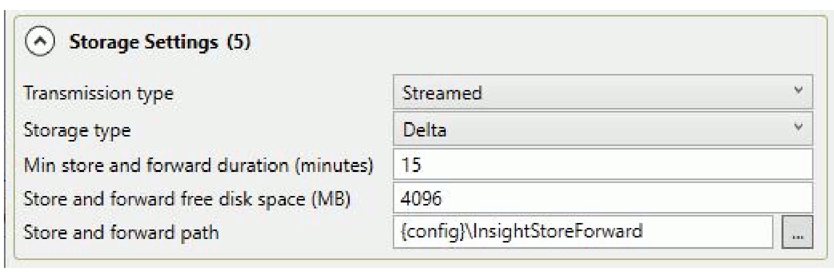
Prevents the DataHub instance from writing to AVEVA Historian.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Storage Settings

The DataHub program uses the AVEVA Historian store-and-forward agent when writing to AVEVA Historian. These settings refer to the configuration of that agent and are documented in more detail in the AVEVA Historian documentation.



Transmission type

The AVEVA Historian transmission type for the forwarded data. Select either **Streamed** or **NonStreamed**.

Storage Type

The type of storage on AVEVA Historian. Normally this should be set to **Delta**.

Min store and forward duration (minutes)

The minimum length of time that data will be saved in the store-and-forward queue while waiting to be transmitted. Data that cannot be transmitted within this time may be discarded.

Store and forward free disk space (MB)

The minimum amount of free space that must be available on disk for store-and-forward to keep data. If the free disk space drops below this number then stored data will be discarded without transmission.

Store and forward path

The path where data will be stored by the store-and-forward mechanism prior to transmission.

Modify Point Names, Data Sampling and Forwarding

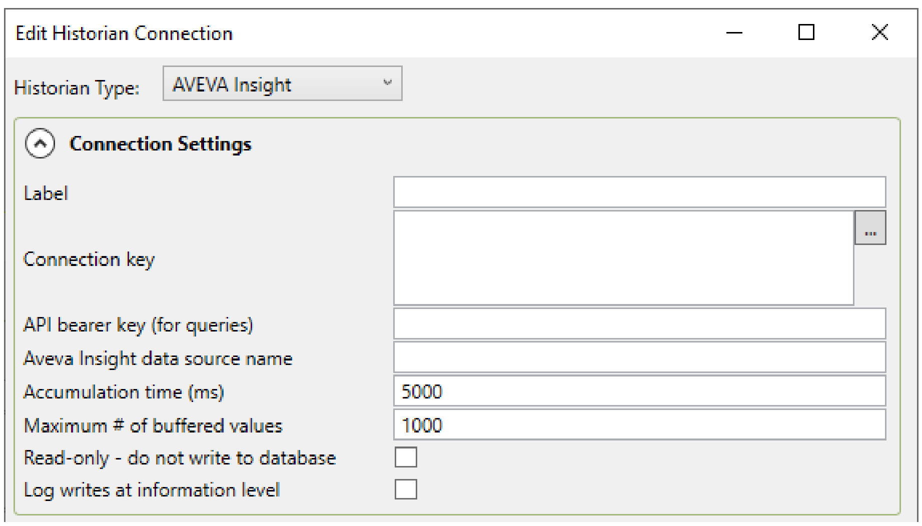
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the AVEVA Historian-specific configuration, you can return to Picking Points in General Options to continue.

AVEVA Insight

From the Edit Historian Connection window you can select AVEVA Insight.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Connection key

The connection key generated by the Insight Publisher application. Insight Publisher will open when you press the " . . . " button beside this field, or it can be downloaded from the AVEVA Insight portal.

API bearer key (for queries)

An API bearer key that you have created through the AVEVA Insight portal. This key is used to authorize the connection from the DataHub instance to AVEVA Insight.

AVEVA Insight data source name

The source name you have configured in the AVEVA Insight portal, or created during the key generation process in Insight Publisher.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to AVEVA Insight. Leaving this field blank means that data will be sent as soon as it is available. Accumulating data before transmission will improve network performance but will add latency.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to AVEVA Insight whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to AVEVA Insight. Setting this value to zero will allow any number of values to be buffered within the accumulation time.

Read-only - do not write to database

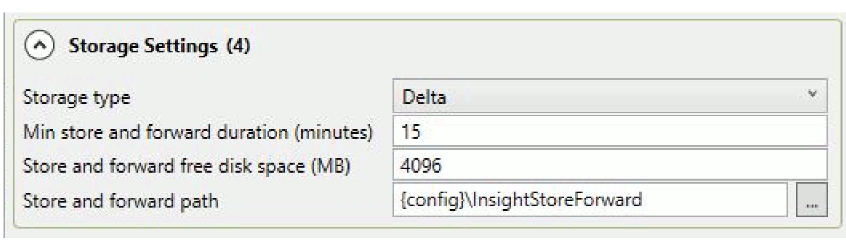
Prevents the DataHub instance from writing to AVEVA Insight.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Storage Settings

The DataHub program uses the AVEVA Historian store-and-forward agent when writing to AVEVA Insight. These settings refer to the configuration of that agent and are documented in more detail in the AVEVA Historian documentation.



Storage Type

The type of storage on AVEVA Insight. Normally this should be set to **Delta**.

Min store and forward duration (minutes)

The minimum length of time that data will be saved in the store-and-forward queue while waiting to be transmitted. Data that cannot be transmitted within this time may be discarded.

Store and forward free disk space (MB)

The minimum amount of free space that must be available on disk for store-and-forward to keep data. If the free disk space drops below this number then stored data will be discarded without transmission.

Store and forward path

The path where data will be stored by the store-and-forward mechanism prior to transmission.

Modify Point Names, Data Sampling and Forwarding

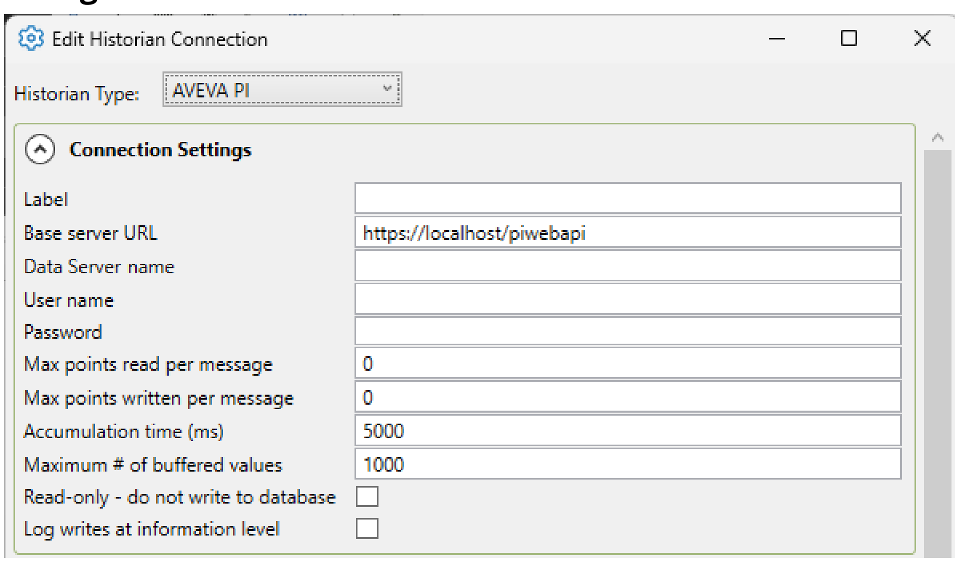
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the AVEVA Insight-specific configuration, you can return to Picking Points in General Options to continue.

AVEVA PI

From the Edit Historian Connection window you can select **AVEVA PI** for reading and/or writing data. The DataHub instance uses the PI Web API to communicate with the PI historian either locally or over a network connection. Read and write transactions take place over HTTPS.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians, like InfluxDB. The label can contain only letters, numbers and the underscore (_) character.

Base server URL

The PI Web API endpoint. This will be `https://hostname[:port]/piwebapi`, where *hostname* is the host name or IP address of the server running PI. If the PI Web API service is configured to use a port other than 443, you must also include a colon followed by the port number. E.g., `https://192.168.1.17:8080/piwebapi`

Data Server name

The Data Server name for the PI Server.

User name

The user name used to authenticate this connection. You must configure users and passwords in the PI Server.

Password

The password associated with the **User name**.

Max points read per message.

The maximum number of values that will be read in a single transaction. By default, PI limits reads to not more than 150,000 values. You can set this to a lower number to reduce the chance that a large query will cause delays in the PI Server. If necessary, the DataHub instance will use multiple read transactions to fully retrieve data over a period.

Max points written per message.

This is the maximum number of values that the DataHub instance will write in a single transaction. If the DataHub instance has more values waiting to be transmitted, it will break the values into multiple transactions of this size or less.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to PI. Setting this value to zero means that no accumulation time will be enforced, in which case **Maximum # of buffered values** will determine how frequently data is written..

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to PI. Setting this value to zero means that values will not be buffered, but instead will be sent as soon as they are available.

The DataHub instance buffers values before transmitting them to PI to improve network efficiency. The two options, **Accumulation time** and **Maximum # of buffered values**, represent alternate ways to express the limit on that buffering. The DataHub instance will transmit accumulated values when either the maximum number of buffered values or the accumulation time is reached, whichever comes first.

Read-only - do not write to database

Prevents the DataHub instance from writing to AVEVA PI.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Modify Point Names, Data Sampling and Forwarding

Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

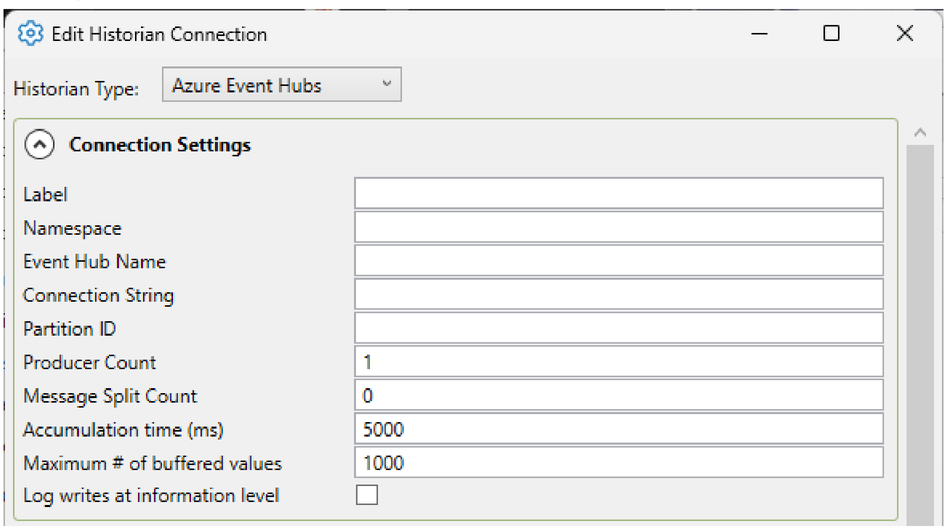
Once you have completed the AVEVA PI-specific configuration, you can return to Picking Points in General Configuration to continue.

Azure Event Hubs

From the Edit Historian Connection window you can select Azure Event Hubs.

This option is used for writing data to Event Hubs. To collect data from an Event Hubs stream, please see Event Streams.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Namespace

The namespace of the Azure Event Hub. This namespace can contain multiple different Event Hubs. Confirm that it is the Namespace being typed into this text box, not the name of the Event Hub itself. If you are using your own Event Hub, go to `https://portal.azure.com/#home`. Then click Event Hubs, under Azure Services and create an Event Hub.

Event Hub Name

The name of the Event Hub that will be written to. After clicking into the Namespace, there is the option to create a new Event Hub. The name of that Event Hub can be provided into this text entry field.

Connection String

the connection string used to connect to and authenticate the Event Hub connection. This can be found in the Event Hubs Namespace page, under **Shared Access Policies**.

Create a new policy key, giving it all of **Manage**, **Send** and **Listen** options.

After this policy key is created, clicking that policy key will open a dialog on the side with many different keys. Copy the key called **Connection String – Primary Key**. This will be what you enter into the Namespace text entry field to gain access to the specified Event Hub within this Namespace.

Partition ID

Enter a specific Partition ID if you would like to write to a specific partition only. If you would like to write to all partitions, leave the Partition ID blank. If you would like to write to multiple specific partitions, create an Azure Event Hubs connection for each partition.

Producer Count

The amount of producers wanted to send items to Azure Event Hubs. The default is 1. This ensures that the messages that are sent maintain time order. If using more than one producer, the throughput increases, but time order of messages is lost.

Message Split Count

The amount of times to split a message batch. For example, if there are 10,000 points, a message split of 5 would split the message into 5 messages of 2000 points each. This is useful to match with the producer count to increase throughput.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to Event Hubs. Setting this value to zero means that no accumulation time will be enforced.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to Kinesis whenever the first of these two limits is reached.

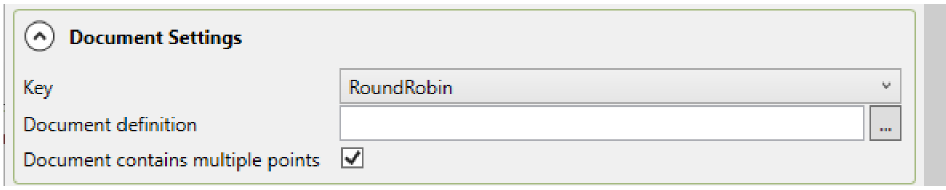
Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to Event Hubs. Setting this value to zero means that all values will be sent as soon as possible.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Document Settings



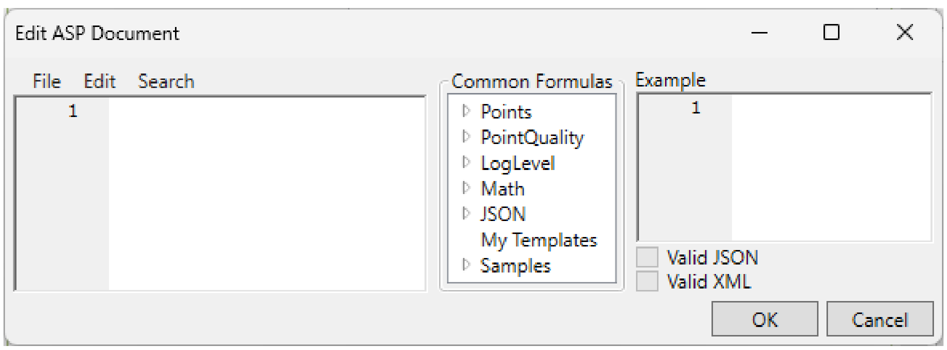
Key

Allows you to specify the key for ordering the messages.

- **RoundRobin** means no key at all, use the default.
- **Timestamp** puts all the messages from one timestamp into the same partition.
- **PointName** puts all the data from a point name in the same partition.

Document definition

Click on the 3 dots on the right hand side to open the Document Definition Dialog.



You can use this editor to construct document definitions. Double-click on any of the items in Common Formulas to put the formula into the editing pane. The Samples list contains a number of sample entries that you can use as-is or as a basis for your own definitions. The syntax and more explanation about ASP documents can be found under ASP Document Definition about 1/2 way down this page. this page.

Document contains multiple points

Specifies whether or not the document definition is processing more than one point. If accumulation time is being used, this should be selected. If using the provided template, please select this checkbox.

Modify Point Names, Data Sampling and Forwarding

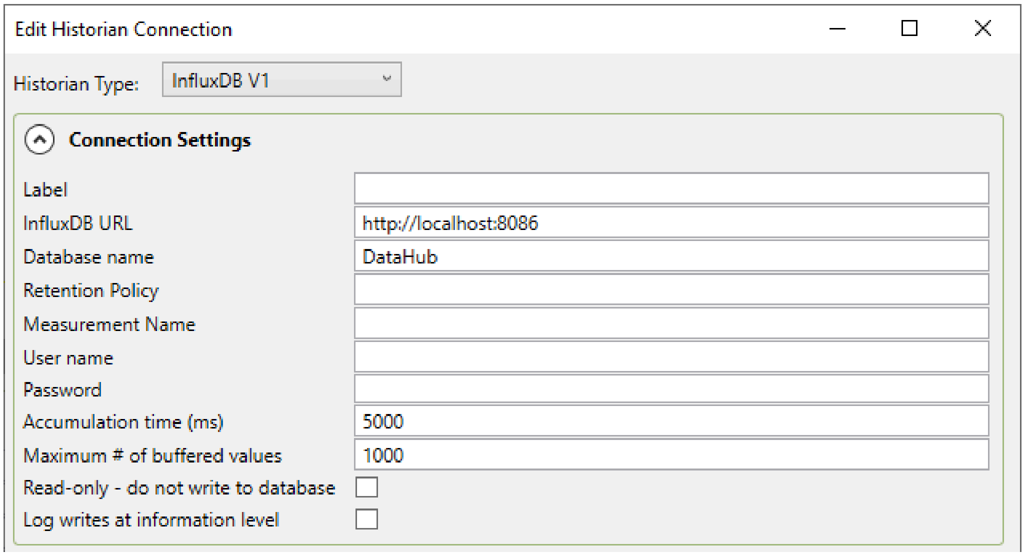
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the Azure Event Hubs-specific configuration, you can return to **Picking Points** in General Options to continue.

InfluxDB V1

From the Edit Historian Connection window you can select InfluxDB.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians, like InfluxDB. The label can contain only letters, numbers and the underscore (_) character.

InfluxDB URL

The URL for the InfluxDB database.

Database name

The name configured in the DataHub instance for the configured InfluxDB instance.

Retention Policy

The name of the InfluxDB retention policy to use. If it does not exist, the DataHub instance will create it. If this is left blank, the connection label will be used as the retention policy name.

Measurement Name

The InfluxDB measurement name to use. If it does not exist, the DataHub instance will create it. If this is left blank, a measurement name of `DataPoints` will be used.

User name

The user name for the configured InfluxDB instance.

Password

The password associated with the **User name**.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to InfluxDB. Setting this value to zero means that no accumulation time will be enforced.

The DataHub instance writes data by batches to InfluxDB. You can change the batching behaviour with these settings. If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to InfluxDB whenever the first of these two limits is reached.

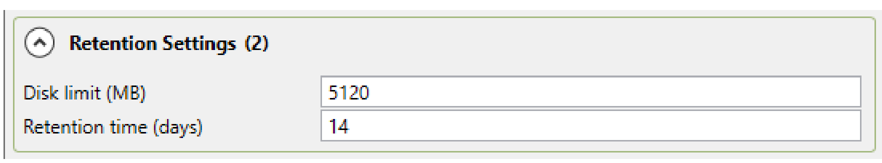
Maximum # of buffered values
: The maximum number of values that the DataHub instance will buffer in memory before transmitting them to InfluxDB. Setting this value to zero means that no values will be buffered.

Read-only - do not write to database
: Prevents the DataHub instance from writing to the InfluxDB data set.

Log writes at information level
: Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Retention Settings

How much and how long the data is retained in InfluxDB.



The DataHub instance creates its own database and retention policy to store the information it collects. If the database already exists, the DataHub instance will use it. The DataHub instance will create a retention policy named `database_name.label` where `database` is the database name you provide, and `label` is the connection label.

You can set the retention disk limit to `0` to disable it and let the disk space grow indefinitely. If the limit is set to a non-zero number, The DataHub instance will estimate the disk usage for the data and attempt to delete data over time to keep the disk usage close to that number. This estimate is not exact, as InfluxDB compresses data on disk and may wait for some time after data is deleted before removing it from disk. Do not set a disk limit that would be close to the actual free disk space available.

You can set the retention time to any number of days from `0.042` (about 1 hour) to `1491308`. If you set the retention time to `0`, the retention time will be infinite.

Disk limit (MB)
: The disk space in megabytes allotted to storing historical data.

Retention time (days)
: The number of days that data will be retained. Data older than this limit will be deleted daily.

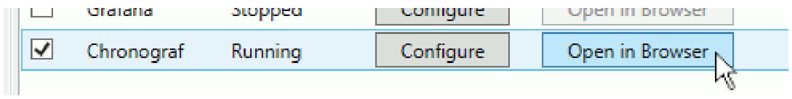
Modify Point Names, Data Sampling and Forwarding

Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

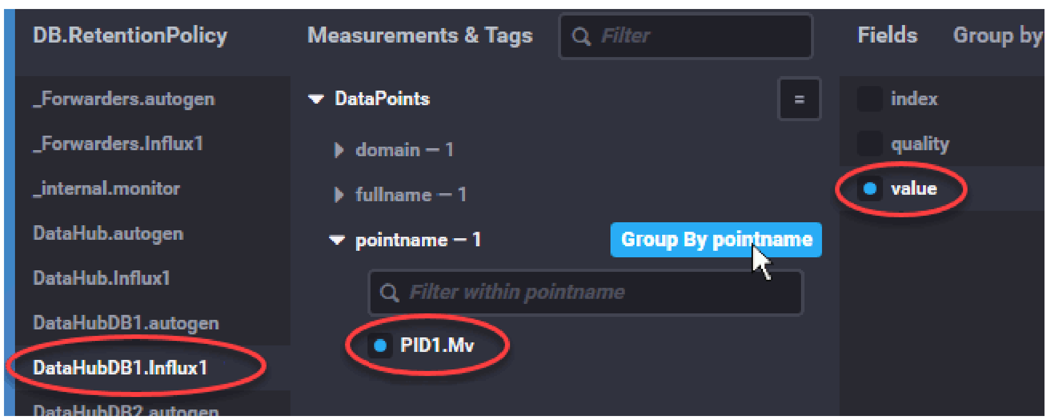
View Data

You can view updates to the InfluxDB database in Chronograf.

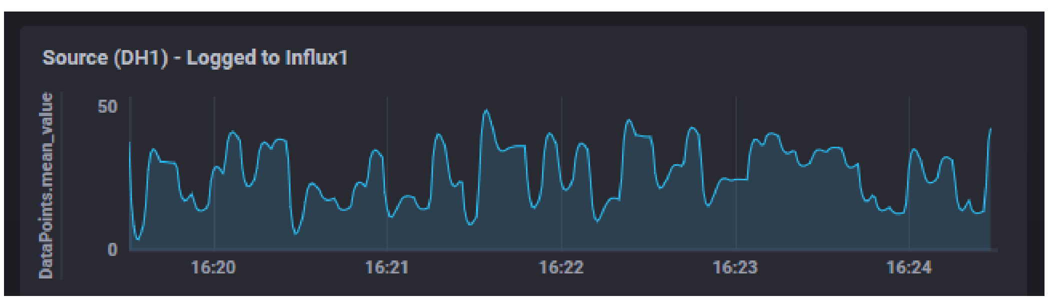
1. Ensure that both InfluxDB and Chronograf are running, and click the Chronograf **Open in Browser** button.



2. Go to **Dashboards** and click **+ Create Dashboard**, then **+ Add Data**.
3. Choose the database you have configured, and the points you want to display in **DataPoints**, under **pointname**.
4. Turn on **Group by pointname** for displaying multiple points, and under **Fields** select **value**.



You should start to see some data appear in the trend at the top of the display. You can change the dashboard name and click the green checkbox to save the dashboard.



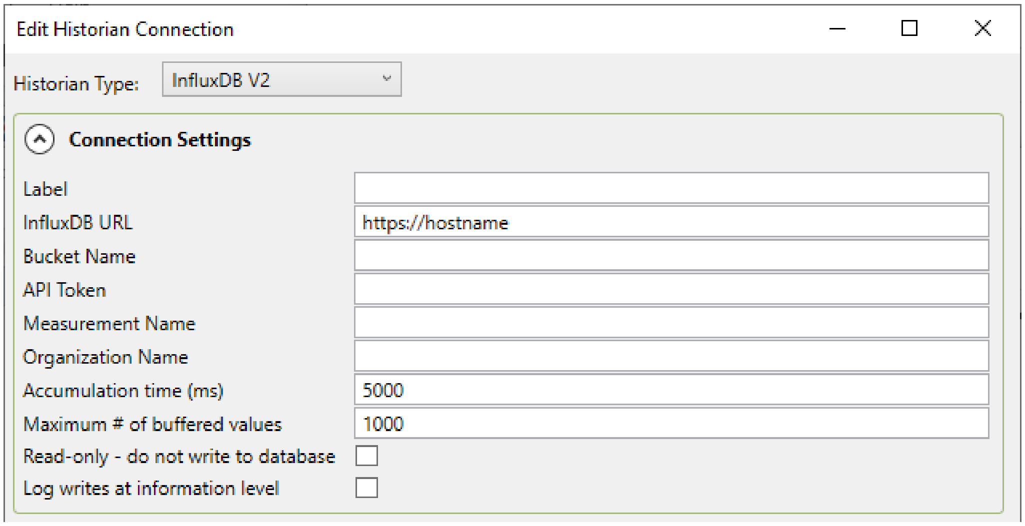
Please refer to the Chronograf documentation for more details.

Once you have completed the InfluxDB-specific configuration, you can return to Picking Points in General Options to continue.

InfluxDB V2

From the Edit Historian Connection window you can select InfluxDB V2.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians, like InfluxDB. The label can contain only letters, numbers and the underscore (_) character.

InfluxDB URL

The URL for the InfluxDB database.

Bucket Name

Your organization's InfluxDB bucket where you will store your data.

API Token

Your InfluxDB authentication token.

Measurement Name

The InfluxDB measurement name to use. If it does not exist, the DataHub instance will create it. If this is left blank, a measurement name of `DataPoints` will be used.

Organization Name

The organization name configured for your InfluxDB account.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to InfluxDB. Setting this value to zero means that no accumulation time will be enforced.

The DataHub instance writes data by batches to InfluxDB. You can change the batching behaviour with these settings. If both this value and

Maximum # of buffered values (below) are specified, then the DataHub instance will write all buffered values to InfluxDB whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to InfluxDB. Setting this value to zero means that no values will be buffered.

Read-only - do not write to database

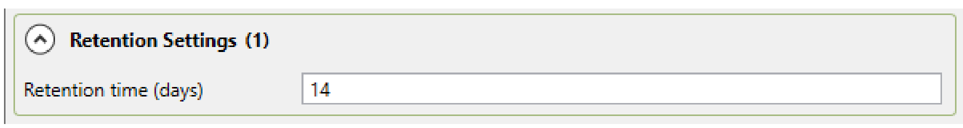
Prevents the DataHub instance from writing to the InfluxDB data set.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Retention Settings

How long the data is retained in InfluxDB.



The DataHub instance creates its own database and retention policy to store the information it collects. If the database already exists, the DataHub instance will use it. The DataHub instance will create a retention policy named *`database_name.label`* where *`database`* is the database name you provide, and *`label`* is the connection label.

You can set the retention time to any number of days from `0.042` (about 1 hour) to `1491308`. If you set the retention time to `0`, the retention time will be infinite.

Retention time (days)

The number of days that data will be retained. Data older than this limit will be deleted daily.

Modify Point Names, Data Sampling and Forwarding

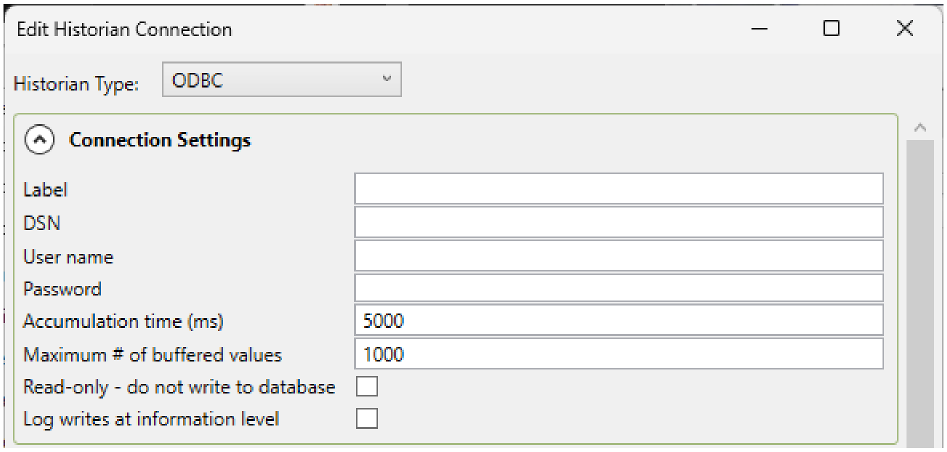
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the InfluxDB V2-specific configuration, you can return to Picking Points in General Options to continue.

ODBC

From the Edit Historian Connection window you can select ODBC.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

DSN

The Data Source Name associated with the database.

User name

The user name for the database.

Password

The password associated with the **User name**.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to the database. Setting this value to zero means that no accumulation time will be enforced.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to Kinesis whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to the database. Setting this value to zero means that all values will be sent as soon as possible.

Read-only - do not write to database

Prevents the DataHub instance from writing to the database.

Log writes at information level

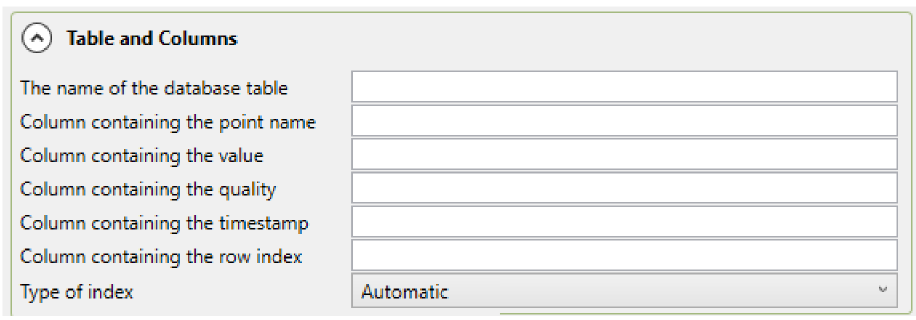
Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Database-specific syntax

The ODBC External Historian performs two operations – Insert and Query. The exact syntax of each of these operations depends on the database server, and so cannot be preconfigured for an arbitrary database target. So, the SQL commands used to interact with the database are provided as ASP scripts that build the SQL commands as they are needed.

Table and Columns

You must provide the names of the table and its columns for the example insert and query statements to function.



The name of the database table
The database table name. You may need to surround the name in quotes or brackets if the database server requires it. You can do that either here or in the insert and query scripts.

Column containing the point name
The name of the column that holds the point name. This column should be a VARCHAR or other string type that is long enough to hold the longest point name.

Column containing the value
The name of the column that holds the point value. This column is typically a high-resolution numeric type, but can be any string or numeric type.

Column containing the quality
The name of the column that holds the numeric point quality. Point qualities are 16-bit integers.

Column containing the timestamp
The name of the column that holds the timestamp for a point value. This column should be a type that can store timestamps to at least millisecond precision.

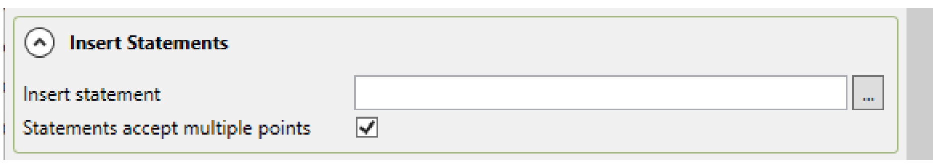
Type of index
The index column is optional when using the database as a source for OPC UA or WebView historical data, but is necessary for store-and-forward. Store-and-forward requires a way to identify which values from the table have been transmitted, and which have not. This is done by remembering the index of the last successfully

transmitted row.

Ideally, the index is a monotonically increasing integer that is automatically incremented whenever a new row is inserted into the table. When it is not possible to use an integer row index, the timestamp can be used. Using a timestamp as an index is imperfect. It is possible to miss rows if they are inserted out of time order relative to previously inserted rows. A 64-bit auto-incrementing integer is the best choice for an index column.

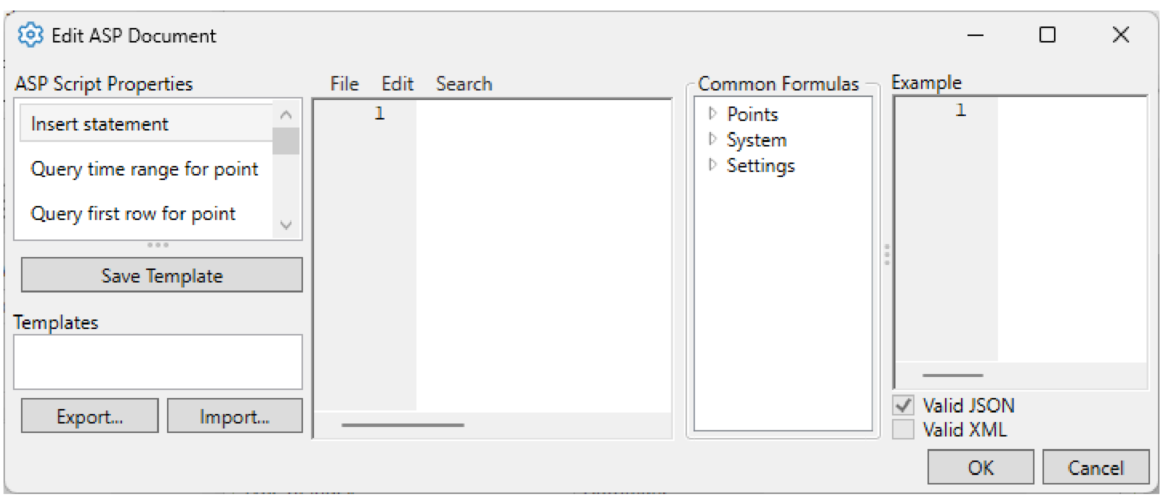
Insert Statements

Insertion requires a single script that is designed to write one or more data point values to a database table. It expects the table to contain one value per row, and to have columns that represent the point name, value, quality and timestamp of each point value. The quality and timestamp are not strictly required.



ASP document editor

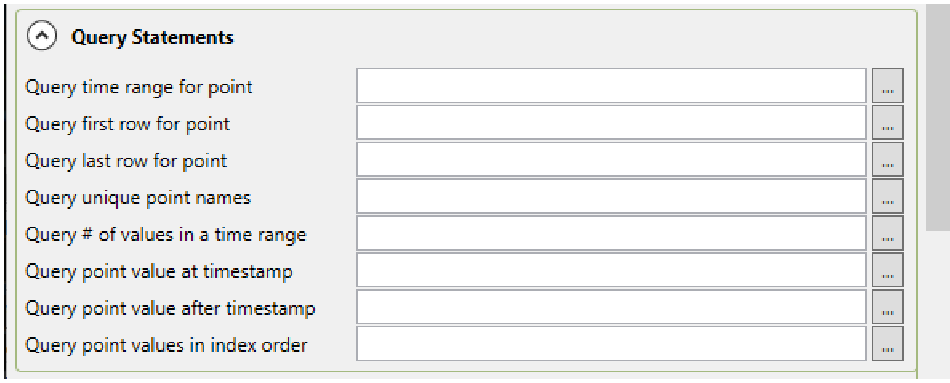
You can use the ASP document editor to create insert and query statements. There are templates available for MySQL, Oracle, PostgreSQL, and SQL Server databases. Just select the one you need and click the **Import** button.



This editor is currently documented in ASP Document Definition for the REST External Historian. Some ODBC-specific information is provided below.

Query Statements

Query statements are used when the **Src** button is checked in the **Write data to Historians** list for this historian. This setting enables the database to act as a data source for other DataHub functions such as OPC UA historical data queries, WebView trend charts, or store-and-forward capabilities in MQTT or tunnel/mirroring.



Query time range for point

Must return the name, value, quality and timestamp for a specified point within a given start and end time. The result set must include any values whose timestamp exactly matches the start or end time. Special variables `startdate`, `enddate` and `pointname` are provided to the query script.

Query first row for point

Must return the name, value, quality and timestamp of the row with the earliest timestamp for the specified point. Special variable `pointname`, is provided to the query script.

Query last row for point

Must return the name, value, quality and timestamp of the row with the latest timestamp for the specified point. Special variable `pointname`, is provided to the query script.

Query unique point names

Must return the unique set of names of all data points for which at least one value appears in the table.

Query # of values in a time range

Returns a single value containing the number of rows matching a specified point name within a given time range, inclusive of the start and end time. Special variables `startdate`, `enddate` and `pointname` are provided to the query script.

Query point value at timestamp

Returns the name, value, quality and timestamp from the row whose timestamp is less than or equal to the specified time, for the specified point name. Special variables `startdate` and `pointname` are provided to the query script.

Query point value after timestamp

Returns the name, value, quality and timestamp from the row whose timestamp is greater than the specified time, for the specified point name. Special variables `startdate` and `pointname` are provided to the query script.

Query point values in index order

The query used by store-and-forward. If you are not using this database as a source for store-and-forward, you do not need to provide this query. If you provide this, it must produce all rows in the table whose index value is greater than or equal to the value of the variable `start`, in index order, up to a maximum row count of `limit`. Special variables `start` and `limit` are provided to the query script. This script does not depend on a particular point name. It returns rows in index order across all point names.

Modify Point Names, Data Sampling and Forwarding

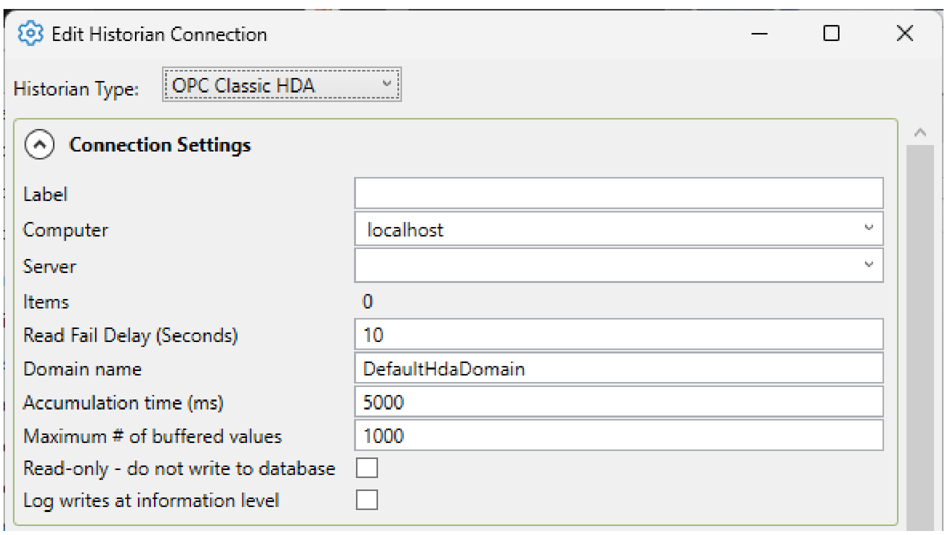
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the ODBC-specific configuration, you can return to **Picking Points** in General Options to continue.

OPC Classic HDA

From the Edit Historian Connection window you can select OPC Classic HDA. This enables the DataHub instance to store data to, and query data from, an OPC HDA historian.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Computer

The computer name for the computer running the Classic HDA historian.

Server

The name of the HDA server.

Items

The number of HDA items selected.

Read Fail Delay (Seconds)

The amount of seconds between attempting another read, if a read has failed. This is to stop the DataHub instance from constantly querying the HDA server for a point that is producing a fail.

Domain Name

The DataHub domain in which the HDA points are listed.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to the HDA historian. Setting this value to zero means that no accumulation time will be enforced.

If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to Kinesis whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before transmitting them to the HDA historian. Setting this value to zero means that all values will be sent as soon as possible.

Read-only - do not write to database

Prevents the DataHub instance from writing to the HDA historian.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Modify Point Names, Data Sampling and Forwarding

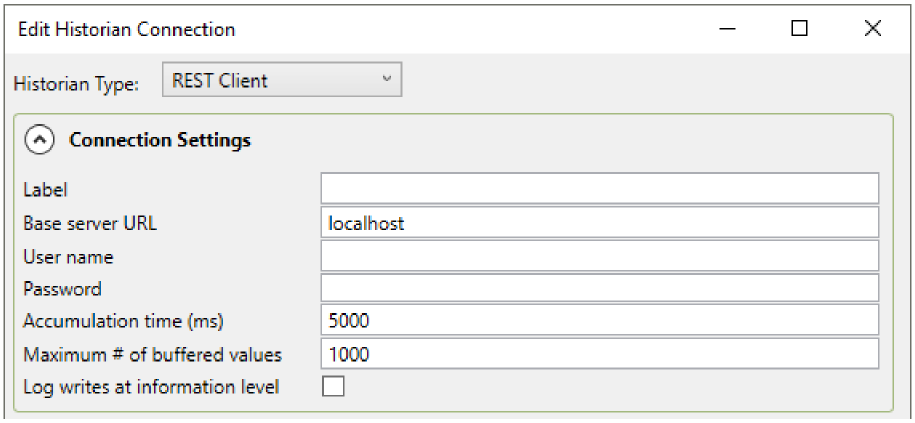
Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the OPC HDA-specific configuration, you can return to **Picking Points** in General Options to continue.

REST Client

From the Edit Historian Connection window you can select **REST Client**. In this implementation of the External Historian the DataHub instance acts as a REST client, transmitting data to a REST server. The DataHub instance makes HTTP calls containing data point values as a payload. The server responds with a success or fail indication.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians, like InfluxDB. The label can contain only letters, numbers and the underscore (_) character.

Base server URL

The URL for the REST service. This is a prefix that is combined with the **Relative path** entry to form the complete URL to which to send data.

User name

The user name for the DataHub instance REST client.

Password

The password associated with the **User name**.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before sending it to the REST server. Setting this value to zero means that no accumulation time will be enforced.

The DataHub instance writes data by batches to the REST server. You can change the batching behaviour with these settings. If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will write all buffered values to the REST server whenever the first of these two limits is reached.

Maximum # of buffered values

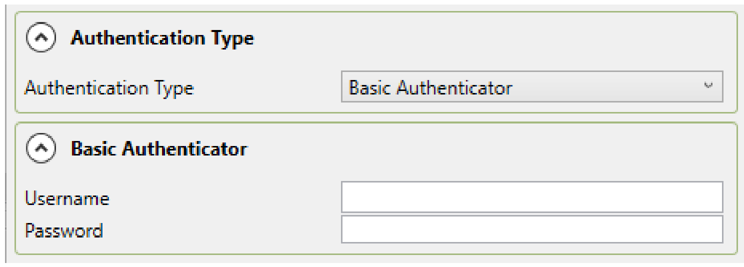
The maximum number of values that the DataHub instance will buffer in memory before transmitting them to the REST server. Setting this value to zero means that no values will be buffered until the accumulation time is reached.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Authentication Type

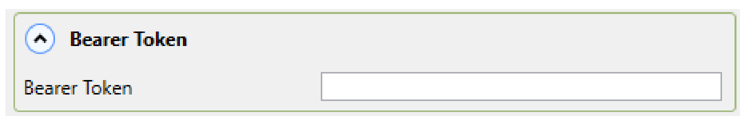
Use the **Basic Authenticator** type or choose another option from the list.



If your authentication type is not supported, contact Skkynet.

Bearer Token

Enter the authorization information for your Bearer Token.

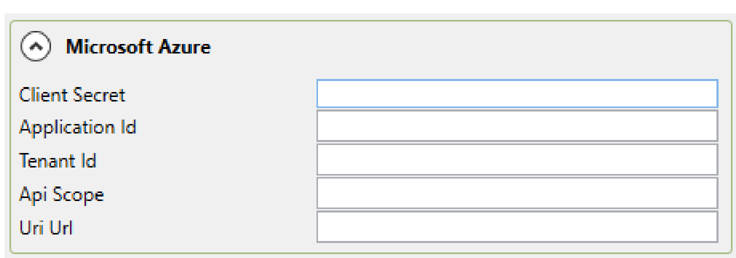


Key Pair with JWT

Enter the authorization information for your JWT Key Pair.

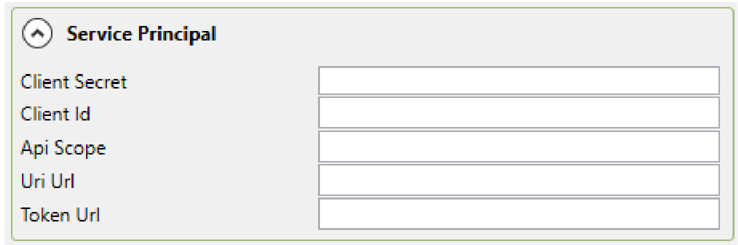
Microsoft Azure

Enter the authorization information for your Cogent DataHub service for Azure account.



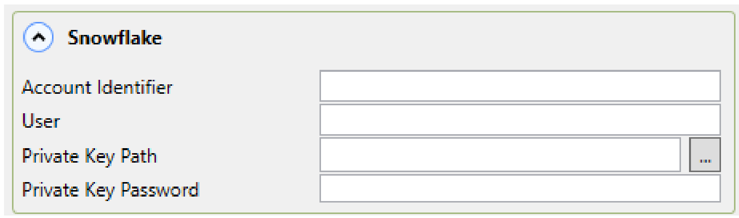
Service Principal

Enter the authorization information for your Service Principal account.



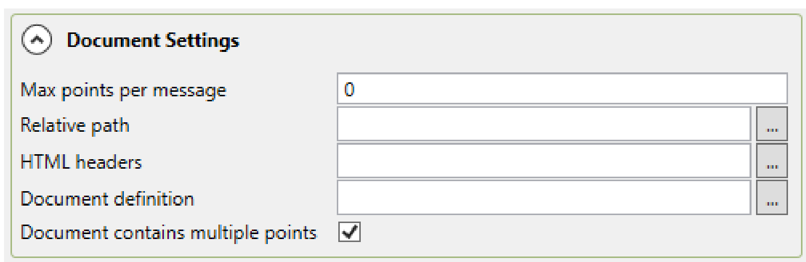
Snowflake

Enter the authorization information for your Snowflake account.



Document Settings

The attributes of the JSON, XML, or other document used to establish the REST connection.



Max points per message.

The REST client can send the accumulated data in one or more messages. This setting determines how many points can be sent in a single HTTP message. If the accumulated points (set with **Accumulation time** and **Maximum # of buffered values**, above) exceeds this number then the values will be split into multiple messages. A value of `0` means that all accumulated points will be sent in a single message.

The following three entries (**Relative path**, **HTML headers** and **Document definition**) define their values using a script that is processed through an ASP processor. This allows you to specify these settings in a way that varies with the data or other information that changes at runtime. See below for the syntax and examples of document definitions.

Relative path

This is the path portion of the URL to which messages are sent. This is appended to the **Base server URL**. The relative path can be left blank, in which case the base server

URL completely specifies the URL to which messages are posted. If the relative path is not blank then it is a script that returns a string. A trivial example could be:

```
<%= "/input" %>
```

or just

```
/input
```

Use this entry when the REST server URL changes, based on other information.

HTML headers

The HTML headers to be added to the HTTP POST message. This is a document consisting of a list of strings in the form `name: value`, one per line. For example:

```
Content-Type: text/json
```

Use this entry when the REST server requires special HTTP headers, typically for authentication.

Document definition

A script that constructs the POST message body using ASP notation. This allows you to construct JSON, XML or custom message bodies that mix point data values with message structure.

Document contains multiple points

This option allows you to choose whether the document is generated once for each point, or operates on a list of points. If this option is set, the variable `points` is defined when processing the document. If this option is cleared, the variable `point` is defined when processing the document.

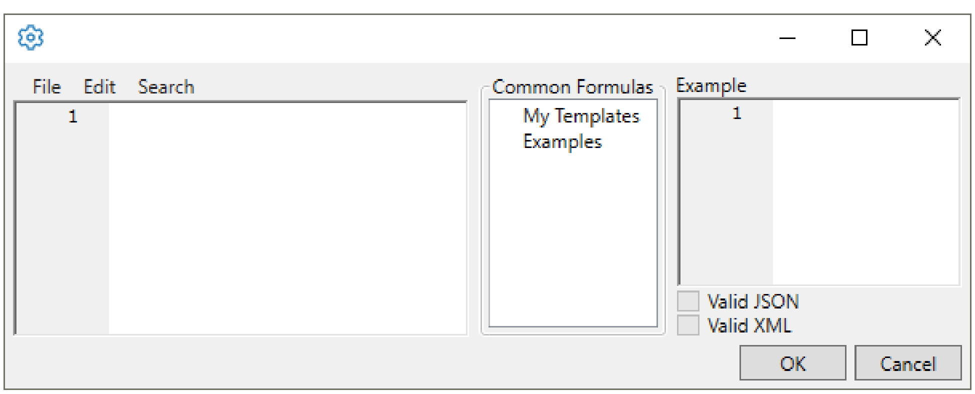
Modify Point Names, Data Sampling and Forwarding

Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the REST Client-specific configuration, you can return to Picking Points in General Configuration to continue.

ASP Document Definition

ASP values are defined in the following dialog:



The left-hand pane contains the ASP document that defines the value. Type your document here.

The center pane contains saved examples and templates that you can load by double-clicking on the template name. Once you have created a document definition you can save it by selecting **File** -> **Save As** to give your template a name. It will then appear in the **My Templates** list.

The right-hand pane contains the result of processing some example point change events using the document definition in the left-hand pane. The two check-boxes, **Valid JSON** and **Valid XML**, will be checked automatically if the resulting document in the Example pane is valid JSON or valid XML. This is to help you identify errors in the document definition when the result should be JSON or XML.

An ASP document is any text document that combines normal text with special ASP directives. The content of an ASP directive is a script, written in S-Sharp. Script expressions and script statements are any valid S-Sharp expressions and statements respectively. S-Sharp is documented here. There are two ASP directives, differing only by an equals sign (=). These are:

<% *`one or more script statements`* >

> This directive instructs the ASP processor to run the script and produce nothing in the output document. You can use this directive to define functions, initialize variables, log messages, etc., where no text should be added to the output document. Script statements can be broken up across multiple <% %> directives so long as the sum of all the directives results in a sequence of valid expressions, including the trailing semicolon character if necessary.

<%= *`one or more script statements`* >

> This directive instructs the ASP processor to execute the script expression and insert the result into the output document. You can use this directive to insert point names, values, timestamps, quality, etc. The script expression must not be a statement—that is, it must not end in a semicolon or a brace that would indicate the end of a statement.

JSON Example

This is an example of a JSON document that is valid for transmitting data to Microsoft Power BI:

```
[
<%
  var point; var i;
  for (i = 0; i < points.Length; i++)
  {
    point = points[i];
%><%= i == 0 ? "" : ",\n" %>  {
    "<%= point.Name %>": <%= point.JsonValue %>,
```

```
    "Date": "<%= point.IsoTimestamp %>"
  }<% } %>
]
```

There is an XML example below.

Breaking down the Power BI example makes it easier to understand. The outermost square brackets `[ ]` are literal brackets that surround a JSON array. Within the array we want to iterate through the list of points that need to be transmitted. The array of points is provided automatically in the variable `points`. The loop through the array of points contains both literal text and scripts within ASP directives. Colorizing the code helps to understand it:

```
[
<%
  var point; var i;
  for (i = 0; i < points.Length; i++)
  {
    point = points[i];
%><%= i == 0 ? "" : ",\n" %>  {
    "<%= point.Name %>": <%= point.JsonValue %>,
    "Date": "<%= point.IsoTimestamp %>"
  }<% } %>
]
```

The text within <% %> directives is script code that produces no output. This represents the script structure, not the document content. Extracting that script code we see the structure as:

```
var point; var i;
  for (i = 0; i < points.Length; i++)
  {
    point = points[i];
  }
```

The document content is a combination of literal text and the result of evaluating code within <% %> directives. Extracting this gives us the structure of the document content:

```
[
<%= i == 0 ? "" : ",\n" %>  {
    "<%= point.Name %>": <%= point.JsonValue %>,
    "Date": "<%= point.IsoTimestamp %>"
  }
]
```

The directive `<%= i == 0 ? "" : ",\n" %>` inserts a comma and a newline character into the resulting document for all items in the points list except the first one.

The directive `"<%= point.Name %>"` inserts the point name within double quotes into the resulting document. Note that we must explicitly add the double quote characters. This will fail for point names that contain double quote or backslash characters. If

you need to escape point names with backslash and double quote characters, use:
`"<%= point.Name.Replace("\\","\\\\").Replace("\"","\\\"") %>"`

The directive `<%= point.JsonValue %>` inserts the point value in JSON format into the output. If the point value is a string this includes surrounding the string in double quote characters and escaping quote and backslash characters.

The directive `"<%= point.IsoTimestamp %>"` inserts the point timestamp in ISO 8601 format.

Data points contain several members that can be inserted into the document:

`Value` – the point value as an object. This can contain any string or numeric type.
`IntVal` – the point value converted to integer.
`DblVal` – the point value converted to double.
`StrVal` – the point value converted to string.
`Name` – the full name of the point, including the domain name, as a string.
`DomainName` – the domain name portion of the point name, as a string.
`Quality` – the point quality as a PointQuality value. Can be converted to integer or string.
`Timestamp` – the point timestamp in UTC as OADate, a double (days since midnight, December 30, 1899).
`DateTime` – the point timestamp in UTC as a DateTime.
`IsoTimestamp` – the point timestamp in ISO 8601 format, as a string.
`JsonTimestamp` – the point timestamp in JSON format, the number of milliseconds since the UNIX epoch start (January 1, 1970 00:00:00 UTC).
`UnixTimestamp` – the point timestamp in UNIX epoch, including decimal milliseconds.
`JsonValue` – the point value in valid JSON format. Strings are surrounded in double quotes with quote backslash characters escaped.

XML Example

This is an example of an XML document that sends a global timestamp and then a series of data points including name, value, quality and timestamp:

```
<DataPoints>
  <Timestamp><%= DateTime.UtcNow.ToString("o") %></Timestamp>
  <Points>
  <%
    var point; var i;
    for (i = 0; i < points.Length; i++)
    {
      point = points[i];
  %>  <Point>
      <Name><%= point.Name %></Name>
      <Value><%= point.Value %></Value>
      <Quality><%= (int)point.Quality %></Quality>
      <Timestamp><%= point.IsoTimestamp %></Timestamp>
    </Point>
```

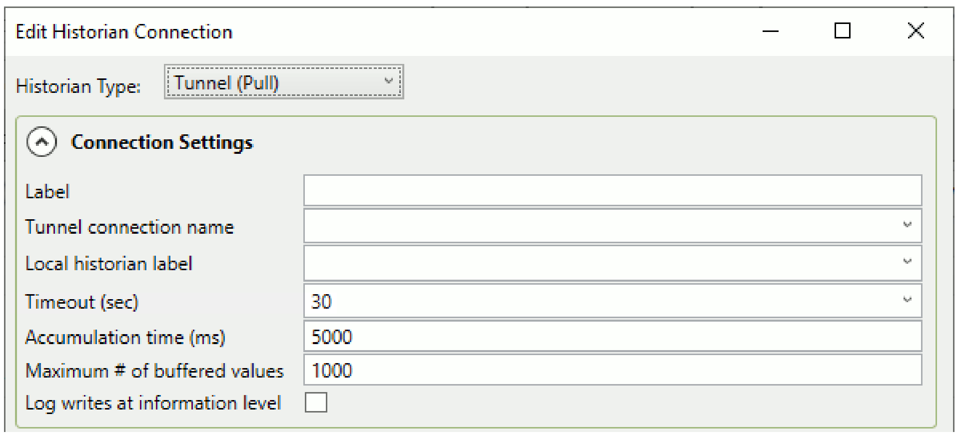
```
  <% } %>
  </Points>
</DataPoints>
```

Tunnel (Pull)

From the Edit Historian Connection window you can select Tunnel (Pull).

The **Tunnel (Pull)** historian type allows you to configure the DataHub instance as a tunnel slave to pull data from a remote external historian and log it to a local historian, by connecting to a DataHub tunnel master running on the remote machine. Please see External Historian 5 - Tunnel (Pull) for more details.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Tunnel connection name

The connection name of the tunnel you have configured to pull data from the remote DataHub instance. See Tunnel/Mirror in the Receiving Side section of the tutorial for more information. See the Tunnel (Pull) tutorial for more information.

Remote historian label

The **Label** configured for the historian on the remote side.

Timeout (sec)

Sets a timeout period, in seconds. If the transaction cannot complete within this time, it will be re-tried on the next transmission cycle. If this DataHub instance cannot write to the destination historian within this period, it abandons the write attempt and requests the same data on the next transmission cycle.

Accumulation time (ms)

The number of milliseconds that the sending DataHub instance will buffer data in memory before it gets pulled across the tunnel. Leaving this field blank means that no accumulation time will be enforced. If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will pull all buffered values across the tunnel whenever the first of these two limits is reached.

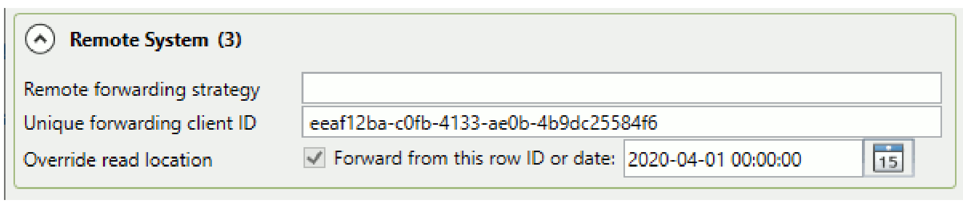
Maximum # of buffered values

The maximum number of values that the sending DataHub instance will buffer in memory before it gets pulled across the tunnel. Leaving this field blank means that no values will be buffered.

Log writes at information level

Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Remote System



Remote forwarding strategy

The label of a forwarding strategy from the External Historian configuration of the DataHub instance on the sending side.

Unique forwarding client ID

A text string unique to this forwarding configuration that allows the historian to identify it. You can use the system-generated string, or enter your own.

Override read location

Allows you to forward a portion of the data set by resetting the start point to a more recent time. The date/time data format is *`YYYY-MM-DD HH:MM:SS`*, and can be edited as needed. The calendar button allows you to quickly enter the date.

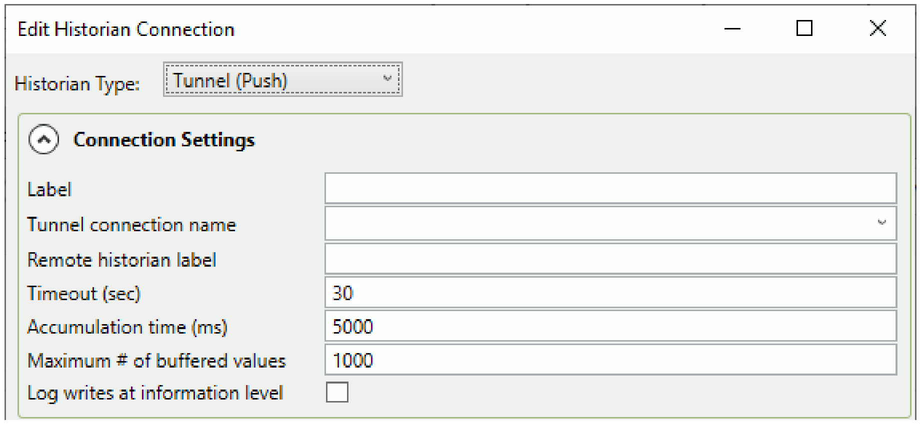
Once you have completed the Tunnel (Pull)-specific configuration, you can return to Picking Points in General Configuration to continue.

Tunnel (Push)

From the Edit Historian Connection window you can select Tunnel (Push).

The **Tunnel (Push)** historian type allows you to configure the DataHub instance as a tunnel slave to forward data from a local external historian to a remote external historian, by connecting to a DataHub tunnel master running on the remote machine. Please see External Historian 4 - Tunnel (Push) for more details.

Connection Settings



Label

A unique text string used to identify this connection. This label is used to identify the connection when configuring store and forward, and to create the database name or retention policy in some historians. The label can contain only letters, numbers and the underscore (_) character.

Tunnel connection name

The connection name of the tunnel you have configured to push data to the remote DataHub instance. See Tunnel (Push) in the tutorial for more information.

Remote historian label

The **Label** configured for the external historian on the remote side.

Timeout (sec)

Sets a timeout period, in seconds. If the transaction cannot complete within this time, it will be re-tried on the next transmission cycle. If this DataHub instance does not receive a response within this period, it assumes that the transmission has failed and abandons it. This DataHub instance will transmit the same data on the next transmission cycle. This timeout is ignored if the associated forwarding strategy is configured to not require acknowledgments.

Accumulation time (ms)

The number of milliseconds that the DataHub instance will buffer data in memory before pushing it across the tunnel. Leaving this field blank means that no accumulation time will be enforced. If both this value and **Maximum # of buffered values** (below) are specified, then the DataHub instance will send all buffered values across the tunnel whenever the first of these two limits is reached.

Maximum # of buffered values

The maximum number of values that the DataHub instance will buffer in memory before pushing them across the tunnel. Leaving this field blank means that no values will be buffered.

Log writes at information level

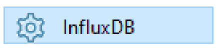
Checking this option causes messages regarding successful writes to the database to be logged at the **Information** level in the DataHub Event Log. If this is not checked then these messages are logged at the **Debug** level and are therefore normally hidden from the user.

Modify Point Names, Data Sampling and Forwarding

Please see Modify Point Names, Data Sampling or Forwarding in Connection Configuration for how to configure these options.

Once you have completed the Tunnel (Push)-specific configuration, you can return to Picking Points in General Configuration to continue.

InfluxDB



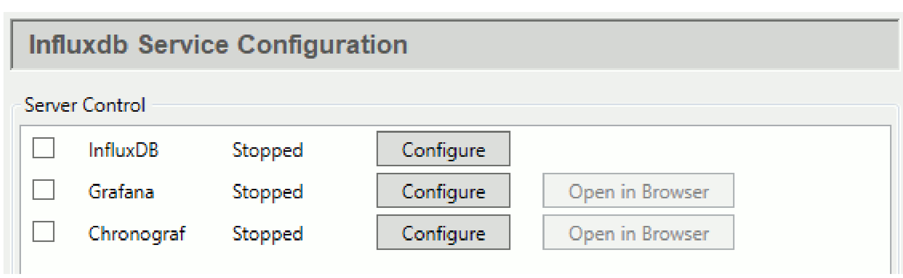
The InfluxDB option lets you run InfluxDB, an open-source time-series data historian that is offered as a plug-in for the DataHub program. The DataHub implementation of InfluxDB includes Grafana, an open source analytics and monitoring tool that can be configured to work with InfluxDB, along with Chronograf, the InfluxDB dashboard.

InfluxDB requires a 64-bit operating system. The DataHub installation of InfluxDB is version 1.x. InfluxDB 2.0 is supported, but must be installed separately. To use your own version of InfluxDB 1.x or 2.0, you should ignore the Configuration options below, and run your own installation. See also Connecting to InfluxDB , External Historian, and Advanced Topics for additional helpful information.

If you install InfluxDB separately, do not put it in the same folder as the DataHub installation. Otherwise your version of InfluxDB will be replaced by the DataHub installer whenever it runs, and your database and files will get overwritten.

Server Control

Here you can start up, configure, and access the three InfluxDB components.



The DataHub program is pre-configured for InfluxDB and its components. Click the check-box and press **Apply** to start any of them. The status should change to **Starting**, and then to **Running**.

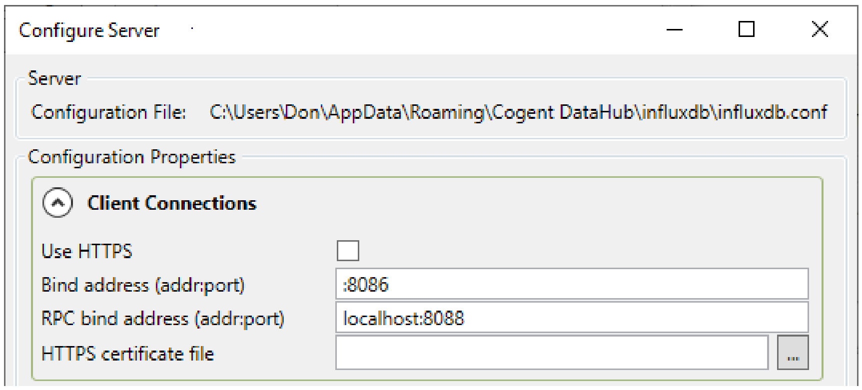
See Connecting to InfluxDB to get started with InfluxDB, or go to the External Historian section for more details on configuring a data connection to your InfluxDB database.

Additionally, the Advanced Topics provide more information about accessing data written by other applications, which fields and tags are used, and the index field and multiple data sources.

If you need to edit the configuration of any component, click the **Configure** button to open the Configure Server window for InfluxDB, Grafana, or Chronograf.

Configuration

This is the Configure Server window for the InfluxDB program itself. Generally, if you do not know what a setting is for, you do not need to change it.



Client Connections

Use HTTPS

If selected, the server will listen for connections as HTTPS instead of HTTP. Use this if security is more important than speed. The client applications will need to use this protocol to connect to this InfluxDB server.

Bind address (addr:port)

Specify a port for the server to listen on (either HTTP or HTTPS). InfluxDB allows you to limit which network interfaces to listen on, as well as the port number. The default value is `:8086`. The special syntax `:1234` indicates to listen on all network interfaces.

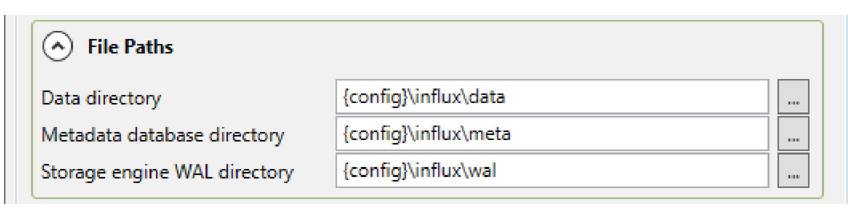
RPC bind address (addr:port)

TBD

HTTPS certificate file

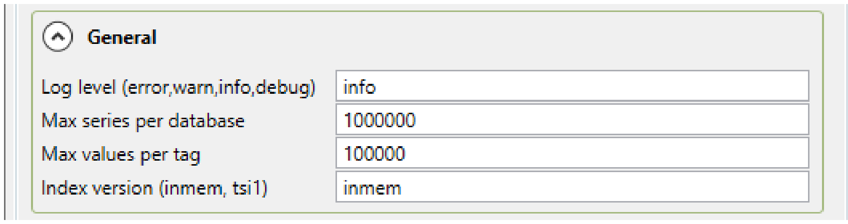
Enter the location of the SSL certificate if you have chosen to use HTTPS. This should be a file in PEM format, including the private key.

File Paths



You can set the file path to the InfluxDB database on disk. The string `{config}` will be replaced with the DataHub configuration folder, and `{install}` with the DataHub installation folder. Normally the data, metadata, and WAL folders should be placed within the same parent folder.

General



Log level

Specify the severity level of messages that the InfluxDB server should write to its log file.

Max series per database

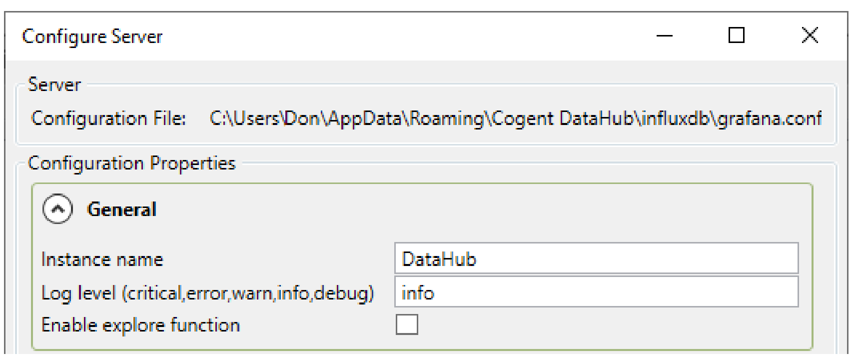
TBD

Max values per tag

TBD

Grafana

This is the Configure Server window for Grafana, the analytics and monitoring tool that works with InfluxDB:



General

Instance name

You can change the default name, `DataHub`, to any other name.

Log level (critical, error, warn, info, debug)

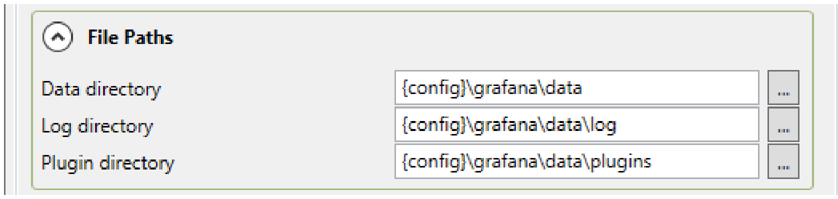
Specifies the severity level of messages that Grafana should write to its log file.

Enable explore function

Enables the Grafana explore function. See https://grafana.com/docs/features/explore/

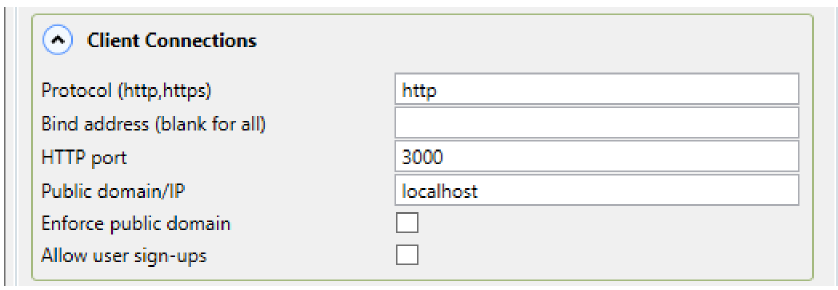
for more information.

File Paths



Set the file locations for the Grafana data, log and plugin folders. The string `{config}` will be replaced with the dh; configuration folder, and `{install}` with the DataHub installation folder. Normally these folders should be placed within the same parent folder.

Client Connections



Protocol (http, https)

Enter the protocol that you want Grafana to support.

Bind address (blank for all)

Grafana will listen on only the address specified here, or on all addresses if this is left blank.

HTTP port

The port for the HTTP or HTTPS clients to connect.

Public domain/IP

The public domain name or IP address of this Grafana server. See https://grafana.com/docs/installation/configuration/#domain for more information.

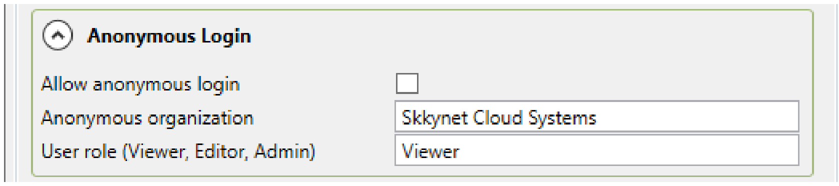
Enforce public domain

Enforces the use of the public domain. See https://grafana.com/docs/installation/configuration/#enforce-domain for more information.

Allow user sign-ups

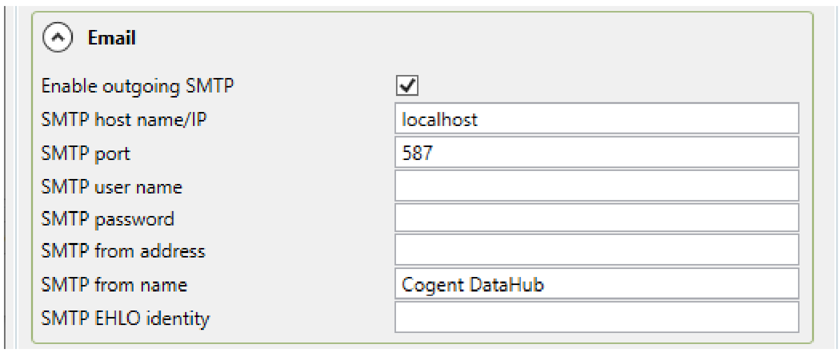
Checking this box allows users to sign up for an account, and create their own user names and passwords. If this box is not checked then the Grafana administrator must create new user accounts.

Anonymous Login



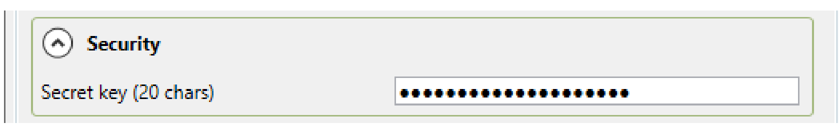
Enter the appropriate information for the email account that Grafana will use for sending out emails. See https://grafana.com/docs/installation/configuration/#smtp for more information.

Email



Enter the appropriate information for the email account that Grafana will use for sending out emails. See https://grafana.com/docs/installation/configuration/#smtp for more information.

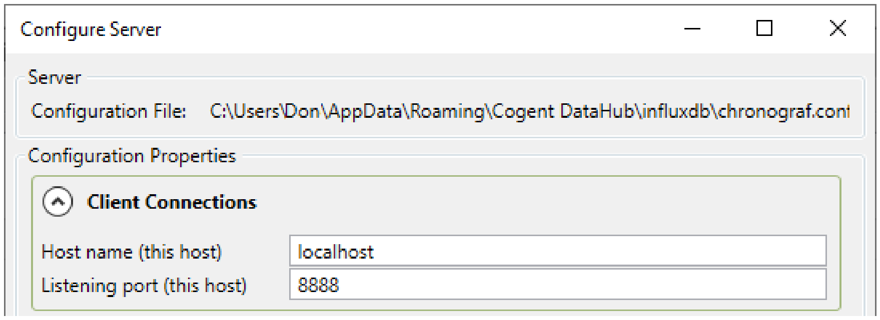
Security



Enter the appropriate information for the email account that Grafana will use for sending out emails. See https://grafana.com/docs/installation/configuration/#smtp for more information.

Chronograf

This is the Configure Server window for Chronograf, the InfluxDB dashboard:



Client Connections

Chronograf accepts inbound connections from any appropriately configured client. It is configured by default to allow all connections without authentication, so entries here will limit connections to only those clients running on the machine on which Chronograf is running.

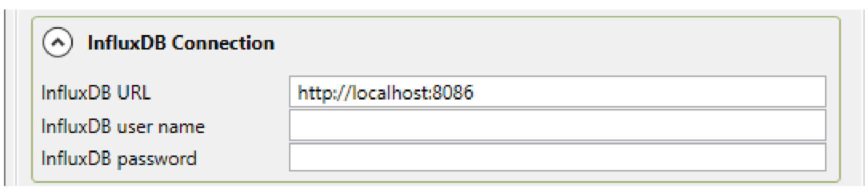
Host name (this host)

The computer name or IP address of the computer running Chronograf and the DataHub program.

Listening port (this host)

The port that has been opened to accept incoming Chronograf client connections.

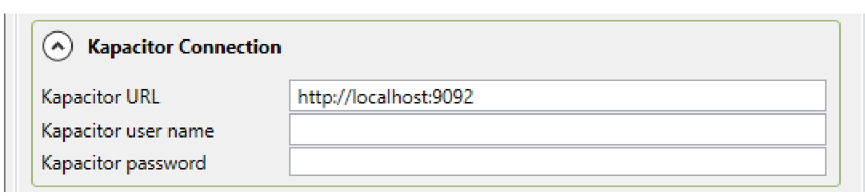
InfluxDB Connection



Chronograf connects to Influx DB using the **URL**, **user name**, and **password** specified here.

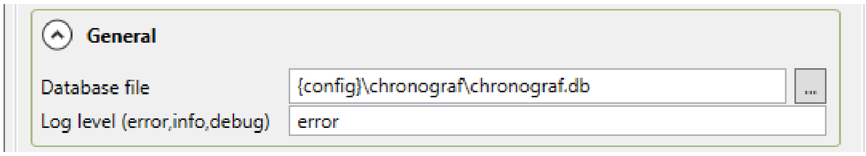
Kapacitor Connection

Kapacitor is a data processing engine for InfluxDB that can used for streaming analytics and anomaly detection.



The **URL**, **user name**, and **password** for Kapacitor can be entered or edited here.

General



Database file

The name of the Chronograf database file. The string `{config}` will be replaced with the DataHub configuration folder, and `{install}` with the DataHub installation folder

Log level (error, info, debug)

Specify the severity level of messages that Chronograf should write to its log file.

Advanced Topics

Accessing data written by other applications

The DataHub program can read InfluxDB data written by other applications, but there are some limitations, particularly on store and forwarding.

This is what a DataHub instance writes when it is populating InfluxDB:

Fields

- `value` – If the value is a number, then this will be written.
- `text` – If the value is not a number, then this will be the text representation of the value.

  Only one of `text` or `value` is provided for any data value
- `quality` – the OPC DA quality as a number, e.g. Good quality is stored as `0xC0`.
- `index` – a monotonically increasing record number. Every time the DataHub instance writes any value for any point to this database it increments this index.

Tags

- `fullname` – the fully qualified point name, including the DataHub domain name. e.g., `DataPid:PID1.Pv`
- `domain` – the domain name of the point, without the colon. e.g., `DataPid`
- `pointname`– the point name without the domain and colon. e.g., `PID1.Pv`

Property

- `timestamp` - required by InfluxDB for each record. The DataHub instance sets the record timestamp to the source timestamp of the point value, not the clock time at the time of write.

The DataHub program can read any data from InfluxDB that is written this way. If another application writes to InfluxDB, it can write extra tags and fields, and the DataHub instance will still be able to read the record, as long as it also includes the tags and fields that the DataHub instance uses.

Which fields and tags are used?

The DataHub program uses InfluxDB for three purposes. How it is being used determines which of the fields and tags are required.

1. **Logging historical data** uses all the fields and tags, although the domain and pointname tags are just a convenience for Grafana and Chronograf users.
2. **Acting as the backing store** for OPC UA and WebView historical queries requires:
   - Fields: `value` and/or `text`, and `quality`
   - Tags: `fullname`

   If you can mimic this format in your InfluxDB writer then the DataHub program can act as the converter from InfluxDB to OPC UA HA (Historical Access).

   OPC UA HA is an interface to an external data store. It requires a readable External Historian in addition to the OPC UA feature.

3. **Acting as the storage for store-and-forward** in MQTT and external historians requires:
   - Fields: `value` and/or `text`, `quality`, and `index`
   - Tags: `fullname`

   If you want to use InfluxDB as a store-and-forward source for the DataHub program then there is some extra complexity around the index field, which is required for all store-and-forward operations.

The index field and multiple data sources

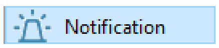
The index must be incremented for each record that is written. That is, it must be strictly monotonic. Values can be skipped, but each index must be greater than the index of the previous record. If the index is not strictly monotonic then store-and-forward will fail to transmit all records. To ensure that index entries are monotonic, you must normally limit the system to only one writer.

However, if you never plan to use store-and-forward, the index does not matter. You can write data from multiple sources and still use InfluxDB as a source for charting and OPC UA HA. These use cases rely only on the timestamp. InfluxDB does not require timestamps to arrive in increasing order, so you can write from as many clients as you like, and just set the index to zero for all records.

If you want to write data from two DataHub instances to InfluxDB, you can use store-and-forward from DataHub instance #1 to DataHub instance #2 over a tunnel. This way, DataHub instance #2 is responsible for the index, and it would ensure that the proper index is maintained. This lets you use the resulting InfluxDB database for store-and-forward, charting and OPC UA. You could also send the live data from DataHub instance #1 over a tunnel and let DataHub instance #2 write it to InfluxDB.

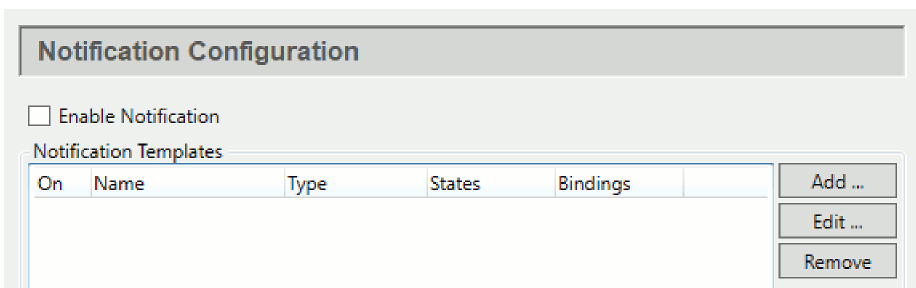
Briefly, multiple data sources can write to InfluxDB, but if you want to store and forward the data using the DataHub instance, you must write the data from a single source. Typically that single source is the DataHub instance itself.

Notification



The Notification option allows you to generate alarms, events and notifications for conditions based on data point values. When a condition is met, a notification can be emitted by changing a data point or sending email, SMS, OPC A&E or social media messages.

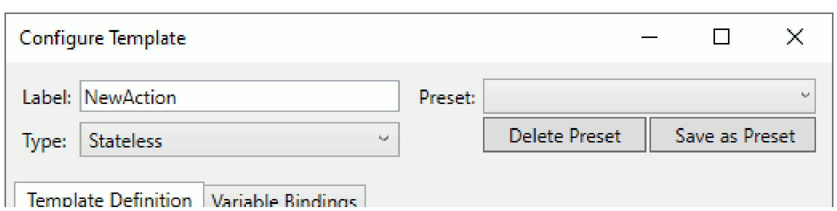
For step-by-step instructions to get started using this option, please see Making Notifications.



The **Enable Notification** checkbox enables or disables all templates and notifiers. The **Add** and **Edit** buttons open the Configure Template window to create or modify notification templates.

Notification Templates

Templates are created and modified in the Configure Template window.



Label

A text string that identifies this template.

Type

Stateless

Examines each Condition for each defined state in order, and executes the

`IfTrue` script for the first true condition.

A data point change will result in at most one `IfTrue` script being executed. This is useful when you want to perform an action on every point change, with the action depending on the point value.

Stateful

Examines each Entry Condition for each defined state in order, and executes the `OnEntry` script for the first true condition. Once the state has been entered, no further scripts will be executed until the Exit Condition for that state is met, at which time the `OnExit` script is executed and then each Entry Condition will be examined again to possibly enter a new state.

A data point change will result in at most one `OnExit` script and one `OnEntry` script being processed. This is used for conditions that consist of multiple mutually-exclusive states, similar to OPC A&E conditions.

Every State

Examines the Condition for every defined state, and if that condition is true then executes the `IfTrue` script.

A single data change could result in multiple `IfTrue` events being triggered. This is used when you simply want to specify a condition/action that gets re-evaluated on every point change.

OPC A&E Condition

This is a form of Stateful template that also generates data points that implement the data point format for OPC A&E Conditions. The OPC A&E server feature uses these points to create and transmit OPC Conditions to connected OPC A&E clients. This template also monitors the OPC A&E acknowledgement point for each condition to respond to acknowledgements from external clients.

This is used when you want to generate and manage OPC A&E alarms from process data.

OPC A&E Event

This is a form of Stateful template that also generates data points that implement OPC A&E Simple Events. This is used when you want to generate transient events from process data. Events will only be generated when there is a state change and an entry condition to a new state succeeds.

OPC A&E Event (Stateless)

This is a form of Stateless template that also generates data points that implement OPC A&E Simple Events. This is used when you want to generate transient events from process data. Events will be generated any time a trigger causes one of the state entry conditions to succeed.

OPC A&E Condition Alerter

This is a form of Stateless template that monitors OPC A&E Condition points provided by external OPC A&E servers. When an A&E condition event occurs, this template will extract the condition information and make it available to the Condition and `IfTrue` scripts to allow notification based on the A&E information.

This is used when you want to send an email, SMS, etc. based on OPC A&E events from an external OPC A&E server.

OPC A&E Event Alerter

This is a form of Stateless template that monitors OPC A&E event points provided by external OPC A&E servers. When an OPC A&E Simple or Tracking event occurs, this template will extract the event information and make it available to the Condition and `IfTrue` scripts.

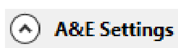
This is used when you want to send an email, SMS, etc. based on OPC A&E events from an external OPC A&E server.

Preset

The **Save as Preset** allows you to save any notification template for re-use. Once saved, the template name appears in the **Preset** drop-down list. Thereafter you can select from the Preset list to populate a new template, which you can then modify. Modifying the template does not modify the preset.

Template Definition

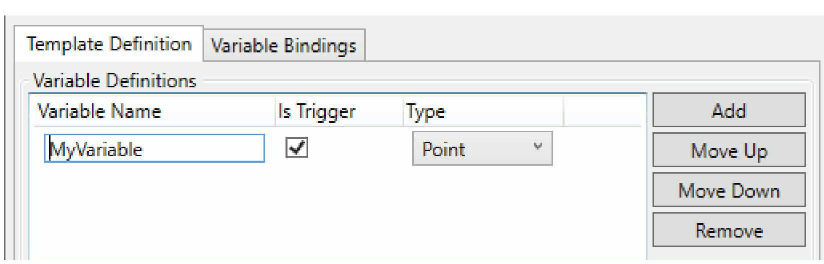
The DataHub instance uses templates to let you create many similar notifications from one source. Each template consists of variables associated with states and scripts, to which point values can be assigned.

Event Settings 

(for **OPC A&E Condition** and **OPC A&E Event** types only)

- **A&E Data Domain**: The DataHub data domain configured for OPC A&E data. This is where the OPC A&E data will be written. If you have also installed the OPC A&E feature then these events will be available to OPC A&E clients.
- **Condition Name**: For **OPC A&E Condition** only, a name for this condition.
- **Source (Script)**: The source of the A&E condition or event that can trigger a script. See Event Settings (Scripts) below.
- **Category**: The OPC A&E category for this condition or event.
- **Accept incomplete ACK**: Selecting this option allows you to acknowledge a condition by writing `1` to the corresponding point in `OPCAE:Ack.`*`condition-name`*. This provides the ability to acknowledge a condition from any data source.
- **OnAcknowledgeScript**: For **OPC A&E Condition** only, a **script** that runs when this condition is acknowledged.

Variable Definitions



Variable Name

A text string of only letters, numbers and the underscore (_) character, with no spaces or other characters, so that this name can be used as an identifier in a script.

Is Trigger

When selected, any change to point(s) assigned to this variable will trigger re-evaluation of the states, according to the Type of the template (Stateful, Stateless or Every State). Only points can be triggers.

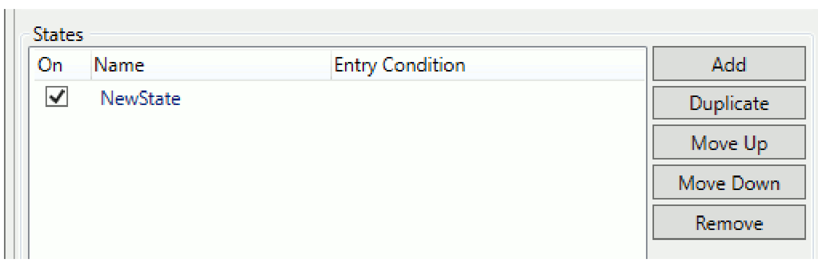
Type

One of:

- **Point**: a DataHub point, whose value, quality, and timestamp will be available to Condition and Action scripts.
- **Integer**: a 64-bit integer literal.
- **Double**: a double-precision floating point literal.
- **String**: a character string.

States

Notifications are based on the *state* of the system, which is determined by point values and possibly other factors.

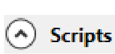


Each state has a **Name** and typically an **Entry Condition**, as defined in **State Properties**, below. The states are evaluated in sequence from the top to the bottom of the list. You can use the **Move Up** and **Move Down** buttons to change the order of evaluation.

State Properties

The state properties available depend on the **Type** defined for the template.

In **Settings**, the **Name** is a text string that identifies the state. States are evaluated when a data point that **Is Trigger** has a change in value or quality. The **Only trigger on Good quality** option indicates that a point change that has a bad quality should be ignored by this state.



Scripts run when the associated conditions are met. The options for scripts and conditions depend on the type of notification.

- For State, Stateless, and Alerter types, the `IfTrue` script runs whenever the

Condition is met.

- For Stateful, OPC A&E Conditions and OPC A&E Events types, the **OnEntry script** runs whenever the **Entry condition** is met while the action is in that state. If no `OnExit` script is specified then the **Exit** condition is defined to be the inverse of the **Entry** condition.

Some or all of the following properties are available for **OPC A&E Condition** and **OPC A&E Event Types**.

Event Settings (Scripts)

The Event Settings properties that are defined as scripts allow you to create strings that include action-specific information like the name of the trigger point. For example, if the trigger variable is called `MyTrigger`, then it may be helpful to define **Source (Script)** (see above) as `MyTrigger.Name` and **Message** as:

```
MyTrigger.Name + “ has reached “ + MyTrigger.Value
```

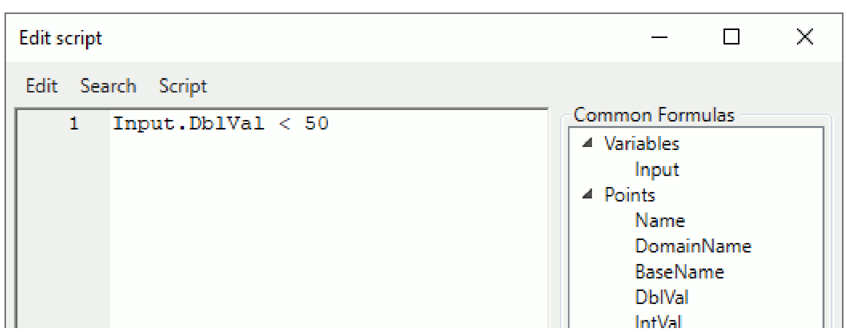
- **Message**: A message associated with the A&E condition or event.
- **Description**: A description of the A&E condition.
- **Definition**: A definition of the A&E condition.

Event Settings

- **Severity**: The severity of the A&E condition or event. Severity must be in the range of 1 to 1000.
- **Requires Ack**: Sets this OPC A&E condition as requiring acknowledgement if it enters this state.
- **Is Inactive State**: Sets this state of the A&E condition to an inactive state. OPC A&E clients often use this indicator to decide whether to display the condition to an operator.

Scripts

Scripts are used to set criteria for states and to assign notification actions.



The scripting language is S-Sharp, which is documented here.

Common Formulas

The script editor includes a list of common script formulas and fragments. You can position the edit cursor in the edit window, and then double-click any of the formulas to insert the text into the edit window. You can also make use of many classes and methods defined by the .NET framework.

- **Variables:** All of the variables you have defined for this template.
- **Points:** Properties of DataHub points that are accessed by using dot (`.`) syntax on a variable name, if that variable is of type Point.
- **Application:** Functions that are supplied by the application. Most of these functions correspond to similar MQTT Advanced Parer functions, which are documented in this section of the MQTT documentation.
- **Notifiers:** Any notifiers you have configured.
- **LogLevel:** Used in the “level” argument of the `app.Log` function.
- **PointQuality:** Each possible value of DataHub point quality. This is used as the *`quality`* argument in the app.WritePoint function.
- **Math:** A selection of common mathematical functions.
- **Statistics:** The available statistics for a point that is being tracked using the `app.Statistics` function

  Notification scripts can make use of sliding-window statistics to assist with more complex conditions. For example, you may only wish to generate a notification if a data point value has exceeded a threshold and it has been trending strongly upward over the past 60 seconds. To do that, you would need to know the slope of the recent values for that point.

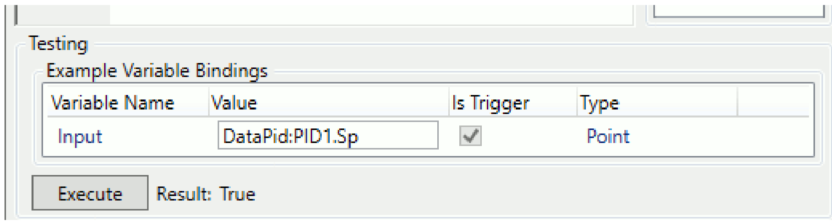
  When you include a formula of `app.Statistics(point, seconds)` in your script, the script engine will automatically begin collecting statistical information for that point, for a period specified in seconds, starting from the first execution of the script. Subsequent calls to the same formula will then have access to all of the statistical measurements available, computed over the time period (or less if statistics have been gathering for less than the time period). The available statistics are:

  - **Average:** A simple average of all measurements within the time period.
  - **TimeWeightedAverage:** The time weighted average of all measurements within the time period. Measurements that hold a value for a longer time will have a larger effect on this average.
  - **Count:** The number of measurements in the time period.
  - **Slope:** The slope of the linear regression `Y = mX + B` over the time period, producing `delta Y/day`.
  - **Intercept:** The X-intercept of the linear regression `Y = mX + B` over the time period, producing the date of `Y = 0`.
  - **SampleStdDev:** The sample standard deviation `(N-1)` of all measurements in the time period.
  - **SampleVariance:** The sample variance `(N-1)`.
  - **PopulationStdDev:** The population standard deviation `(N)`.

- **PopulationVariance:** The population variance `(N)`.

Testing

You can test your script by entering values for the variables and pressing the **Execute** button. This will execute just this script, as if its trigger condition had been met, using the variable values that you enter into the Testing area. You must supply values for all variables. If your script has side effects, such as sending an email or SMS message, then those side effects will occur.

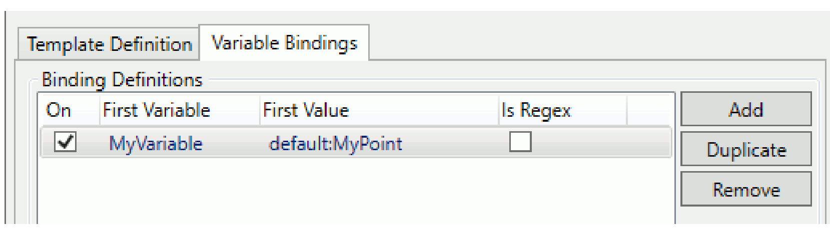


Variable Bindings

DataHub points and other values are bound to templates, providing an easy way to reuse and reconfigure notifications as needed. Binding is done by assigning points or values to template variables. In the Template Definition section you are supplying placeholders for data points and values. Here in the **Variable Bindings** section you are creating one or more sets of concrete values for those placeholders.

Binding Definitions

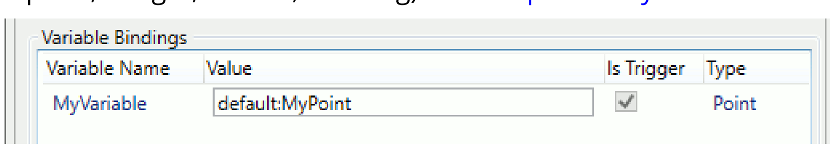
A binding definition is the set of all concrete values for a single instance of the action template. That is, each line of the **Binding Definitions** list specifies all the values for the variables in the template, and each line constitutes a distinct instance of the template. For example, if you want to generate a notification based on the water levels in `Tank1` and `Tank2`, you would create a separate binding definition for each of `Tank1` and `Tank2`. The template specifies how to handle notifications for tanks in general, and the two binding definitions then apply that to tanks 1 and 2.



Only the **First Variable** binding is displayed in this list to help you identify each binding definition.

Variable Bindings

Variables are bound by entering values according to each variable's **Type** (a DataHub point, integer, double, or string) defined previously.



The *first variable* in the binding definition is treated differently from the others. This variable can be defined as a regular expression instead of a simple string. This regular expression can match any number of data points, and each match will be treated as a distinct binding definition. This allows you to create a single binding definition that applies to all data points matching a pattern. Regular expressions use .NET Regex syntax. The comparison succeeds if the regular expression matches any part of the point name, so if you want a full string match ensure that the regular expression is bounded by the ^ and $ characters (start and end of string respectively).

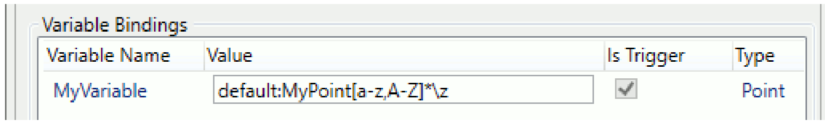
For example, if we have 2 tanks, whose levels visible in the points `Plant:Tank1.level` and `Plant:Tank2.level`, then the pattern `Plant:Tank[0-9]+\.level` will match any point whose name is `Plant:Tank` followed by any sequence of digits, followed by the string `.level`. Thus, this one binding will apply to both tanks. If we later add a third tank, named `Plant:Tank3.level`, then this binding will apply automatically to it without any change to the notification configuration.

When the first variable binding is a regular expression, we may also want to make other variable bindings relate to that regular expression. For example, we may want to create a new point, `Plant:Tank1.alarm`, which has a value of `0` in normal operation and `1` when the level is too high. In that case, we would have two variables, named `Input` and `Output` where `Input` is `Plant:Tank1.level`, and `Output` is `Plant:Tank1.alarm`. The `OnEnter` and `OnExit` scripts in the notification template would write values of `0` or `1` to the `Output` variable as appropriate.

However, if we use a regular expression to match all tanks, then we need a way to say that `Output` is `Plant:Tank1.alarm` when `Input` is `Plant:Tank1.level`, but `Output` is `Plant:Tank2.alarm` when `Input` is `Plant:Tank2.level`, and so on. We can accomplish this with regular expression *captures*. A capture is a portion of the input string that matches a portion of the regular expression. Captures are denoted by parentheses in the regular expression.

For example, in our tank expression, `Plant:Tank[0-9]+\.level` we would like to identify the numeric sub-expression and use it to define `Plant:TankN.alarm`, where `N` is any number. We do this by adding parentheses around the numeric portion of the expression: `Plant:Tank([0-9]+)\.level`. This will result in a capture that contains only the digits after the word `Tank`. There can be multiple captures in the regular expression, and they will be numbered in order starting from zero.

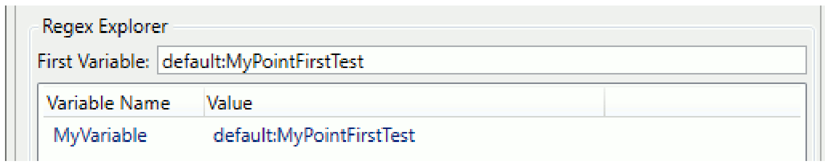
Now, to construct an alarm point name that corresponds to the level point, we can define `Output` as `Plant:Tank{0}.alarm`. The `{N}` syntax tells the binding to substitute the Nth capture from the regular expression in the `Input` variable into that position in the binding of the `Output` variable. In this example we want the first capture, which is `{0}`. You cannot use the `{N}` syntax in the first variable binding, since that is the regular expression binding that produces the captures. Captures are strings, so numeric .NET format substitution qualifiers cannot be used.



An explanation of the use and syntax of .NET Regular Expressions can be found here. Please see Regular Expressions in the Making Notifications chapter for an example.

Regex Explorer

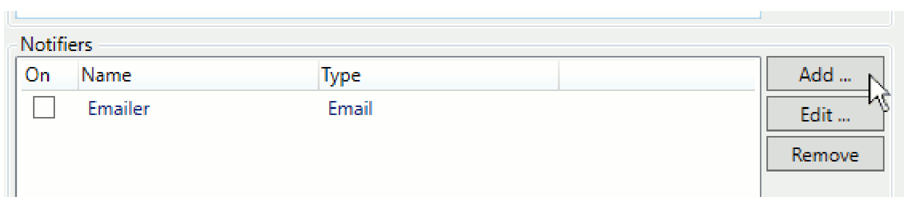
You can use the Regex Explorer to see how a regular expression will be implemented.



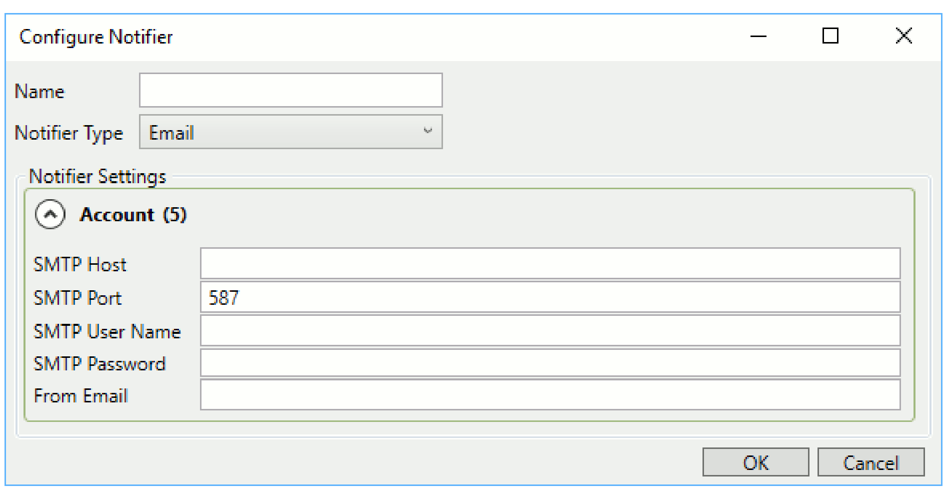
In the **First Variable** entry field, enter the name of a data point. If it meets the criteria of the regular expression, it will be displayed in the **Value** column. All other variables in the binding definition will be displayed, with the capture substitutions shown so you can verify that both the regular expression and its captures are what you intend.

Notifiers

To add a notification template, press the **Add** button...



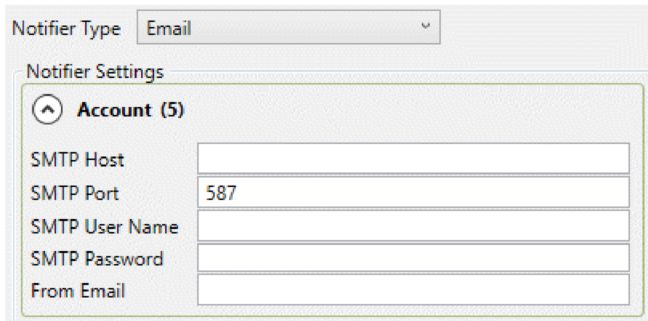
...to open the **Configure Notifier** window:



Enter a **Name** to name this notifier. The name must be a text string consisting of only letters, numbers and the underscore (_) character, with no spaces or other characters, so that it can be used as an identifier in a script.

Then choose one of the following, and enter the necessary details:

- **Email**



SMTP Host, **SMTP Port**, **SMTP User Name**, **SMTP Password**,

The appropriate entries for the SMTP account from which the emails will be sent. Email is always sent using TLS. Attempts to send email via a plain-text email server will fail.

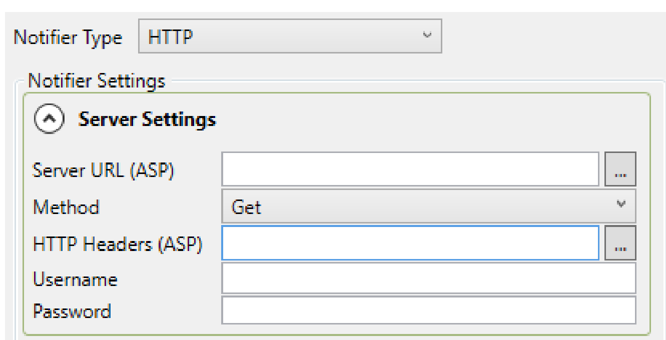
From Email

The email address from which the emails will be sent.

- **HTTP**

This option allows you to emit data to an HTTP server, like an SMS gateway.

Currently in the proof-of-concept stage.



Server URL (ASP)

The URL for the HTTP server that this notifier will connect to.

Method

The HTTP method (GET or POST) for this notifier.

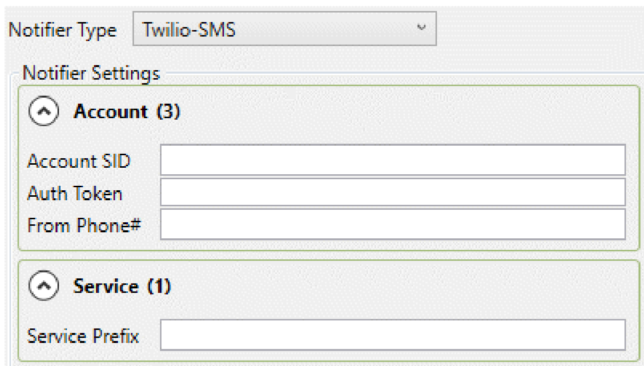
HTTP Headers (ASP)

ASP code that will be added to the HTTP message header.

Username and **Password**

The user name and password required by the HTTP server.

- **Twilio**



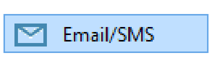
Account SID, **Auth Token**, **From Phone#**

The service ID, authentication token, and phone number for the account from which the text messages will be sent. This information is available from your Twilio account. If your Twilio account is being managed by Skkynet then you should have received this information from them.

Service Prefix

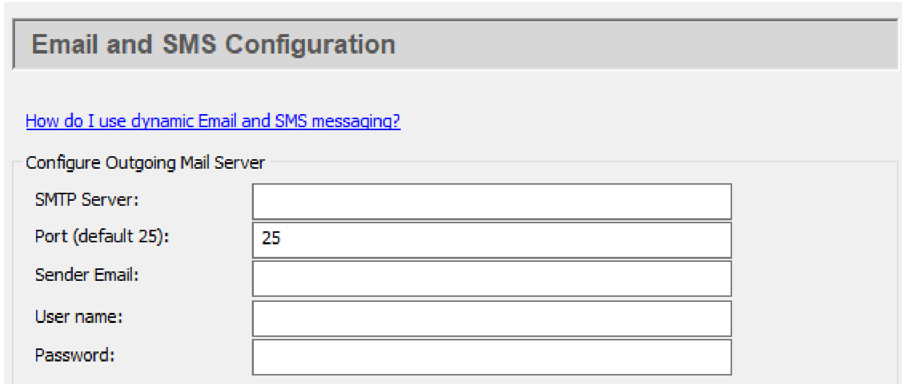
The Twilio service prefix for the service you are using. The defaults are blank for **Twilio-SMS** and `whatsapp` for **Twilio-WhatsApp**. As more Twilio services become available, you can use this service prefix to direct the messages to other social networks and delivery mechanisms.

Email/SMS



The Email/SMS option lets you configure the DataHub program to send emails and SMS text messages. The outgoing mail server is configured once, and each email message is configured separately.

For more information about sending emails and SMS messages, please refer to *Email and SMS*.



Configure Outgoing Mail Server

SMTP Server:

The name of the SMTP server. You can use the same SMTP server listed in your email client program.

Port (default 25):

The SMTP port number (typically this is port 25).

Sender Email:

The email address of the sender. This will appear in the `From` field of the email.

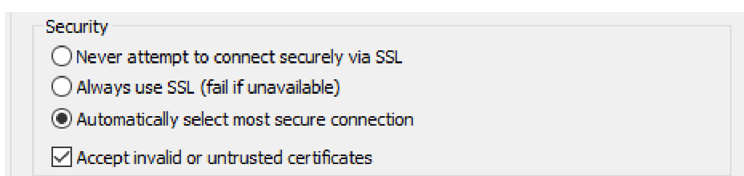
User name:

The log-in name you use to access this SMTP account.

Password:

The applicable password.

Security



Never attempt to connect securely via SSL

Ensures that SSL is not used.

Always use SSL (fail if unavailable)

Ensures that SSL is always used, and that any connection attempt without it will fail.

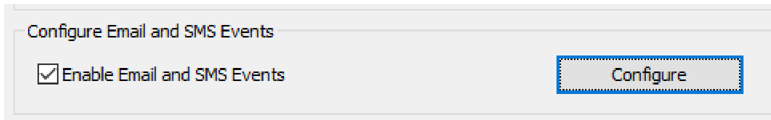
Automatically select most secure connection

Allows the DataHub instance to choose the most secure type of connection available on the mail server.

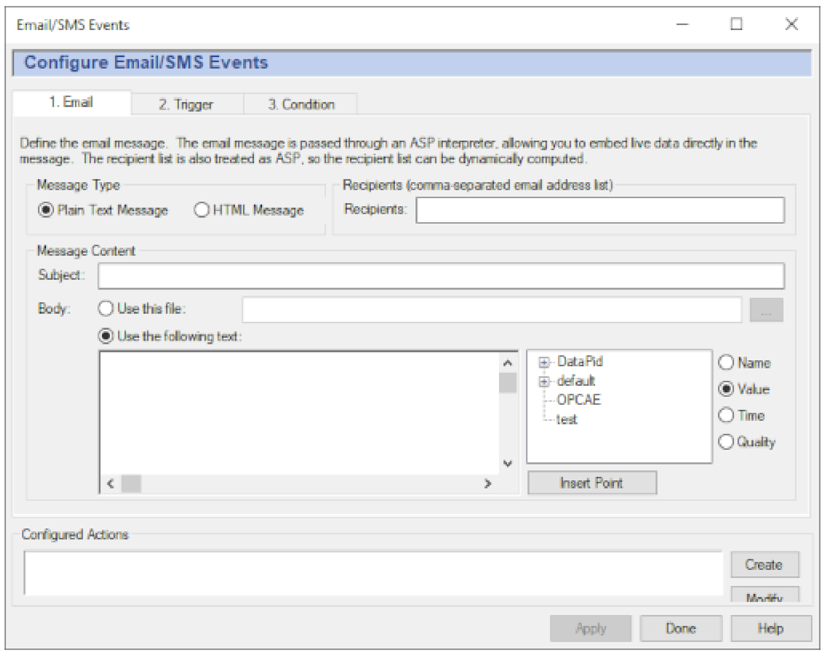
Accept invalid or untrusted certificates
Ignores security certificate warnings.

Click the **OK** button to submit your entries.

Configure Email and SMS Events



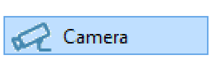
To Configure Emails press the **Configure** button to open the Email/SMS Events window:



A complete explanation for this window can be found in *Email and SMS*, starting with the Sending a Test Message.

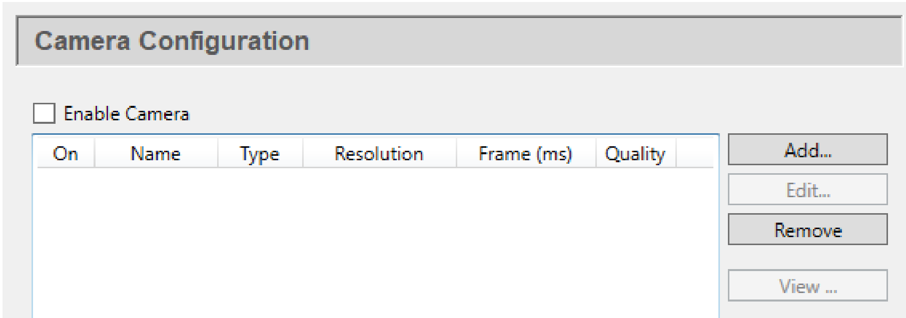
Click the **OK** button to submit your entries.

Camera



The Camera option allows you to stream images and videos from USB cameras, as well as from IP cameras that implement standard JPG and Motion JPG interfaces. This allows the DataHub program to collect video from any compliant camera on your network and make the video frames available as data points that can be tunneled and processed by any DataHub client.

Click here to watch a video.

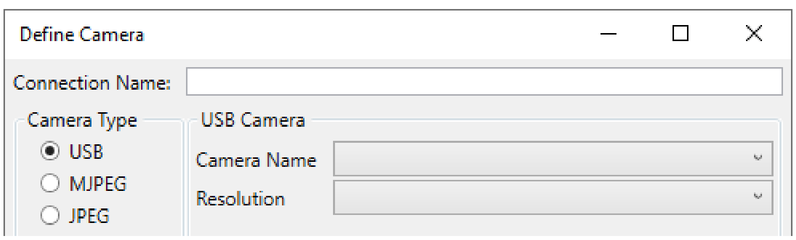


Check the **Enable Camera** box to enable a camera. You can configure as many cameras as your system resources will allow, and activate each one using its corresponding **On** check box in the list.

To add a new camera, click the **Add** button. To edit the configuration of an existing camera, double-click it here, or select it and press the **Edit** button, which opens the **Define Camera** window (see below). To remove a camera configuration, highlight it and click the **Remove** button. To view a camera's output, click the **View** button.

Define Camera

To add a new camera, press the **Add** button, which opens the **Define Camera** window. Enter any name for the **Connection Name**.



Camera Type: USB

Camera Name:

Choose a camera that is available on your system.

Resolution

The resolution of the camera image, in pixels, along with the number of frames per second that a video image will be captured.

Frame Timing (ms)

The time lag between each frame, in milliseconds.

Camera Type: MJPEG or JPEG

URL

The URL for the camera data. An IP camera usually exposes multiple URLs, for different purposes. Check your camera documentation, and choose the URL that gives a client access to the raw JPG images, or to the Motion JPG feed.

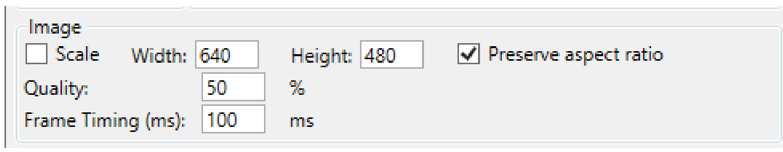
User name

The user name for this camera.

Password

The corresponding password for this camera.

Image



Scale

Allows you to scale the original image, according to these parameters:

Width

A maximum width, in pixels.

Height

A maximum height in pixels.

Preserve aspect ratio

Ensure that the image keeps it original aspect ratio, potentially overriding one of the above entries.

Quality

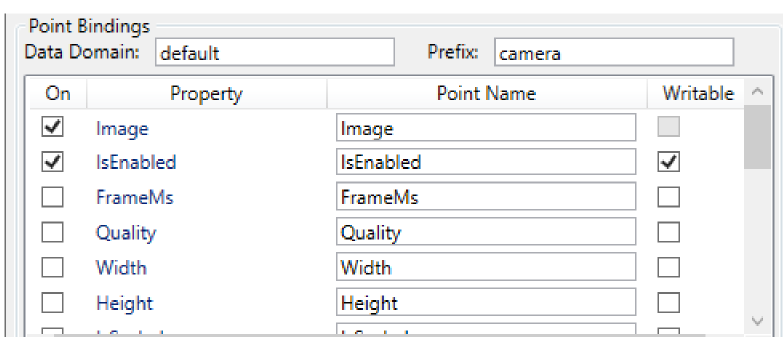
The picture quality, expressed as a percent. Where high resolution image quality is not needed, lowering this setting can significantly conserve system resources.

Frame Timing (ms)

The time lag between each frame, in milliseconds.

Point Bindings

Enabling any or all of these point bindings allows you to monitor the camera settings as DataHub points. By checking the **Writeable** option, you can make changes to these settings at run time.



Data Domain

Allows you to create or specify the DataHub data domain for these points.

Prefix

Allows you to append an identical prefix to the name of each point. This is helpful when multiple cameras have been configured.

On

Turns the point binding on or off.

Property

The camera property associated with the point.

Point Name

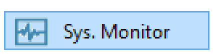
The point name for the camera property, which can be edited.

Writeable

Determines whether a user can write back to this point to control the camera or modify its settings.

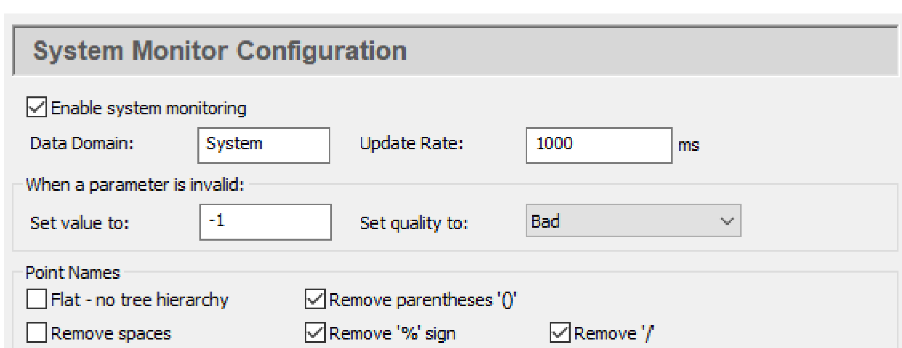
The **Pan**, **Tilt**, **Zoom**, **Roll**, **Exposure**, **Focus**, and **Iris** properties may or may not be supported, depending on the camera hardware.

System Monitor



The System Monitor option allows you to access any system performance data item, such as CPU usage, memory usage, process ID, disk space, network traffic, etc. with the DataHub program.

For example, by monitoring process ID you could determine whether a particular process is running or not. Any information accessed here becomes part of the DataHub data set, and can thus be tunneled across the network, used in scripts or as email triggers, viewed in a spreadsheet, stored in a database, etc.



To enable system monitoring, check the **Enable system monitoring** box. There are several configuration options.

Data Domain:

The name of any DataHub data domain. The values retrieved from the system will be shown as points in this data domain.

Update Rate:

The frequency that the system is polled and all selected points are updated. The minimum polling time is 100 ms., so the value entered here cannot be less than `100`.

A high update rate (a low number here) for many data points could use a great deal of CPU.

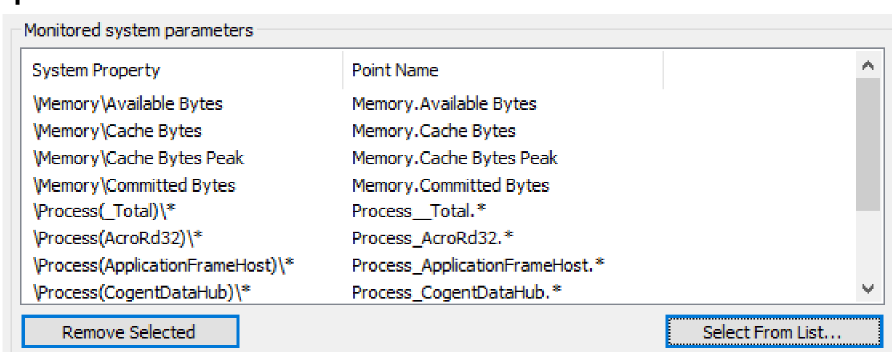
When a parameter is invalid

A parameter will be invalid if the object being monitored is not available. For example, if a process is not running then the parameters for that process will all be invalid. This is a useful way to monitor a system process or other object. For example, you could use a script or other client to watch a process ID, and when the process ID becomes `-1` you could generate an alarm indicating that the process is no longer running.

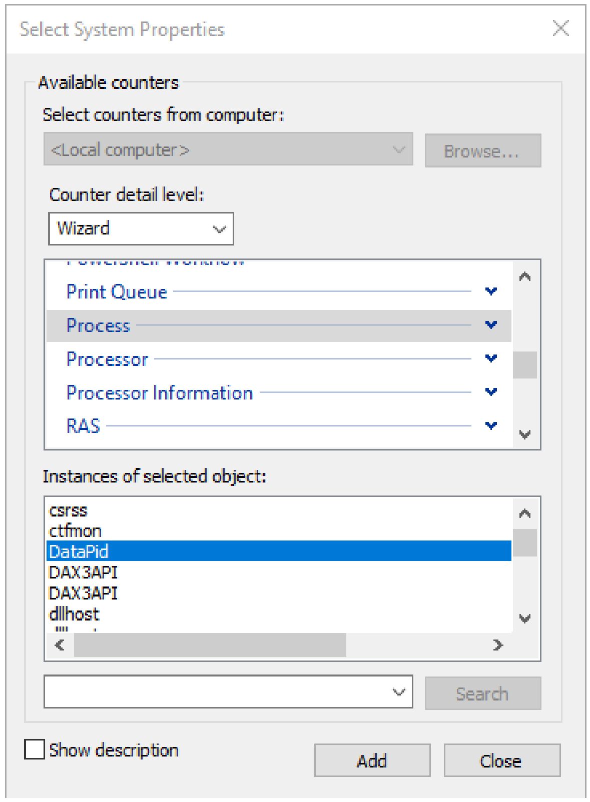
Point Names

The System Monitor automatically creates DataHub point names based on the names of the system properties. Some client programs cannot work with point names containing special characters. This section allows you to specify which characters will be removed from the property name when constructing the point name.

Monitored system parameters



This list shows the system properties you have chosen, and their corresponding point names in the DataHub instance. To add names to the list, click the **Select From List** button. This will open the Select System Properties dialog:



Depending on your system, this dialog may take a few seconds to appear. If it does not come up, the Event Log will contain a message. Otherwise, just be patient, it will open eventually.

In the Select System Properties dialog you can specify which items to add to your list of monitored system properties, according to these criteria:

- **Performance object** A list of all available objects, such as CPU, Memory, Process, Print Queue, TCP, etc.
- **Counters** All of the available data categories related to the selected performance object. You can choose all counters, or select specific counters from the list. The **Explain** button opens a window with an explanation of the selected counter.
- **Instances** All of the instances of the chosen performance object. For example, if you chose Process for your performance, this list will show all of the processes running on your system. You can choose all processes or select specific processes from the list.

  A number in this list normally indicates a selection from multiple objects of a given type, and `_Total` means the total across all of the objects. For example, if you are looking at `Processor` in a multi-processor machine, you will see a number (`0`, `1`, etc.) for each processor and a `_Total` for the cumulative statistic over all processors.

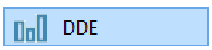
1. Select a performance object, and counters and instances as applicable.
2. Click the **Add** button to add the selected items to the **Monitor system parameter** list

in the DataHub Properties window.

3. Click the **Apply** or **OK** button in the Properties window when you are finished making your choices and filling the list, to apply your changes. You should be able to view the results in the Data Browser.

   If you change your mind on what points to monitor, you can change the list at any time. Any points you remove from the list will continue to exist in the DataHub instance until it is shut down and restarted. Please refer to the section called “Data Points” for more information on creating and deleting points.

DDE



The DDE option lets you configure the DataHub program to act as a DDE client and/or DDE server for **DDEAdvise** messages. For more information on DDE, please refer to the section called “DDE Protocol” and Appendix G, *DDE Overview*.

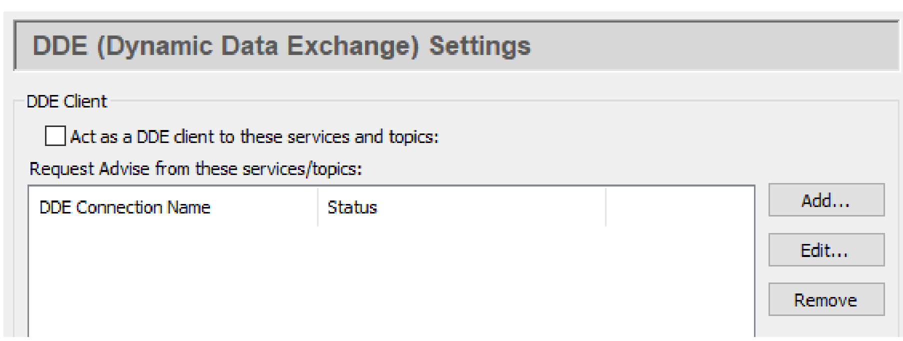
For information about connecting to Excel using DDE, please refer to *Excel Connections* For flexible Excel networking without DDE, see DataHub™ Add-in for Microsoft Excel..

Click here to watch a video.

DDE Client

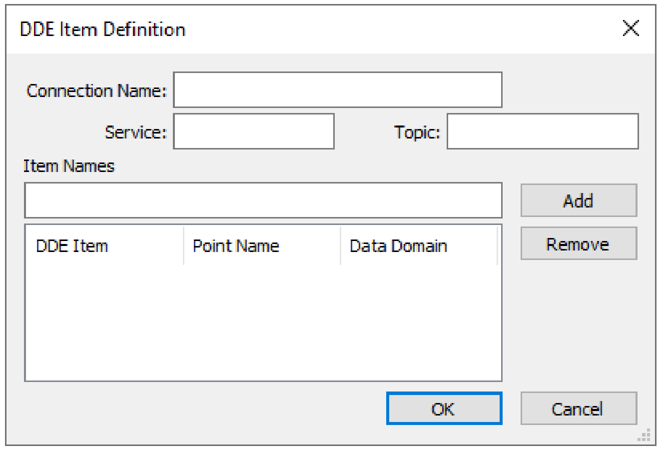
To act as a DDE client, check the **Act as a DDE client** box.

For best performance, ensure that a DDE server is running when using the DataHub instance as a DDE client. A DDE client can consume substantial system resources trying to connect if a DDE server is not available.



To add a new service or topic, press the **Add** button. To edit a service/topic, double-click it or select it and press the **Edit**. To remove a service/topic, select it and press the **Remove** button.

Double-click a selection, or pressing the **Add** or **Edit** button opens the **DDE Item Definition** Window:



Here is what must be entered:

Connection Name

A name used by the DataHub instance to identify the connection. There should be no spaces in the name. It doesn't matter what name is chosen, but it should be unique to other connection names. Each connection can have only one Service and one Topic, but it can have multiple Items.

Service

The service name of the DDE server to this client.

Topic

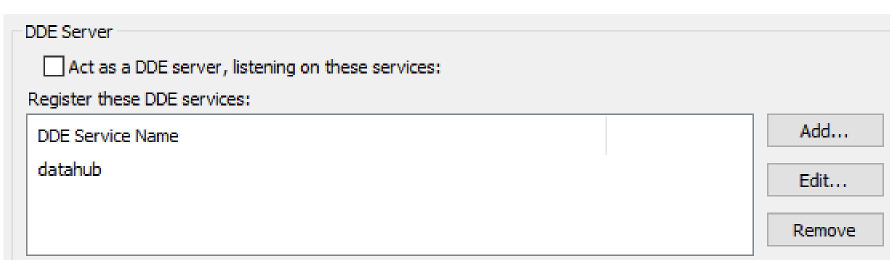
The DDE topic under which the data will be sent.

Item Names

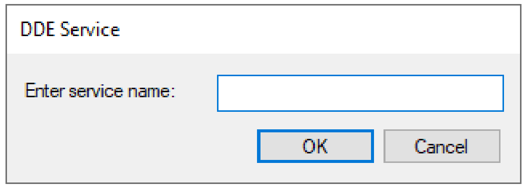
The DDE item name, which corresponds to a point name in the DataHub instance. If that point doesn't exist in the DataHub instance, it will be created. Enter a name for each item and press the **Add** button to add items. To remove an item, highlight it and press the **Remove** button. Once all the information is entered correctly, press the **OK** button to enter the definition.

DDE Server

To have the DataHub instance act as a DDE server, check the **Act as a DDE server** box. The default service name is `datahub`.



To add a DDE service name to the list, click the **Add** button and enter the name in the **DDE Service** Window:

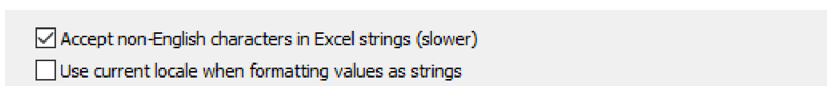


To edit a DDE service name, double-click it or select it and press the **Edit**. To remove a DDE service name, select it and press the **Remove** button.

It is currently possible to have more than one instance of the DataHub program, with one or more DDE service names in common, running on a single machine. If you plan to configure a system like this, you should ensure that each DataHub instance has unique data domain names. Otherwise, when any two of those DataHub instances are acting as servers, it is not possible to predict which one of them a given client will send data to.

Options

These options affect both server and client behavior.



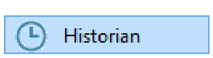
Accept non-English characters in Excel strings (slower)

This causes Excel to send strings of Unicode characters correctly, although slower than numerical data.

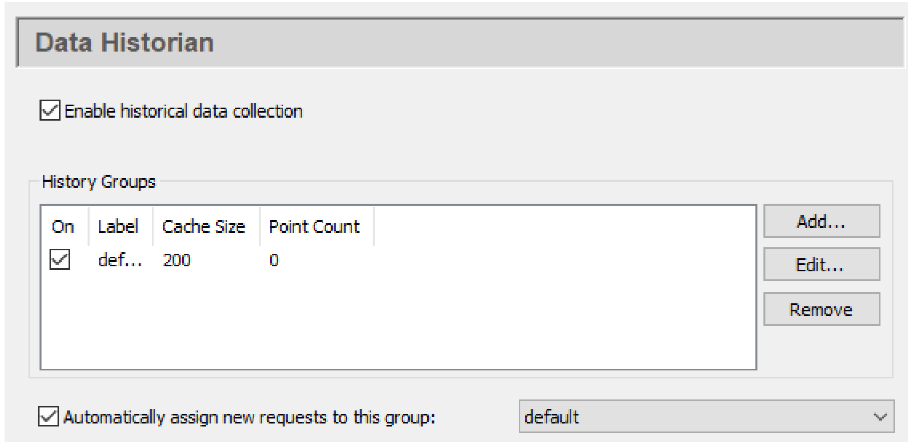
Use current locale when formatting values as strings

This will cause the DataHub instance to transmit and receive floating point values according to the current locale. For example, the value `123,456.789` in a North American locale might be `123.456,789` in a European locale.

Historian



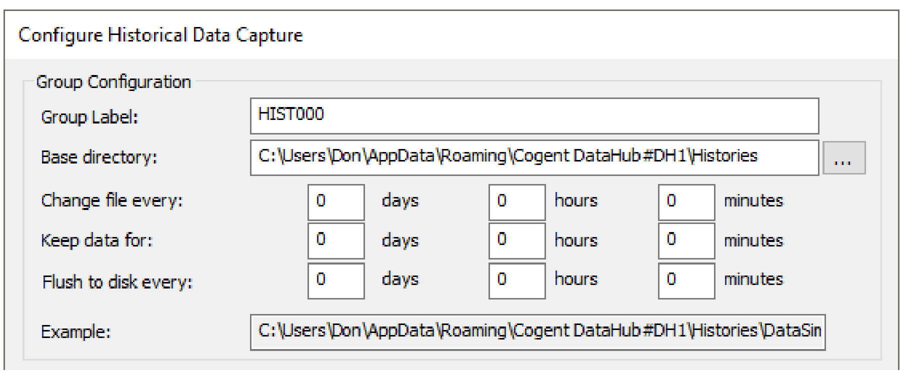
The Historian option allows you to collect and store histories for groups of data points. It gets configured automatically by the Quick Trend option, and can be configured manually as well.



Check the **Enable historical data collection** box to enable the Historian. Histories for one or more points are created and stored in groups. You can create as many groups as your system resources will allow, and activate the data collection for that group using its corresponding **On** check box in the list. To edit a history group, double-click it here, or select it and press the **Edit** button to open the **Configure Historical Data Capture** window (see below). To remove a group, highlight it and click the **Remove** button.

Group Configuration

To add a history group, press the **Add** button, which opens the **Configure Historical Data Capture** window:



Group label:
: Any text string, used to identify the group. The DataHub instance will assign a numbered label by default if nothing else is specified.

Base directory:
: The directory in which the histories will be stored.

Change file every:
: How often to close a recorded history file, and open another.

Keep data for:
: How long to store data on disk.

Flush to disk every:

How often to flush the data from memory and write it to disk.

Example:

The directory tree and example filename that the history will be written to.

Deadband

A deadband is used to reduce the amount of data stored by only storing data if there is a significant change in value. This approach is superior to simply reducing the sampling frequency, which will lose information when data changes quickly, and will waste storage by saving the same values when data doesn't change. The deadband approach defines a resolution below which changes in data are deemed to be 'noise' and therefore ignored.

Absolute change:

Sets the deadband range to a single value. Any new value differing from the *baseline* (current value) by less than the number entered here will not be recorded. If a value's difference from the baseline is greater than or equal to this number, that value gets recorded and it becomes the new baseline for the absolute change deadband.

Percent change:

Sets the deadband range to be a percent of the last logged data value. Every new value is compared to that value, and if their percentage difference is less than the number entered here, the new value will not be recorded. If the difference is greater than or equal to this number, the value is recorded and that value becomes the new baseline for the percent change deadband.

If absolute change and percent change are used together there is an AND relationship between them. The Historian will ignore any value falling within either deadband. Only those values falling outside all deadbands (or equal to the outermost) will be recorded.

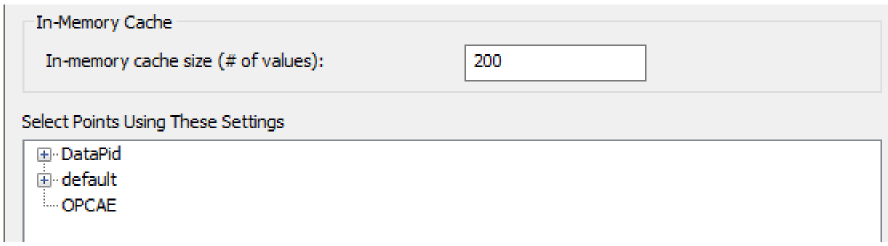
Maximum time between values:

Sets the maximum time period (in seconds, a real number) to deadband. When the maximum time is reached, the next new value received will be recorded, even if its value doesn't exceed the deadband. Note that the system does not automatically generate and insert a value when the maximum time is reached; it waits for the next new value. Whenever a new value is recorded the time calculation is restarted. If the maximum time parameter is not used, there is no time limit on how many values are ignored within a deadband.

Maximum number of skipped values:

Sets a maximum number of values to skip for the deadband. When the maximum number is reached, the next new value will be recorded, even if it doesn't exceed the deadband. Whenever a new value is recorded the *countlimit* is restarted. If the *countlimit* parameter is not used, there is no count limit on how many values are ignored within a deadband.

In-Memory Cache



In-memory cache size (# of values):

Determines the amount of memory allocated to storing values. This is specified by entering a number of values.

Select Points Using These Settings

Any number of points can be selected for the group, using the selection tree.

Click the **OK** button to save the group configuration and return to the Historian section of the Properties window. Then click the **OK** or **Apply** button in the Properties window to ensure t

Querying Data in the Historian

It is possible to query the Historian to extract raw data as well as statistics like minimums, maximums, averages, variances, standard deviations and so on over a given time period. This is done with a script that accesses the `Historian` class, explained in detail with an example in the DataHub Scripting manual.

Historian File Format

The format for the Historian files consists of consecutive records as follows:

timestamp

An 8-byte floating point number indicating the number of seconds since January 1, 1970 00:00:00, UTC time, in IEEE floating point format.

value

An 8-byte floating point number, in IEEE floating point format.

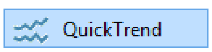
quality

A 2-byte integer number encoding OPC quality, in little-endian order (Intel byte order):

```
OPC_QUALITY_MASK = 0xc0;
OPC_STATUS_MASK = 0xfc;
OPC_LIMIT_MASK = 0x3;
OPC_QUALITY_BAD = 0;
```

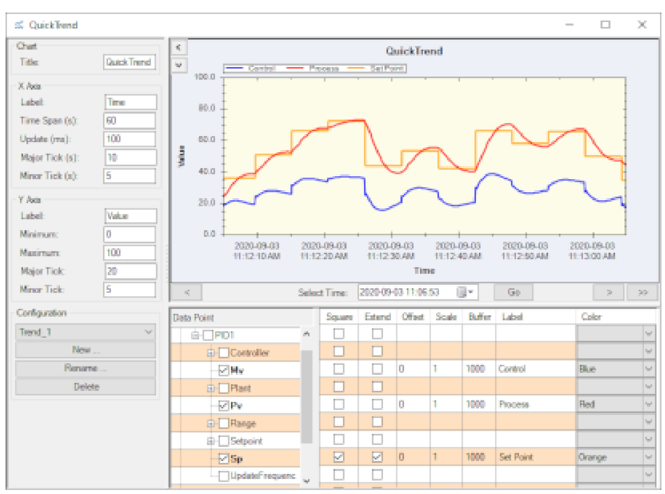
```
OPC_QUALITY_UNCERTAIN = 0x40;
OPC_QUALITY_GOOD = 0xc0;
OPC_QUALITY_CONFIG_ERROR = 0x4;
OPC_QUALITY_NOT_CONNECTED = 0x8;
OPC_QUALITY_DEVICE_FAILURE = 0xc;
OPC_QUALITY_SENSOR_FAILURE = 0x10;
OPC_QUALITY_LAST_KNOWN = 0x14;
OPC_QUALITY_COMM_FAILURE = 0x18;
OPC_QUALITY_OUT_OF_SERVICE = 0x1c;
OPC_QUALITY_WAITING_FOR_INITIAL_DATA = 0x20;
OPC_QUALITY_LAST_USABLE = 0x44;
OPC_QUALITY_SENSOR_CAL = 0x50;
OPC_QUALITY_EGU_EXCEEDED = 0x54;
OPC_QUALITY_SUB_NORMAL = 0x58;
OPC_QUALITY_LOCAL_OVERRIDE = 0xd8;
```

Quick Trend



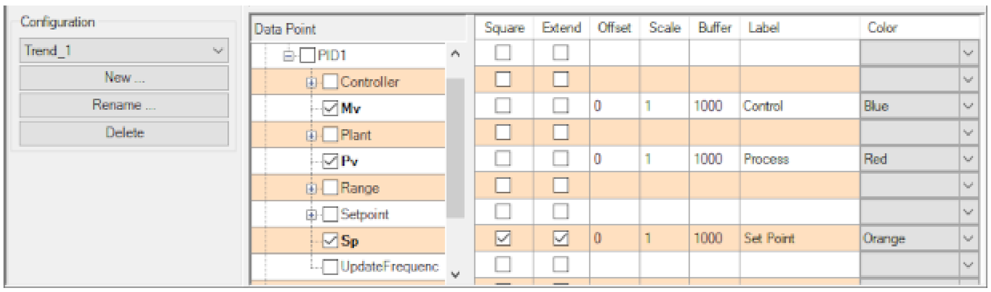
The QuickTrend option lets you create a live trending graph for any number of data points in any DataHub data domain. It automatically configures the DataHub Historian or the selected External Historian for all enabled points. You can configure the X and Y axes of the graph, zoom in on a particular area, and apply offsets and scales to raw data to plot widely disparate values together in a single chart.

To configure a quick trend, press the **Open quick trend window** button:



Configuration

QuickTrend supports multiple display configurations, which you can manage using the **Configuration** options. The top button opens a dropdown list that contains all named configurations. The **New...**, **Rename...**, and **Delete** buttons let you create, rename, and delete configurations.



Data Points

You can select any number of data points to trend, from any data domain. Any point you select gets added automatically to the DataHub Historian or the selected External Historian configuration. The following options determine how the data will display in the chart.

Square
: Removes interpolation of the line between two data changes, giving the plot a step-like appearance. This is useful for square functions.

Extend
: When checked, this option extends the plot of a point's value as a straight line until the point changes value. With this option unchecked, no plot is shown until a point changes value. Then a straight line is plotted connecting the original value to the new value.

Offset
: A value entered here will be added to each value of the point, creating an offset plot. This lets you view widely differing values in the same window.

Scale
: A value entered here will be multiplied by each value of the point, creating an enhanced (or diminished if a fractional value) plot.

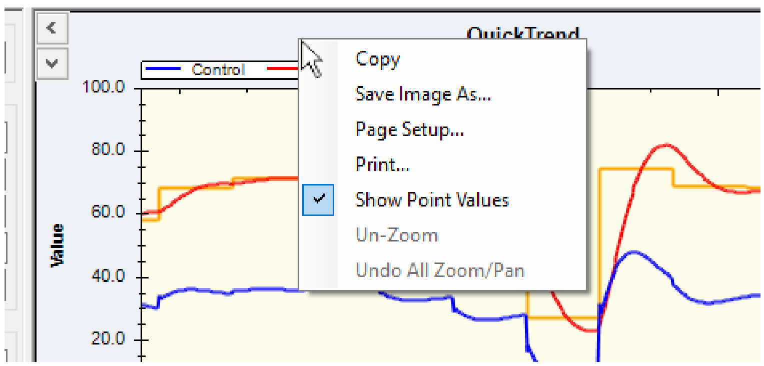
Buffer
: This value determines how many data changes for this point will be stored in the local history, to allow for scrollbacks to review recently plotted data.

Label
: Allows you to change the label for the point, whose default is the simple point name.

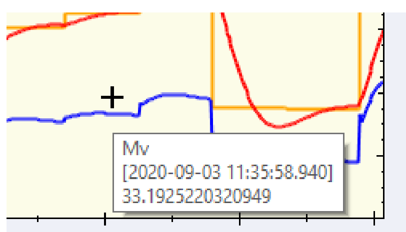
Working with the Display

There are a few features of the display that are not immediately obvious.

- You can scroll backwards and forwards through the history of the trend using the left and right arrow buttons, or choose a specific date and time with the calendar and time selector. The double-right arrow button returns the display to real-time trending.
- You can resize the trend display by dragging the gray borders on the left side or bottom. Move the mouse until you see a white, double-headed arrow, and drag.
- To zoom in to a part of the display, drag the mouse over the area that you want to zoom in on. To zoom back out and resume real-time trending, click on the **Reset Pan/Zoom** button at the bottom of the window.
- To show a constant value as a horizontal line, you can simply create a DataHub point whose value never changes, create a plot for it, and check the **Square** and **Extend** options.
- For other features, the QuickTrend display has a menu available on a right mouse-click.



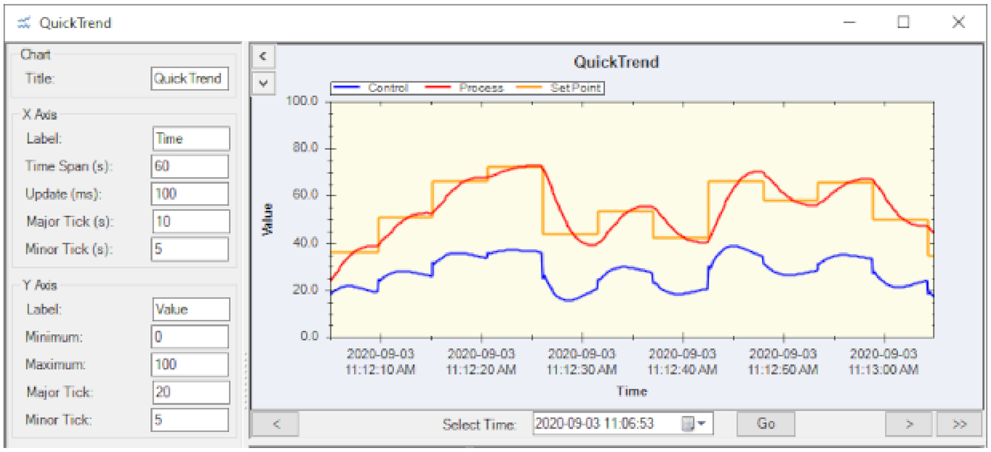
Using this menu you can copy, save, or print the current display, as well as unzoom and undo a zoom or pan. You can also hide or show point values, and reset the scale to the default.



Chart

Title:

The name of the chart, which will appear at the top.



X Axis

The X axis displays the time coordinate.

Label:
: Any text string, displays at the bottom of the chart.

Time Span (s):
: The total number of seconds that the chart will span.

Update (ms):
: The update rate for the trend, in milliseconds.

Major Tick (s):
: The time interval between major tick marks, in seconds.

Minor Tick (s):
: The time interval between minor tick marks, in seconds.

Y Axis

The Y axis displays the value coordinate.

Label:
: Any text string, displays at the far left of the chart.

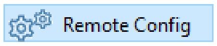
Minimum:
: The minimum value to include in the chart.

Maximum:
: The maximum value to include in the chart.

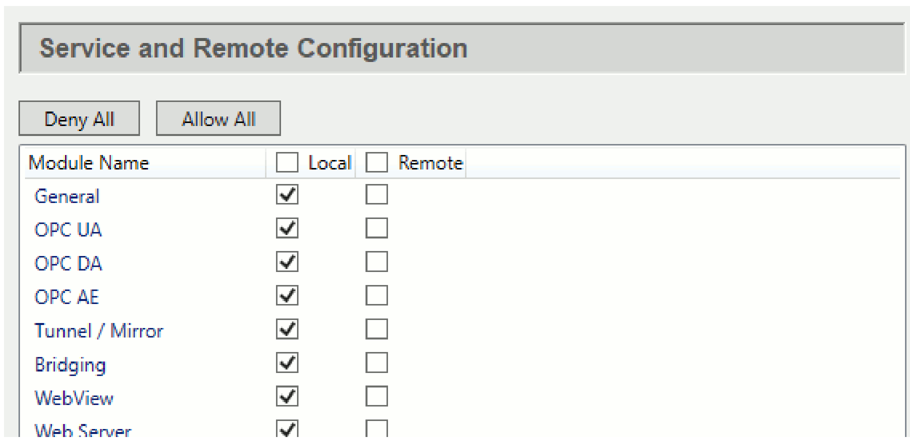
Major Tick:
: The value between major tick marks.

Minor Tick:
: The value between minor tick marks.

Remote Config



The DataHub installation includes the Remote Config program, a tool that lets you connect to the DataHub program while it is running as a Windows service, or when it is running on a different computer on the network. The Remote Config option here in the Properties window lets you specify what configuration options the Remote Config program will have access to.

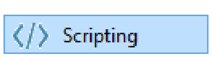


You must configure the DataHub program to allow remote configuration for any features that you wish to be able to remotely configure. For example, you may want to remotely configure Tunnel connections, but not allow scripts to be configured except from the local computer.

Check the boxes of the features you want to be configurable. Checking a box in the **Local** column allows connections only from the Remote Config program running on the same machine, whereas boxes in the **Remote** column allow connections from the Remote Config program running on a remote machine. If you uncheck **Local** and check **Remote**, then a user on the local machine will not be able to configure that feature. The **Deny All** and **Allow All** buttons uncheck or check all the boxes.

For more information on using the Remote Config program, please refer to the Remote Config section.

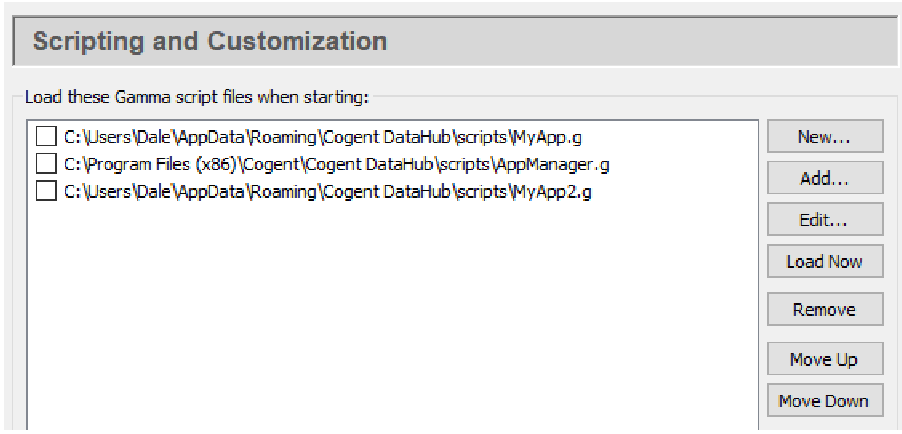
Scripting



The Scripting option lets you write, edit, and run scripts, as well as work with configuration files. Please refer to the DataHub Scripting manual for more details.

Load these Gamma script files when starting:

Here you can create and access Gamma scripts.



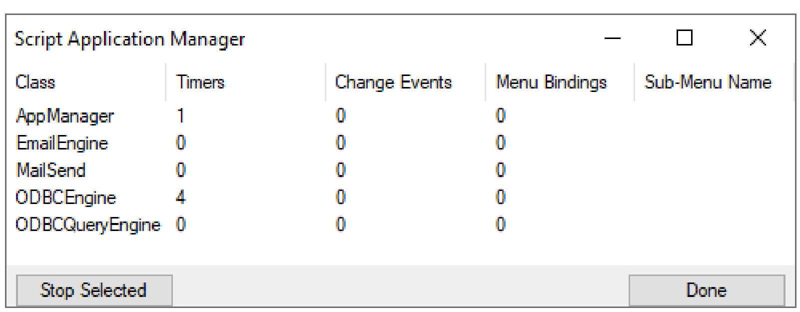
The DataHub Scripting manual has a more complete explanation for these options, but briefly they are as follows:

- **New** creates a new script from parameters you specify.
- **Add** lets you add a script to the list.
- **Edit** opens the script in the Script Log for editing.
- **Load Now** loads the selected script into the Gamma interpreter for immediate processing.
- **Remove** deletes the selected script from the list.
- **Move Up** and **Move Down** move the selected script up and down in the list

Script Manager

The DataHub Script Application Manager let you view a list of scripts and stop a running script. To access it, press the **Script Manager** button.

This will open the Script Application Manager window:



To stop a script, highlight it, and press the **Stop Selected** button.

The columns display the following information:

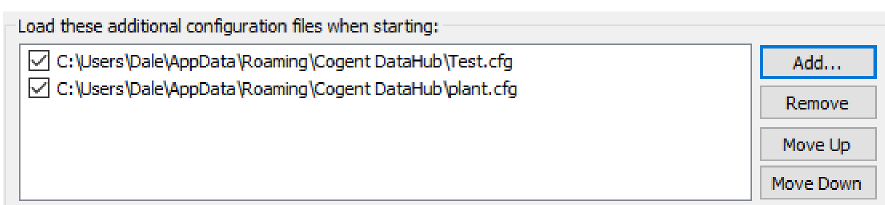
- **Class**: the name of the instance of the Application class created in the script.
- **Timers**: the number of timers active in this script.
- **Change Events**: the number of change events active in this script.
- **Menu Bindings**: the number of menu entries that this script has placed in the system tray menu.
- **Sub-Menu Name**: the name of the submenu in the system tray menu into which this script has placed its menu entries.

Load these additional configuration files when starting:

Configuration files let you start a DataHub instance from a known configuration. Normally there is one configuration file that comes with the DataHub distribution. Each change you make in the Properties window gets written to that file automatically, and saved. However, it is also possible to create and/or edit configuration files with a text editor (see the section called "Configuration Files").

Any additional configuration files must be listed here in order to be read by the DataHub instance. The files in the list are used in order from the top down, with the last file taking precedence. That is, if a value is assigned to a variable from within a configuration file, its value will be changed by subsequent assignments, whether they come from within that config file or from any other.

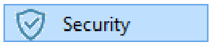
Creating or editing configuration files should only be attempted by experienced users.



The **Add** button opens a standard file browsing window, from which you can choose configuration files to add. The **Remove** button removes the configuration file that is highlighted.

The **Move Up** and **Move Down** buttons rearrange the order of the configuration files. Order is important. These files are read from the top down; variables change with each subsequent assignment, taking on the last value assigned.

Security



The Security option lets you configure permissions for your DataHub user accounts as well as for MQTT, OPC Classic, OPC UA, tunnel/mirror, TCP, and DDE connections. For more information and how-to instructions for DataHub security, please see Using Security.

The DataHub security model in version 11 is entirely different from previous versions, and uses a different database file. Instead of `settings.sqlite`, the file name is `securityV11.`*`nn`*`.sqlite` (where *nn* is a minor schema version).

When you run v11 for the first time the DataHub engine creates the new security database file with default entries, and migrates the security data (i.e., users and permissions) from any previously installed version, including special OPC UA security rules.

To carry over permissions from your previous version, the DataHub engine replicates each set in an identically named role with the string "`_migrated`" appended to the name, to distinguish it from similar elements in the v11 version. For example, `BasicConnectivity` would become `BasicConnectivity_migrated`.

If you revert from v11 back to v10 the v10 security database file remains unchanged, and you will find your settings to be as they were the last time V10 was used.

Overview

When configuring security you act as an administrator, restricting access and allowing only authorized connections to the data and functionality of a DataHub instance. Security is administered through several constructs:

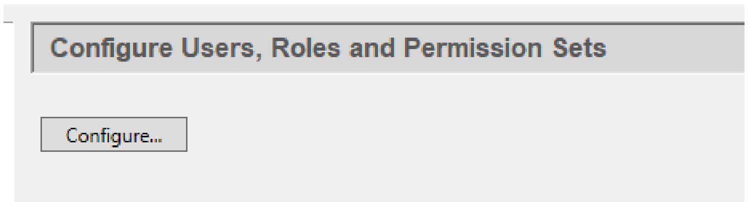
- **User** - An identity provided to programs or devices authorizing them to connect to the DataHub instance.
- **Principal** - A login context for a specific user. It consists of two parts:
  1. Connection source (**IP pattern**)
  2. Connection protocol (**Interface**, e.g., TCP, OPC, MQTT)
- **Role** - A collection of permissions for DataHub data and functionality.
- **Permission** - A means of controlling and regulating access to specific DataHub application- and data-level functions.

These security constructs are owned by one of two organizations:

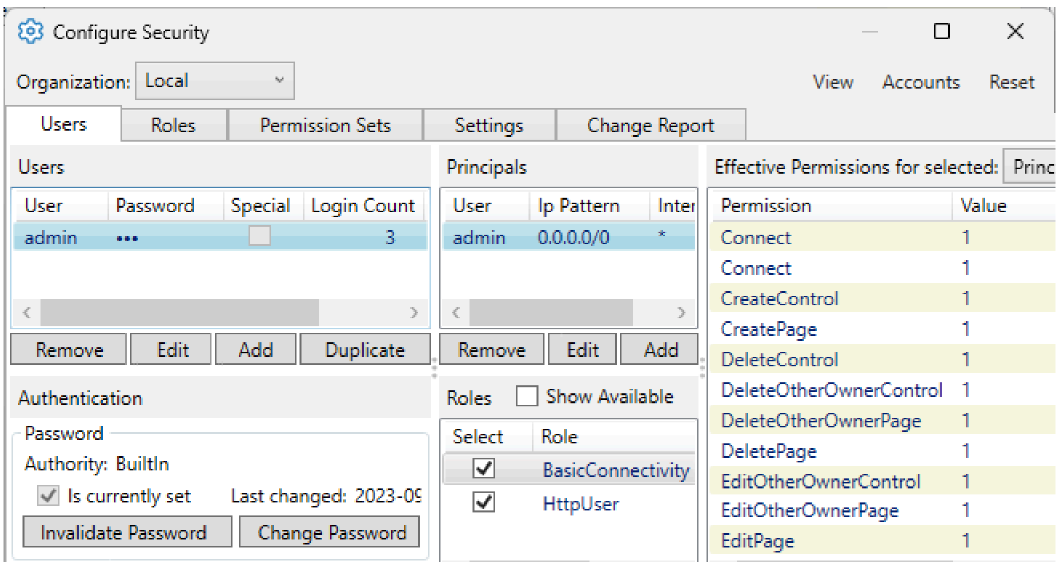
1. The **Internal Organization** is defined and managed by the DataHub instance. It is standard and cannot be changed or edited by the administrator, but its constructs are

available for use while configuring users, principals and roles that belong to the Local organization.

2. The **Local Organization** is configured and maintained by the administrator. Think of it as 'your' organization.



Click the **Configure** button to open the Configure Security window.

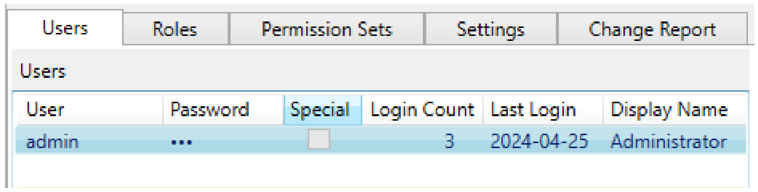


For **Organization**, use **Local**. The **Internal** organization is not configurable by the user. The **View** and **Tools** menus are described below.

The **Users** tab is the main work area. You will be doing most of your security configuration here—defining local users and principals, and associating those principals with pre-defined Internal roles. The **Roles** and **Permission Sets** tabs are used if you need to customize the defaults. The **Settings** tab is for changing the interface settings. The **Change Report** tab shows what changes you have made before clicking **Apply** or **OK** to apply them.

Users tab - User

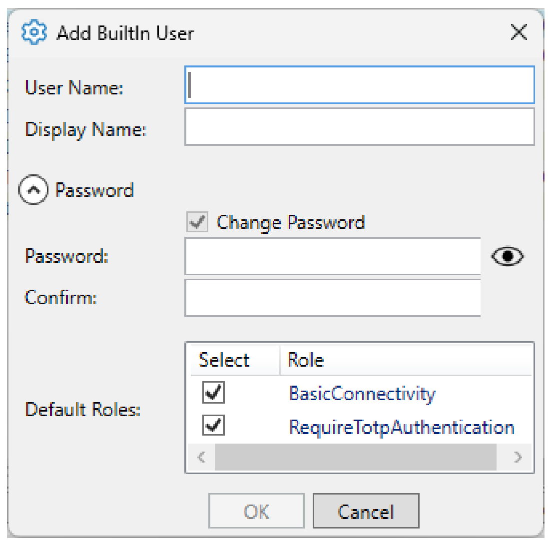
The **Add**, **Edit**, **Duplicate**, or **Remove** buttons allow you to create, edit or delete users. As you edit any item in the Security interface, uncommitted changes are displayed in red and listed on the **Change Report**. These changes are applied when you click **Apply** or **OK**.



Add offers three options for user type:

Add BuiltIn User

A BuiltIn user is managed and authenticated by the DataHub instance. That is, when a user attempts to log in, the user name and password credentials are passed to the DataHub instance to validate. As such, each BuiltIn user requires a distinct user name and a valid password.

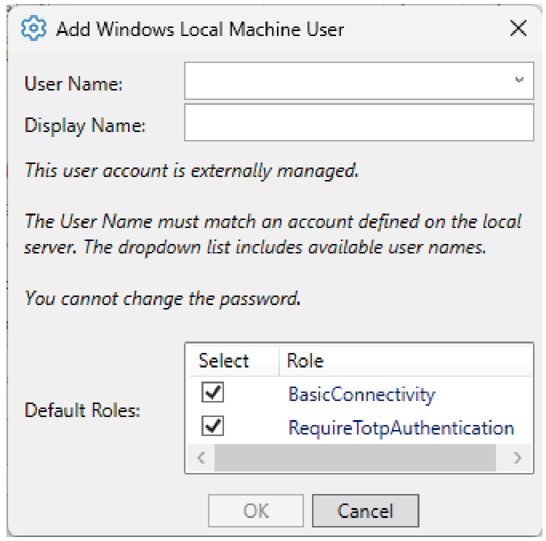


Each user has a required **User** name and an optional **Display Name** for convenience.

Similar dialogs are provided as needed to edit a user name or change a password.

Add Windows Local Machine User

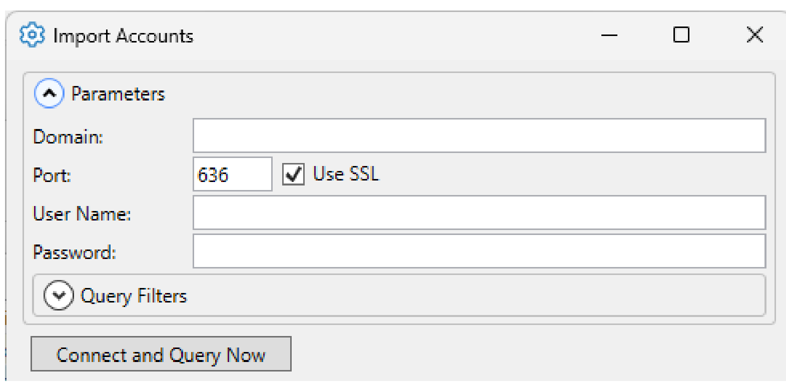
A Windows Local Machine User is authenticated by the machine running the DataHub instance. The user entry is maintained as a proxy. This enables data and functional permissions to be assigned to the user, while relying upon authentication to be handled by Windows.



You can choose one of the available Windows users from the drop-down list. Each such Windows account can be selected only once.

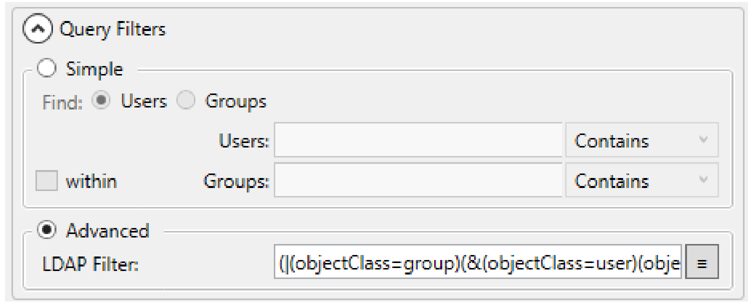
Import LDAP Domain Users and Groups

You can also create proxy user accounts that are managed and authenticated by an external LDAP server, using the **Import Accounts** dialog.



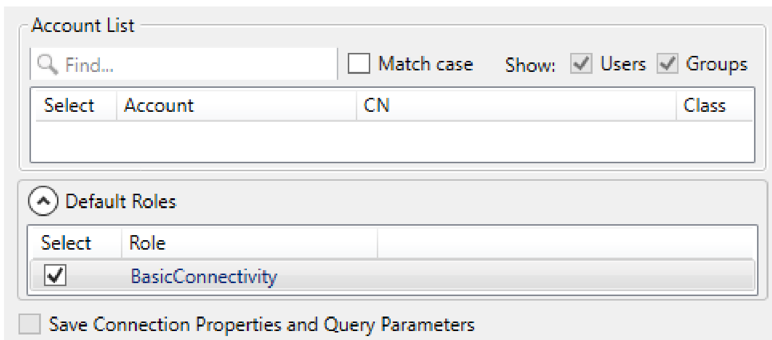
Enter the **Parameters** information as needed. You can get the **Domain** and **Port** information from your network security administrator. Use your LDAP user name and password credential to connect to the LDAP server. Pressing the **Connect and Query Now** button populates the **Account List**.

The **Query Filters Simple** options allow you to filter on **Users**, **Groups**, or **Users within Groups**. Under **Advanced** you can apply a specific LDAP filter, using standard LDAP filter syntax.



Please see LDAP Authentication in Using Security for more information.

The **Account List** options let you search the list, and display only users, groups, or both. To choose users and/or group accounts, check the **Select** box for each one.

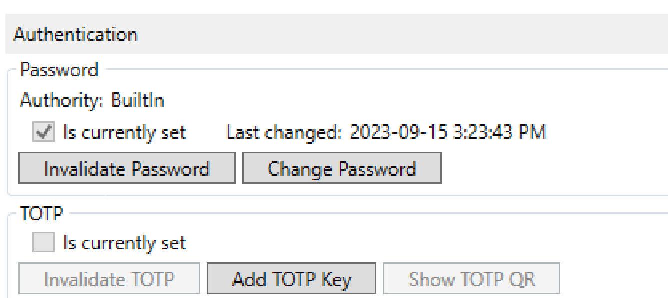


The **Default Roles** options are there for convenience. You can also check the **Save Connection Properties and Query Parameters** box to avoid having to re-enter the parameters each time you want to import an account. These two options are only enabled after you have successfully connected to the LDAP server.

Press the **OK** button to confirm and close the dialog.

Users tab - Authentication

DataHub software supports multi-factor authentication (MFA). Typically, this area displays each authentication factor for the selected user and allows you, as the administrator, to configure other authentication specifics.

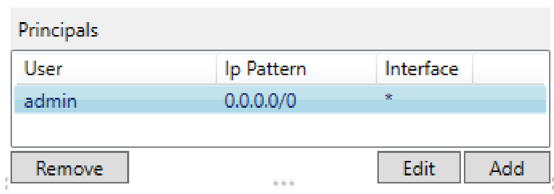


In addition to the use of a password, you can also configure a user account to require a TOTP token. To enable TOTP (time-based one-time password) authentication, at least one principal needs to be included in the `RequireTotpAuthentication` role.

Modify the password and TOTP configuration for each user.

Users tab - Principals

View, add, and edit one or more **Principals** for each user. Each principal is associated with a specific **User** account and defined with an **IP Pattern** and **Interface**.



IP Pattern

The connection source, using CIDR (Classless Inter-Domain Routing) notation. For example:

- `0.0.0.0/0` matches any IP address
- `135.92.0.0/16` matches any address that matches the first 16 bits
- `175.91.16.1/32` matches only the address `175.91.16.1`

Interface

The connection protocol, which must be one of `*` (any), `DDE`, `Mirror`, `MQTT`, `OPC`, `OPCUA`, `TCP`. For example, a principal could be configured to only authorize connections via MQTT. Even if someone knew the user name and password (and could therefore authenticate), the connection would not be permitted access to applications or data.

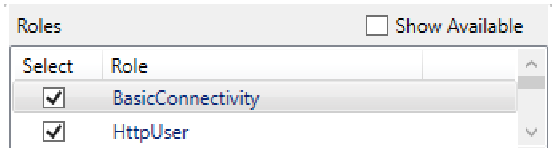
Each principal can be assigned different roles.

By default, each new user gets a principal for **Ip Pattern** `0.0.0.0/0` and **Interface** `*`, and is assigned role membership of `BasicConnectivity` and `RequireTotpAuthentication`. These defaults can be changed in Settings.

Requiring TOTP authentication only makes sense for an interactive user account. When creating user accounts for things like Tunnel/Mirror and MQTT, do not add the user to the `RequireTotpAuthentication` role.

Users tab - Roles

Choose roles for each principal (above).



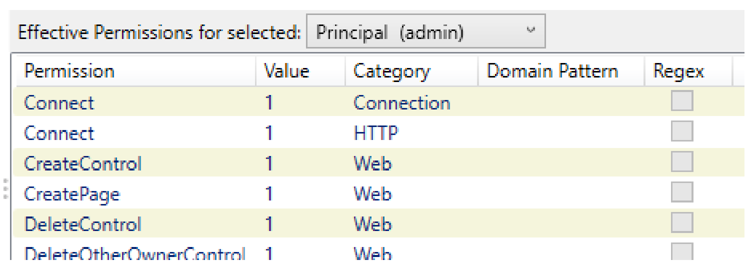
The **Show Available** option lets you view all available roles. Use the **Select** checkboxes to add or remove roles for the selected principal.

Users tab - Effective Permissions

At run-time, the DataHub instance determines effective permissions by

1. Identifying the principal that best matches the connection context (i.e., comparing the incoming IP address against principal IP patterns and the incoming connection protocol against the principal interface).
2. For the best-match principal, identifying all its member roles.
3. Aggregating all permissions assigned to any of the principal-roles.

To facilitate administrative understanding and troubleshooting, effective permissions for each selected principal are listed in the right-most pane, **Effective Permissions**.

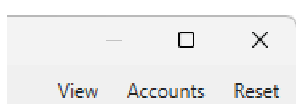


Choosing **Principal** shows all permissions for all roles of the currently selected principal. Choosing **Role** shows just the permissions for the selected role.

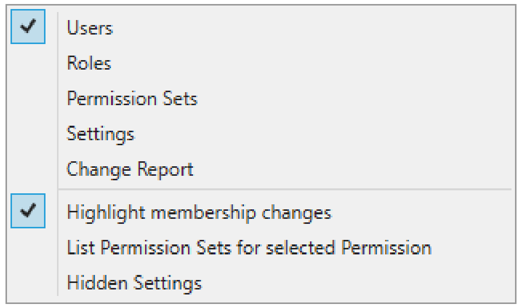
Choosing between **Principal** and **Role** has no impact on the effective permissions determined by the DataHub instance at run-time. This is merely a tool for administrative analysis.

Menus

There are three menus for Security Configuration: **View**, **Accounts**, and **Reset**.



The **View** menu allows you to switch between tabs and to customize the interface.



Highlight membership changes

Colors the labels of roles and permission sets red whenever they are added or changed. This highlighting remains in effect until you click the **Apply** or **OK** button

List Permission Sets for selected permissions

In the **Permission Sets** tab, opens a list of all permission sets to which the selected permission is assigned.

Hidden Settings

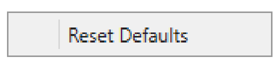
In the **Settings** tab, displays all of the hidden (rarely used) settings.

The **Accounts** menu offers one option:

Import from Active Directory / LDAP...

Opens the Import Accounts dialog that allows you to import an LDAP user, which is also used for adding an LDAP user (see above).

The **Reset** menu offers one option:

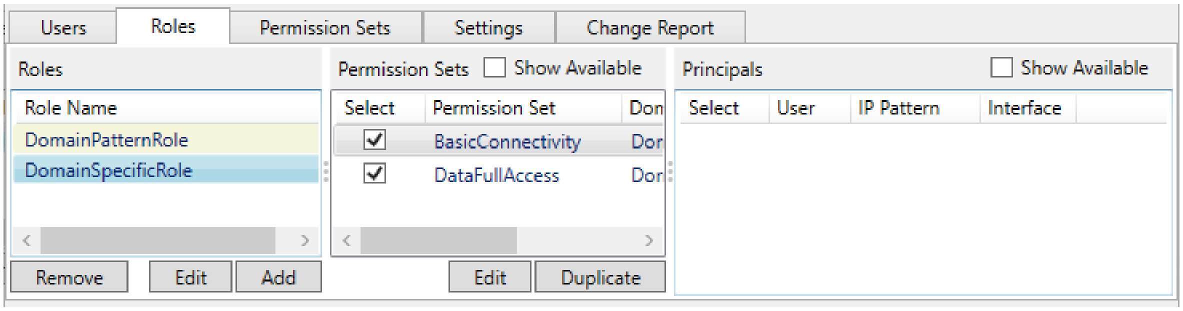


Reset Defaults

Restores the system defaults without changing any users, roles or permission sets that you have created. This is not reversible.

Roles tab

Here you can add, modify or remove roles for your Local organization, as well as associate permission sets and principals with them.



Typically, users in the Local organization are configured with pre-defined roles from the Internal organization. You will only need to create your own roles to specify other sets of data permissions. For more information see Custom Data Permissions.

Roles

The **Add** and **Edit** buttons prompt you for a role name. The **Remove** button immediately removes the selected role.

Permission Sets

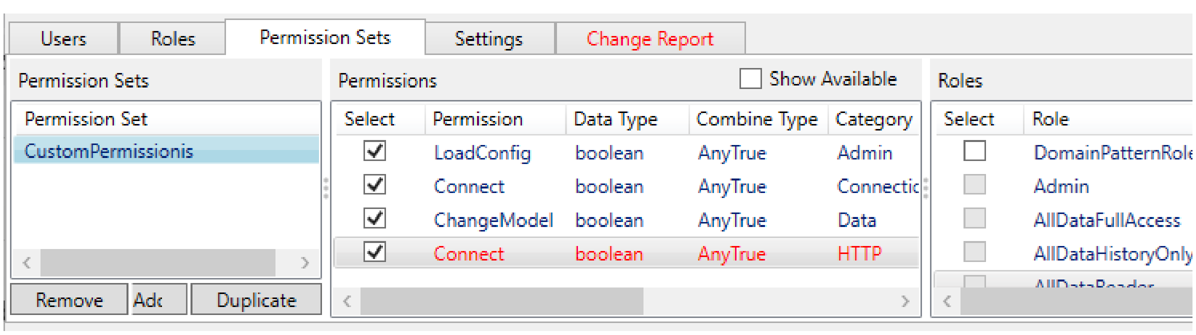
The **Show Available** option lets you view all available permission sets. Use the **Select** checkboxes to assign or remove them from the selected role. The **Edit** and **Duplicate** buttons prompt you for a DataHub domain pattern, entered as a string. You can use an exact domain name, or match a pattern using regular expressions, whose use and syntax can be found here. The **Remove** button immediately removes the selected permission set.

Principals

The **Show Available** option lets you view all available user principals that can be assigned. Use the **Select** checkboxes to assign or remove them from the selected role.

Permission Sets tab

This option lets you add, modify, duplicate or remove permissions sets for your Local organization, as well as duplicate permission sets in the Internal organization.



As with roles, users in your Local organization are typically configured with pre-defined permission sets from the Internal organization. This option is available for creating custom permission sets not available there. For more information see (link to How-To Advanced section)

Permission Sets

A list of the permission sets available for the Internal or Local organizations. Only the Local organization sets are editable, using the **Add** and **Edit** buttons. The **Remove** button immediately removes the selected permission. The **Duplicate** button allows you to duplicate Internal or Local permission sets.

Permissions

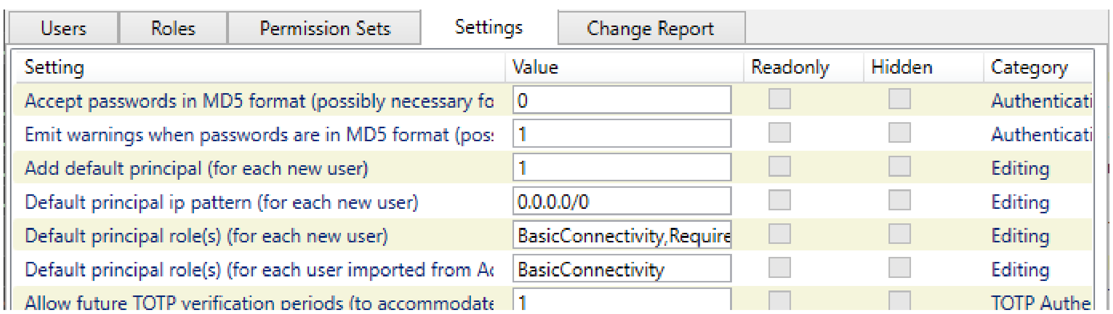
The **Show Available** option lets you view all available permissions. Use the **Select** checkboxes to assign them to, or remove them from, the selected permission set.

Roles

The **Show Available** option lets you view all available roles. Use the **Select** checkboxes to assign the current permission set to, or remove it from, the various roles.

Settings tab

Here you can customize the Configure Security interface itself, according to several settings.



By category, here is what is available:

Editing

These options let you edit the default settings for principals.

TOTP Authentication

These options allow you to accommodate discrepancies in clock settings between the computer running DataHub software and the verification device for TOTP.

TOTP Configuration

Let you configure the TOTP application name and issuer.

TOTP QT Code Configuration

Gives you the ability to use or not use a QT code, and if so, what colors it should be.

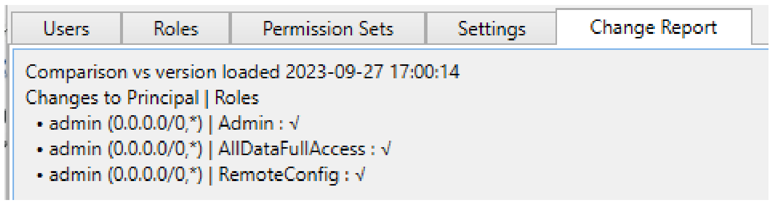
Warnings

Various warnings as described in the interface. Setting **Warn when using the default**

'admin' password to 0 turns off the dialog that appears when starting the DataHub instance.

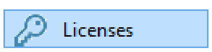
Change Report tab

The system keeps a record of all uncommitted changes.

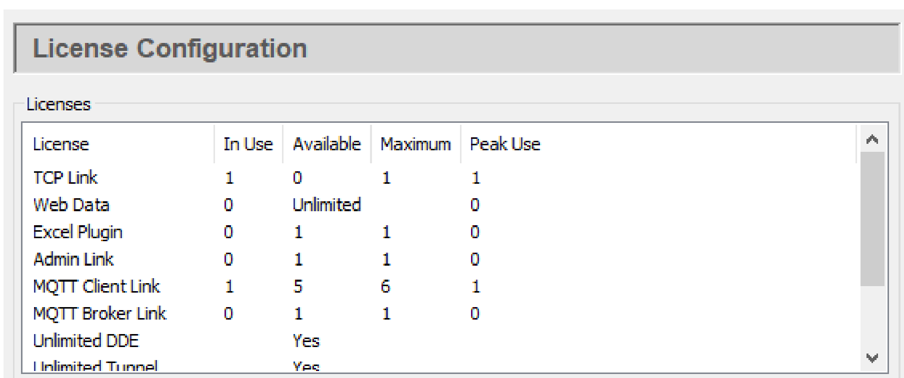


While editing security, all of your changes are displayed in red and listed in this report. These changes get applied when you click the **Apply** or **OK** button, and the report is erased.

Licenses



The Licenses option lets you view and install licenses for the Cogent DataHub program. When it starts up, a DataHub instance will run in demo mode (one hour time limit) if no licenses are found. If a valid license is found, the DataHub instance switches to license mode, and every connected DataHub instance then also requires a license.



License Configuration

Licenses

License	In Use	Available	Maximum	Peak Use
TCP Link	1	0	1	1
Web Data	0	Unlimited		0
Excel Plugin	0	1	1	0
Admin Link	0	1	1	0
MQTT Client Link	1	5	6	1
MQTT Broker Link	0	1	1	0
Unlimited DDE		Yes		
Unlimited Tunnel		Yes		

Licenses

This table lists each kind of license, and its current usage.

Running a DataHub instance on a Microsoft Azure virtual machine requires a special license key. Contact Cogent for details. Normal practice is to use the Cogent DataHub service for Azure.

License

All of the kinds of licenses available.

In Use

How many of each kind of license are currently being used.

Available

How many of each kind of license are not being used and are still available.

Maximum

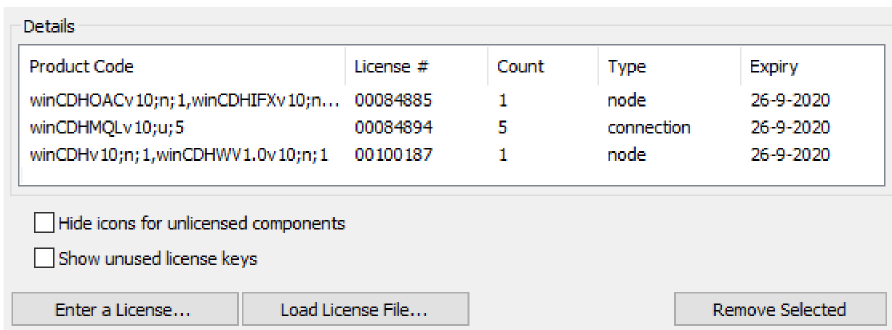
The maximum number of each kind of license currently installed.

Peak Use

The highest number of each kind of license that has been used since the beginning of the current session.

Details

The **Details** list shows some of the information embedded in each license string currently installed.



Product Code

One or more codes for the license pack or add-on license product(s) that correspond to this license string.

License #

The license number.

Count

The maximum number of licenses available in this license string.

Type

Either node (unlimited) or connection (a per-connection license).

Expiry

If this is a time-limited demo license, the date on which it expires, or `never` for a permanent license.

There are two general viewing options for licenses:

Hide icons for unlicensed components

Completely removes the greyed-out property icons for DataHub features that are not licensed.

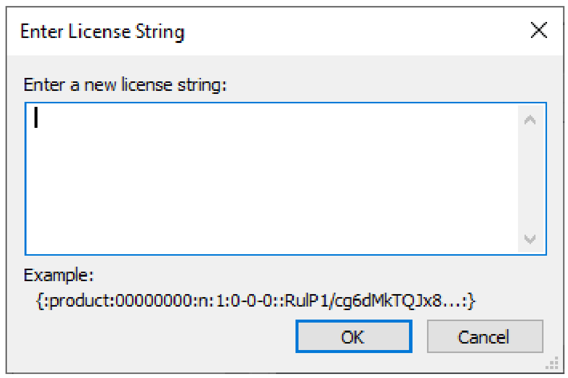
Show unused license keys

It is possible that a license file may contain upgrade licenses for several different versions or instances of the DataHub program. If one or more license files have been loaded, checking this box will show in the **Details** list all the licenses available, including those that might be for older versions or other DataHub installations.

Installing Licenses

Licenses can be entered individually or loaded from a file.

- The **Enter a License...** button opens the **Enter License String** window:



  Here you can paste or manually enter the text string for the license provided by Cogent.

  - For DataHub version 10 and later, select everything including the `{:` and `:}` characters.
  - For DataHub versions 8 and 9, select everything including the first and last `:` characters.

  Running a DataHub instance on a Microsoft Azure virtual machine requires a special license key. Contact Cogent for details. Normal practice is to use the Cogent DataHub service for Azure managed application.

  The license string may contain the characters `l` (lower case L) and `1` (one) which can look nearly identical in some type fonts. If possible, it is best to copy and paste the string, rather than retyping it.

- The **Load License File...** button opens a Windows file selection window. Browse to find the directory and license file that you want to load. License files end with a `.lic` extension. Once you have found the license file, click the **Open** button to load the file. (Please refer to Configuration and License File Locations in Configuration Files for more information on license file locations.)

To remove a license from your system, select one or more licenses in the **Details** window, then click the **Remove Selected** button.

Troubleshooting License Installation

The possible causes of a license installation problem are:

1. **Different DataHub version.** Each DataHub version (v7, v8, v9, v10, etc.) has a different license.
2. **Running on Azure.** The DataHub program requires a special license key when running on a Microsoft Azure virtual machine. Contact Cogent for details. Normal practice is to use the Skkynet DataHub managed application for Azure.
3. **A typographical error.** If you are hand-entering the license key, watch out for mistakes between lower case letters `L` and `1`, and between the upper case letter `O` and the numeral `0`.
4. **A copy/paste error.** If you are copying and pasting the key, make sure that you include the correct leading and trailing characters in the key.
   - For DataHub version 10 and later, include the `{:` and `:}` characters.
   - For DataHub versions 8 and 9, include the first and last `:` characters.

   If you are having trouble with a copy/paste, try opening Notepad and copying the license keys into it. Once the license keys are in Notepad, replace all of the "-" (minus sign) characters in the license keys by selecting and re-typing the - sign. You might notice that minus signs in the key are actually converted to something else, like a box or an exclamation mark. You need to change them back, then try adding the license code to the DataHub instance again.
5. **Unicode characters.** If you copy a space into the entry field, it may be a Unicode space instead of an ASCII space. The entry field will automatically strip ASCII spaces, but it cannot distinguish Unicode spaces. This could happen if you are working with a non-English character set that defines its own space, such as Japanese.
6. **Invalid duplicate key.** The DataHub `licenses.lic` file may contain an invalid license key with the same license number. To fix:
   1. Delete the `licenses.lic` file from the DataHub configuration folder (usually `C:\Users\`*`username`*`\AppData\Roaming\Cogent DataHub`).
   2. Restart the DataHub instance.
   3. Install the new license key.

If none of these are helpful, please contact support@skkynet.com and send a copy of the `licenses.lic` file, along with the version number of the DataHub instance you have installed it on.

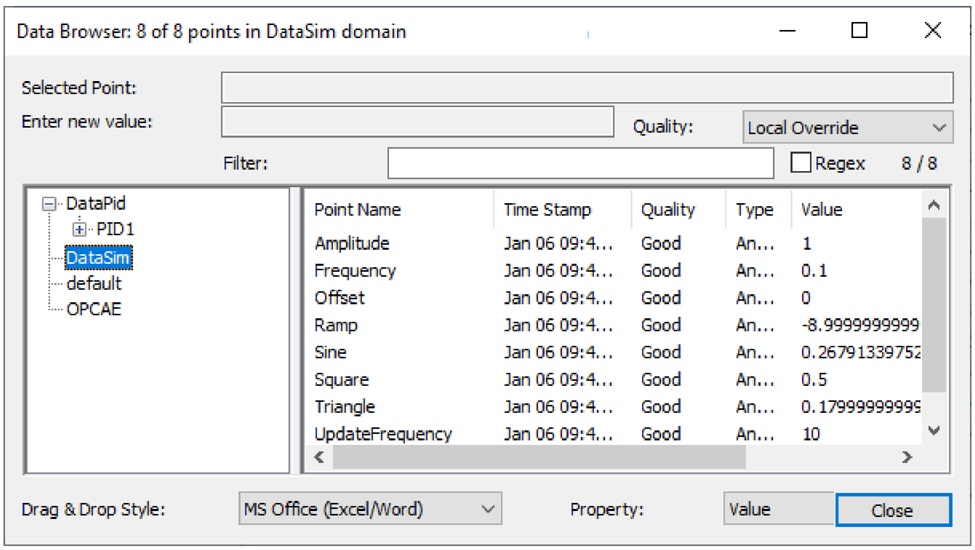
Other Windows and Programs

Data Browser

Overview

This window gives a real-time view into the DataHub program. You can open this window in either of two ways:

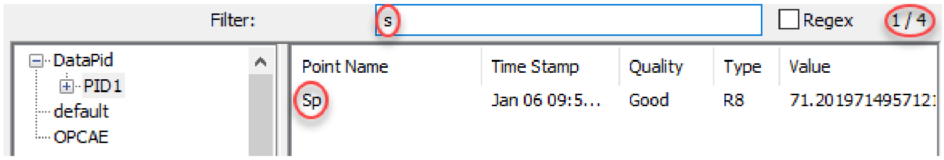
- Click the **View Data** button in the Properties window.
- Right click the DataHub icon in the system tray and select **View Data** from the pop-up menu.



All data domains in the DataHub program are shown in the tree on the left, and all the points of the selected data domain are listed on the right. Clicking on a point name selects it, and puts its name into the **Selected Point** field at the top of the window. A snapshot of the value of the point at the time you clicked appears in the **Enter new value** field. You can change the value of the point by entering a new value in this field (i.e. type in the value and press the **Enter** key). You can also drag the column headers to change the order of the columns.

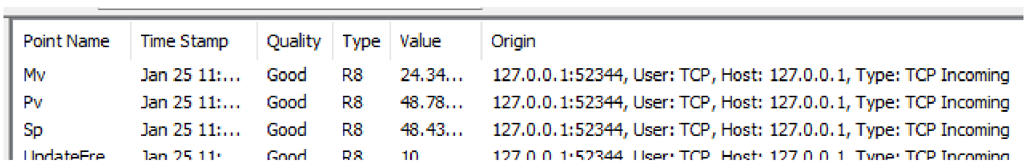
Point Filter

You can use the **Filter** option to display subsets of points, according to what you type in the entry field. Checking the **Regex** box causes the DataHub instance to treat your entry as a regular expression. The native DataHub Properties window interface uses PCRE (Perl-Compatible Regular Expression) format, whose use and syntax can be found here. The Remote Config tool uses .NET regular expression format, whose use and syntax can be found here.

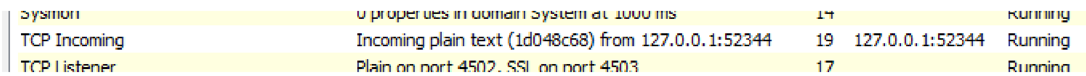


Origin column

The **Origin** column displays information about the source of the most recent change to the point. This information will be different depending on the type of the source.



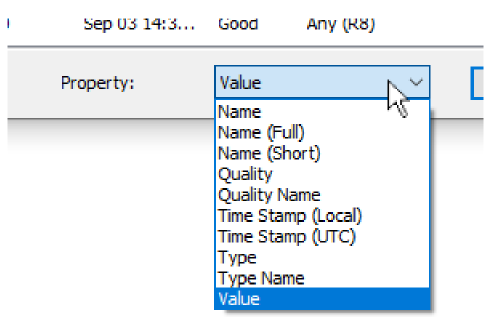
The information in this column comes from the Connection Viewer window.



Drag and Drop Style and Property

There are several options for the drag and drop style, depending on the program in which you want to place the data. In addition, there is a **Snapshot (Plain Text)** option that allows you to put in labels and data properties that don't change.

The Data Browser also provides a way to select the **Property** of a data point to drag and drop, such as timestamp, quality, and point type.



The following properties are available:

Name

The name of the point, including its data hierarchy of assemblies, subassemblies, attributes, and properties, if any. For example:

```
PID1.Range.Amplitude
```

Name (Full)

The name of the point, including its data hierarchy and also domain name. For example:

```
DataPid:PID1.Range.Amplitude
```

Name (Short)

The short name of the point, without any of the data hierarchy. For example:

```
Amplitude
```

Quality

The quality of the point, an integer.

Quality Name

A text string that corresponds to the integer value of the quality of the point.

Time Stamp (Local)

The local time stamp, in seconds. In Excel, you can format this using a custom format for the cell. For example, to display the data and time to the nearest millisecond in a worksheet cell, you can use `m/d/yyyy h:mm:ss.000` as your custom format. Note that the milliseconds use a dot, not a colon.

Time Stamp (UTC)

The UTC time stamp, in seconds. You can format this in Excel using a custom format, as explained above.

Type

The type of the data contained in the point, as an integer.

Type Name

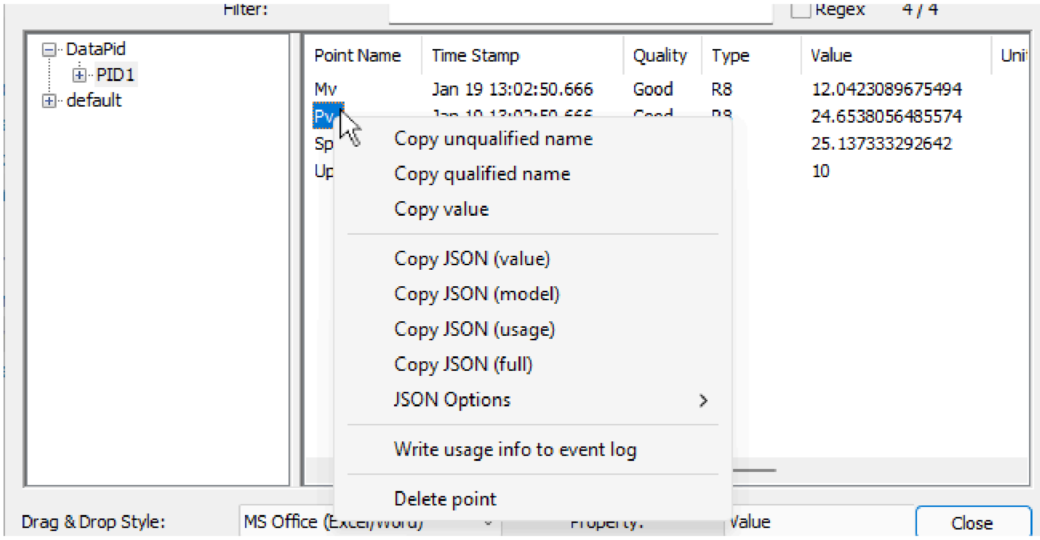
A text string that corresponds to the integer value of the data type.

Value

The value of the point.

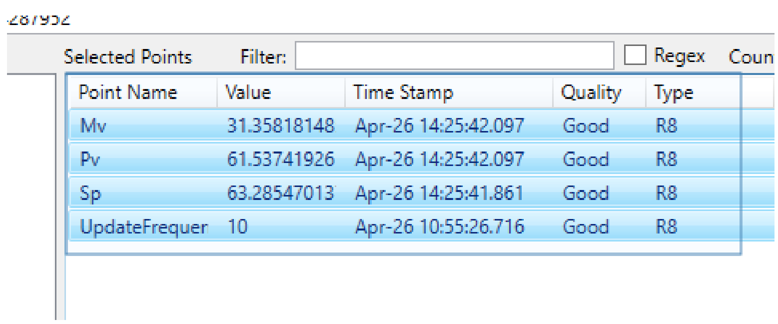
Point meta information

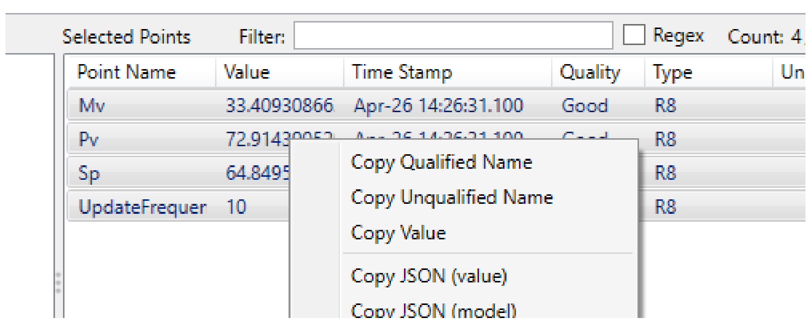
It is possible to copy meta information such as name, value, and a JSON representation from a data point or any level of a branch.



In the Properties window Data Browser you can use the **Shift** key to select multiple points.

In the Remote Config Data Browser, you can drag the mouse to select multiple points.





The following options are available:

Option	**Description**	**Example**
Copy Unqualified Name	The full point or branch name without the domain name.	`PID1.Pv`

<table>
<tr><th>Option</th><th>Description</th><th>Example</th></tr>
<tr><td>Copy Qualified Name</td><td>The full point or branch name including the domain name.</td><td><code>DataPid:PID1.Pv</code></td></tr>
<tr><td>Copy Value</td><td>The value of the point. This is not available at the branch level.</td><td><code>32.1794894015197</code></td></tr>
<tr><td>Copy JSON (value)</td><td>A JSON representation of value and meta data associated with the point or branch.</td><td><pre>{
  "name":"DataPid:PID1.Pv",
  "leafname":"Pv",
  "value":38.708488241669947,
  "quality":192,
  "timestamp":
    "2024-01-19T18:07:51.228Z"
}</pre></td></tr>
<tr><td>Copy JSON (model)</td><td>A JSON representation of model meta data associated with the point or branch.</td><td><pre>{
  "name":"DataPid:PID1.Pv",
  "leafname":"Pv",
  "modeltype":2,
  "type":"R8",
  "access":"rw"
}</pre></td></tr>
<tr><td>Copy JSON (usage)</td><td>A JSON representation of all subscribers and writers to the point.</td><td><pre>{
  "name":"DataPid:PID1.Pv",
  "leafname":"Pv",
  "subscribers":[
    {
      "label":"",
      "description":"Built-in
         Data Viewer",
      "user":"",
      "type":"Built-in
         Data Viewer"
    },
    {
      "label":"127.0.0.1:51924",
      "description":"Incoming
        plain text (1c9ad7d8)
        from 127.0.0.1:51924",
      "user":"TCP",
      "host":"127.0.0.1",
      "type":"TCP Incoming"
    }
  ],</pre></td></tr>
</table>

Option	Description	Example

		`"writers":[`
		`{`
		`"label":"127.0.0.1:51924",`
		`"description":"Incoming plain text (1c9ad7d8) from 127.0.0.1:51924",`
		`"user":"TCP",`
		`"host":"127.0.0.1",`
		`"type":"TCP Incoming"`
		`}`
		`]`
		`}`

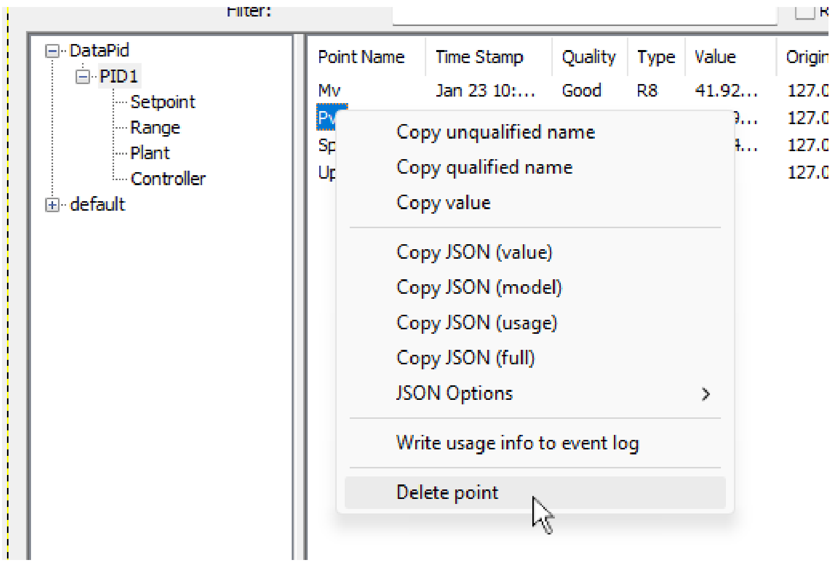
Copy JSON (full)	A JSON representation of all value and meta data associated with the point or branch.	Similar to above examples, with all information.
JSON Options - Formatted	Displays each element in a new line.	Similar to formatted examples above.

JSON Options - Verbose	Displays the full name of each element, otherwise just an initial letter.	`{"name":"DataPid:PID1.Pv",...}`
		vs
		`{"n":"DataPid:PID1.Pv",...}`

JSON Options - Recursive	Includes all branches and points below the current selection.	Similar to above examples, including all lower branches and points.
Write usage info to Event Log	Writes subscriber and writer info for the point to the DataHub Event Log when the point is first registered.	
Delete Point	Hides the point and all associated information.	See Deleting points for details.

Deleting points

You can delete points from the Data Browser by right-clicking the point name and selecting **Delete point**. If you right-click on a branch in the left-hand tree and select **Delete point**, the branch and all its children will be deleted recursively.

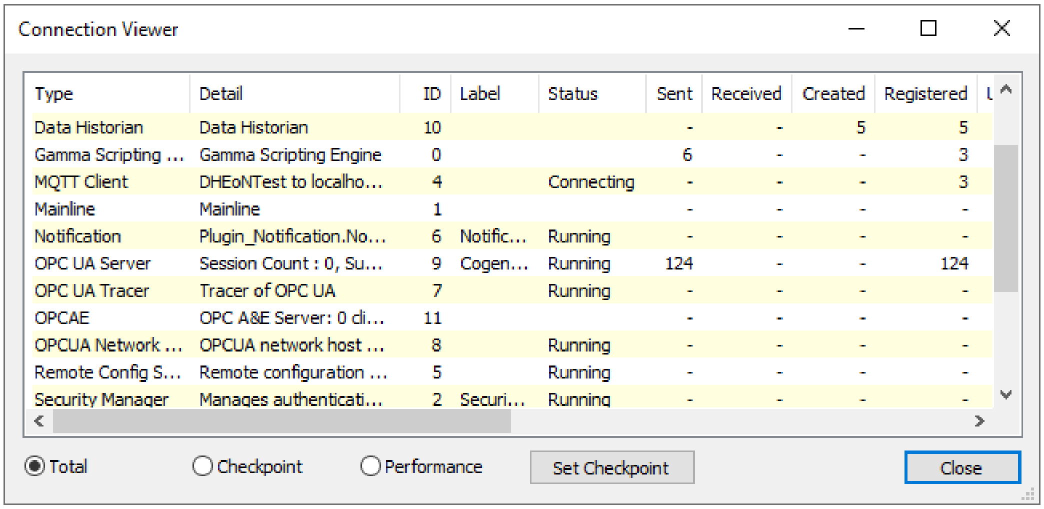


When a point is "deleted" in the Data Browser, it is not really deleted. It is hidden. It behaves as much as possible as if it does not exist, but not entirely. Here's what happens internally:

- When a point is deleted, it is marked as hidden. Any memory associated with the point is retained. Deleting a point will not release memory back to the system.
- When a point is deleted, a data change event is sent to all subscribed clients with a quality of `Not Connected`.
- When a point is deleted, an explicit `(delete pointname)` message is sent to clients that maintain their own copy of the model. This message is sent even if the client is not currently subscribed to the point.
- A deleted point is marked internally as uninitialized. This ensures that re-creating it will cause it to behave as if it is a new point.
- When an application reads, writes or subscribes to a deleted point, the point is undeleted and behaves as if it had been newly created.
- When a point is *un*deleted, an explicit `(undelete pointname)` message is sent to clients that maintain their own copy of the model. This message is sent even if the client is not currently subscribed to the point
- Sending `(delete)` or `(undelete)` to DataHub v10 or lower will generate an error in the Event Log, but will cause no harm.

Connection Viewer

This window gives a real-time view into all DataHub connections. You can open this window by clicking on the **View Connections** button in the Properties window.



Type	Detail	ID	Label	Status	Sent	Received	Created	Registered
Data Historian	Data Historian	10			-	-	5	5
Gamma Scripting ...	Gamma Scripting Engine	0			6	-	-	3
MQTT Client	DHEoNTest to localho...	4		Connecting	-	-	-	3
Mainline	Mainline	1			-	-	-	-
Notification	Plugin_Notification.No...	6	Notific...	Running	-	-	-	-
OPC UA Server	Session Count : 0, Su...	9	Cogen...	Running	124	-	-	124
OPC UA Tracer	Tracer of OPC UA	7		Running	-	-	-	-
OPCAE	OPC A&E Server: 0 cli...	11			-	-	-	-
OPCUA Network ...	OPCUA network host ...	8		Running	-	-	-	-
Remote Config S...	Remote configuration ...	5		Running	-	-	-	-
Security Manager	Manages authenticati...	2	Securi...	Running	-	-	-	-

The various columns identify the connection and show its status, with connection statistics, as follows:

- **Type** The type of connection or thread. All connections of the same type will have the same type name.
- **Detail** Some descriptive information about the individual connection. This can be different even for connections of the same type.
- **ID** An internal ID that can distinguish otherwise identical connections.
- **Label** A label for this connection, where available. Typically, outgoing connections are labelled as part of their configuration. Some connections may provide additional information in this label.
- **Status** An indication of the status of the connection. This is dependent on the type of connection.
- **Sent** The number of data point changes that have been delivered to the thread managing this connection. That is, the number of point changes that the data engine has emitted. This does not necessarily imply that these changes have been forwarded onward to the destination of this connection. For example, an MQTT client connection to an unavailable broker will still see its **Sent** count rise, but those point changes could be held internally in a queue until the broker is again available.
- **Received** The number of data point changes that have been received from the thread managing this connection. This is typically the number of data point changes received from the underlying source, such as an OPC server.
- **Created** The number of data points that are created in the DataHub data engine due to interaction with this connection. For example, a connection to an OPC server will create points in the DataHub instance to correspond to the OPC items in the server.
- **Registered** The number of point registrations made by the thread managing this connection. This is an indication by the thread that it should receive point change notifications from the DataHub data engine. Those point changes will result in the **Sent** count rising.

- **Unregistered** The number of times that the connection thread has unregistered a point in the data engine. This will change whenever the connection thread unregisters a point, even if it was not previously registered.
- **Dropped** The DataHub program makes a trade-off between delivering all data changes vs. maintaining timely delivery. If a connection cannot keep up with the rate of data changes, the DataHub data engine will throttle data transmission by dropping data point changes that are known to be superseded by newer values for the same point. A data change will not be dropped if there is no newer value available for the same point. This ensures that a connection will receive the current value even if it misses intermediate values. Large numbers of dropped values indicate that the connection is unable to keep up with the current data rate.
- **Blocked, Unblocked** Both the DataHub data engine and a connection thread monitor the data transmission rate, and determine whether the connection is able to maintain the data rate. If not, the connection is temporarily blocked, indicating to the data engine that it should begin dropping all intermediate values. When the connection is again able to deliver data, the connection will be unblocked. Frequent changes to the **Blocked** and **Unblocked** counts indicate that the connection is frequently becoming overwhelmed and then quickly recovering.
- **CPU** (Native interface only) The amount of CPU used by the thread managing this connection. When the **Performance** option is selected, the CPU percentage is the average percentage of the CPU resources that the thread has been using since the Connection Viewer window was opened, or the **Set Checkpoint** button was pressed.
- **ThreadID** (Native interface only) The operating system thread ID for this thread.
- **Queue** How many data point changes have been queued to the connection thread by the data engine but have not yet been consumed by the connection thread. If this number grows large and remains large, this typically indicates that the connection is being overwhelmed and does not have sufficient CPU available to handle the data changes. The data engine will eventually block future deliveries if this number becomes too large. Large queues can result in large process memory consumption.
- **Username** The name of the user credential assigned to this connection. This typically is only available for incoming connections.
- **KBytesSent** The number of kilobytes of data sent on this connection. This is typically only meaningful for TCP connections.
- **KBytesReceived** The number of kilobytes of data received from this connection. This is typically only meaningful for TCP connections.

You have the following options for viewing the data

- **Total** Displays all connection statistics from the time that the client connection was first made.
- **Checkpoint** Displays all connection statistics from the last time the **Set Checkpoint** button was clicked or from the time that the client started, whichever is later.
- **Performance** Shows the performance of the connection, in terms of data changes per second, from the last time the **Set Checkpoint** button was clicked or from the time that

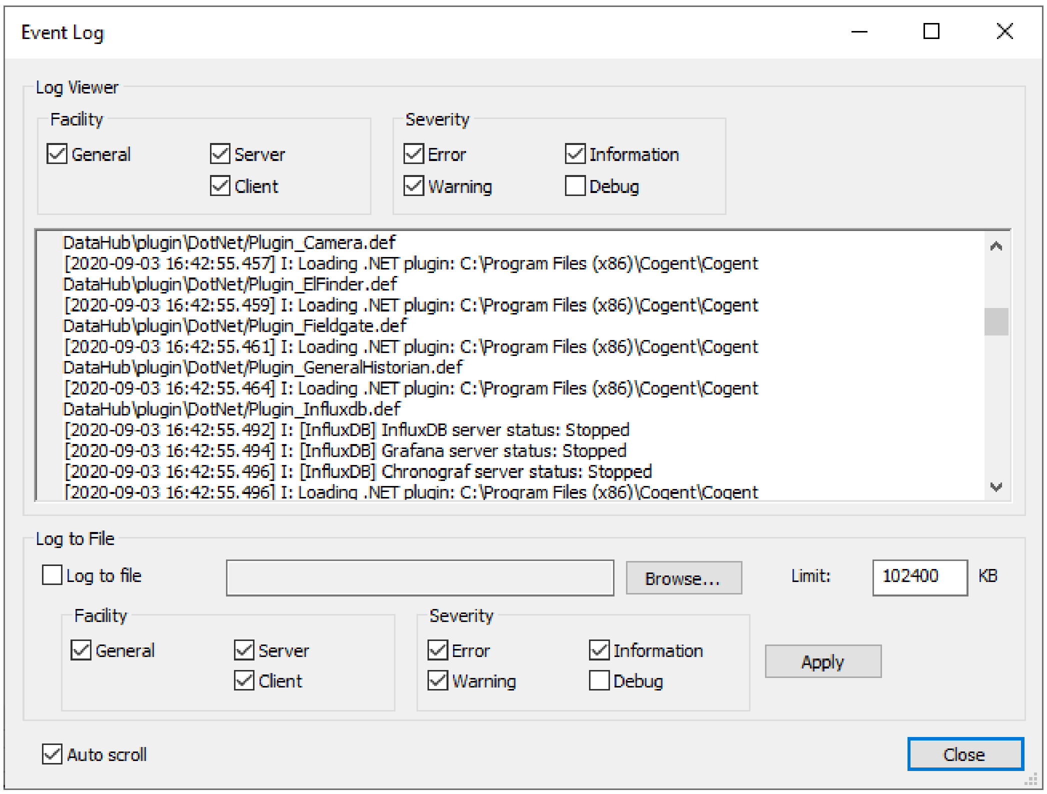
the client started, whichever is later.

- **Set Checkpoint** Records the time and current statistics for each client, for use by the **Checkpoint** and **Performance** options.

Event Log

This window lets you view a log of events from the DataHub instance. You can open this window in either of two ways:

- Click the **Event Log** button in the Properties window.
- Right click the DataHub instance icon in the system tray and select **View Event Log** from the pop-up menu.



You can specify the category of event **Facility** and level of **Severity** by checking or unchecking the related items. It is possible to open multiple **Event Log** windows, and select different **Facility** and **Severity** options in each window.

The **Debug** option is very verbose. Operating in this mode could put an unusually high demand on system resources.

Auto scroll

Unchecking this box stops the scrolling mechanism, keeping the display for the current output, making it easier to read. This box is checked by default.

Log to File

If you wish to save a log, you can have the DataHub instance write the log to a file. Check the **Log to File** box and specify a path and file name in the entry field, typically with a `.log` extension. You can use the **Browse** button to find a file. The **Limit** text entry box allows you to change the maximum file size (default 102,400 Kb).

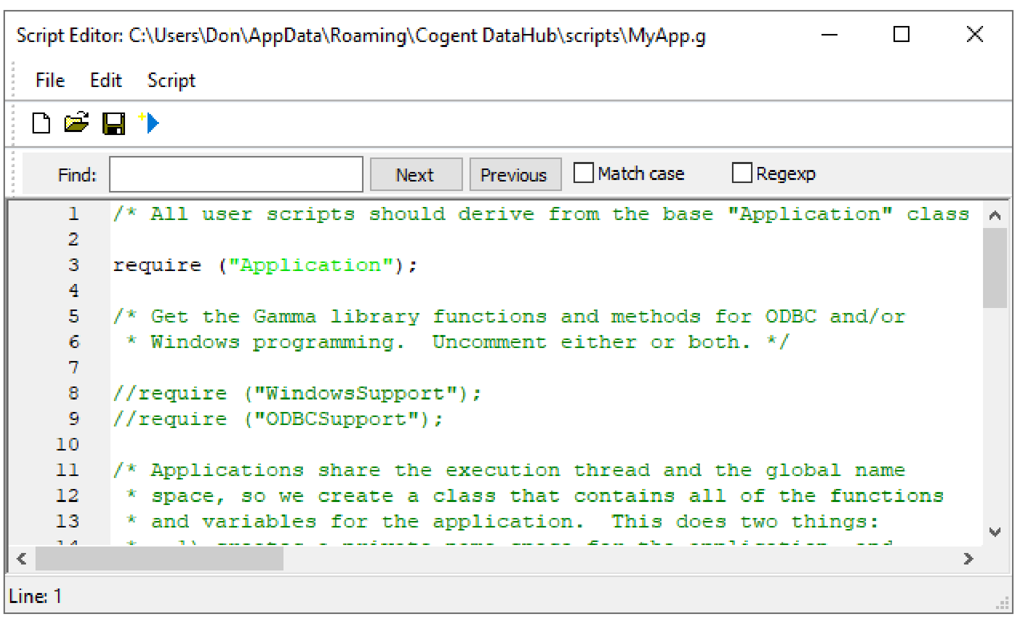
Once the `.log` file reaches the maximum size limit shown in the **Limit** field, it is renamed with a `.log.1` extension, and a new `.log` file is started. Combined, the two files provide at least as much data for analysis as specified in the **Limit** field. This also means that the actual size on disk of the two log files could be as much as twice the **Limit** size at any given time.

Here are some other useful pointers about log file management:

- If the file you specify doesn't exist, the DataHub instance will create it. If the file does exist, the DataHub instance will append log data to the file.
- As long as the **Log to File** box is checked, the DataHub instance will append all log entries to the file, even when a new instance is restarted after a shutdown.
- You can specify the category of event **Facility** and level of **Severity** logged to file by checking or unchecking the related items.

Script Editor

The Script Editor[1] lets you write and edit scripts.



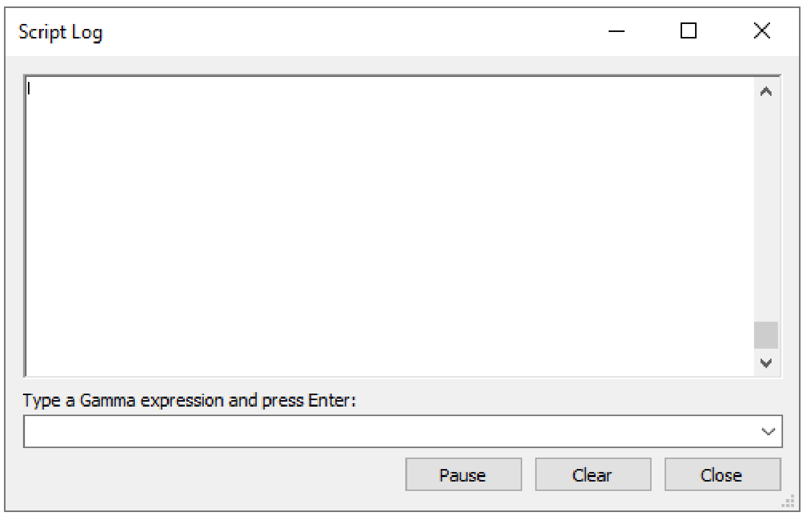
[1]This editor is based on the Scintilla and SciTE editor.

The Script Editor offers features such as context-sensitive highlighting, prompted fill-ins for functions and variable names, automatic indenting, text string searches, and so on. Please refer to the DataHub Scripting manual for detailed information.

Script Log

This window lets you view output from scripts, and interact with the Gamma scripting engine. You can open this window in either of two ways:

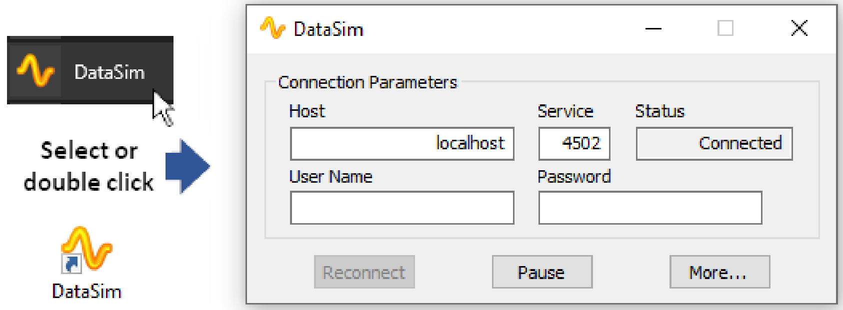
- Click the **Script Log** button in the Properties window.
- Right click the DataHub icon in the system tray and select **View Script Log** from the pop-up menu.



Please refer to the DataHub Scripting manual for detailed information about the Script Log.

DataSim - a data simulation program

DataSim is a data simulation program that creates local data for the DataHub program. It generates data for four different wave patterns, and sends these to a DataHub instance by a TCP connection.



As soon as DataSim starts, it attempts to connect to a DataHub instance and begins generating data. To receive the data, the DataHub instance should be configured as a tunnelling/mirroring master.

Connection Parameters

Host

The name or IP address of the host computer. Since DataSim connects via TCP, this can be any computer on the network running a DataHub instance acting as a tunnelling/mirroring master.

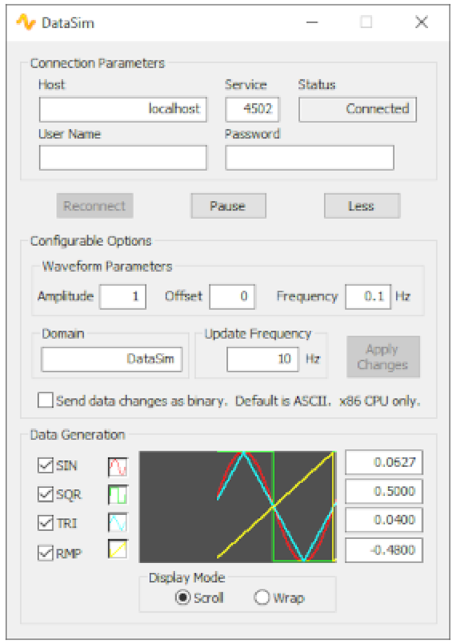
Service

The port number or service name as entered in the **Master service/port** entry box of the DataHub instance.

Status

Displays the attempts to connect, which change to **Connected** when the connection is made.

You can use the **Reconnect** button to reconnect and the **Pause** button to freeze all data generation. Press the **Show** button to view and change some of the data parameters:



Configurable Options

The following options can be set in DataSim, and sent to the DataHub instance;. All of the numeric options have a corresponding point in the DataHub instance that contains the value. Thus, these values can be set from within the Data Browser, by selecting the point name and entering a new value for it.

Waveform Parameters

Amplitude

The height of the wave forms. DataHub Point name: `Amplitude`.

Offset

An offset from zero of the generated data, and thus the wave form. DataHub Point name: `Offset`.

Frequency

The frequency of the wave form. DataHub Point name: `Frequency`.

Data Domain

The Cogent DataHub data domain name for the data points. Any entry in this box changes the connection **Status** to `IDLE`. You must press the **Reconnect** button to reestablish the connection.

Update Frequency

The number of times per second that data changes and is sent to the DataHub instance.

Apply Changes

Applies any changes that have been entered for these configurable options. This button is greyed out until a change has been entered and can be applied.

Send data change as binary...

Allows you to send the data changes from DataSim in binary form, rather than as ASCII characters. This can speed data update rates substantially. This feature is only available on x86 machines.

Data Generation

For each of the following four variables, the check box stops or starts data generation, while the toggle button hides or shows the graph display. The numerical value is shown at the right of the graph.

SIN

Data generates a sine wave.

SQR

Data generates a square wave.

TRI

Data generates a triangular (45 degree) wave pattern.

RMP

Data generates a ramp wave—steadily increasing, followed by a sudden drop.

Display Mode

Controls how the data is displayed in the trend display. **Scroll** moves the wave from right to left as the data is generated. Old data scrolls off the left side of the display as new data scrolls in from the right. **Wrap** adds to the wave from left to right, and writes over old data.

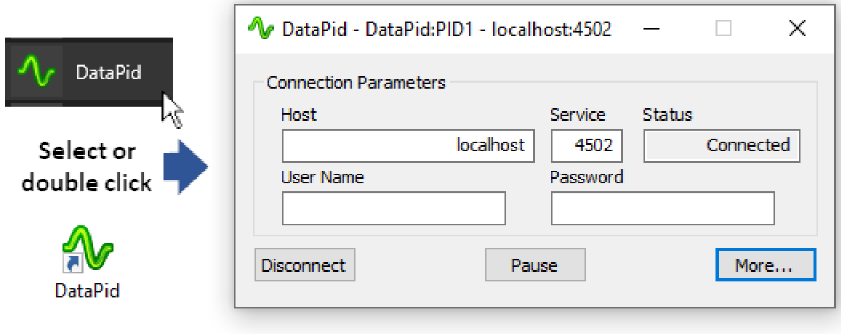
DataPid - a PID loop data simulation program

DataPid is a data simulation program for the DataHub program. It simulates data for a set point, control output, and process variable, and sends these values to the DataHub instance by a TCP connection.

This program is similar to DataSim, but with specialized data. A PID loop is often used by process control engineers to determine the efficiency of their system. A detailed explanation of PID loops is beyond the scope of this manual, but the data generated by this simulator can by used by anyone.

Starting Up

The DataPid can be started from the Windows **Start** menu, the command line, or by clicking on the desktop icon.



As soon as DataPid starts, it attempts to connect to a DataHub instance and begins generating data. To receive the data, the DataHub instance should configured up as a tunnelling/mirroring master.

The DataPid can take several command-line arguments at startup, to assist in running more than one instance at a time. Any combination of the following arguments can be supplied in the Target field of the shortcut, or on the command line.

/d *`data domain name`*

The name of the DataHub data domain in which to write the data that DataPid generates. The default is `DataPid`.

/n *`pid name`*

The name of the PID loop. For example, if *`data domain name`* is `DataPid` and *`pid name`* is `PID1` then the data will the data will be created in a hierarchy beneath the point `DataPid:PID1`. The default is `PID1`.

/h *`host name`*

The name of the computer on which the DataHub instance is running. This can be an address or a name, for example, `127.0.0.1` or `developers.cogentrts.com`. The default is `localhost`.

/p *`port number`*

The port number on the target computer on which to connect. The default is `4502`.

/i

If specified, the DataPid window will be iconified when it starts.

Example:

```
DataPid.exe /i /d test /n pid
```

Connection Parameters

Host

The name or IP address of the host computer. Since DataSim connects via TCP, this can be any computer on the network running a DataHub instance acting as a tunnelling/mirroring master.

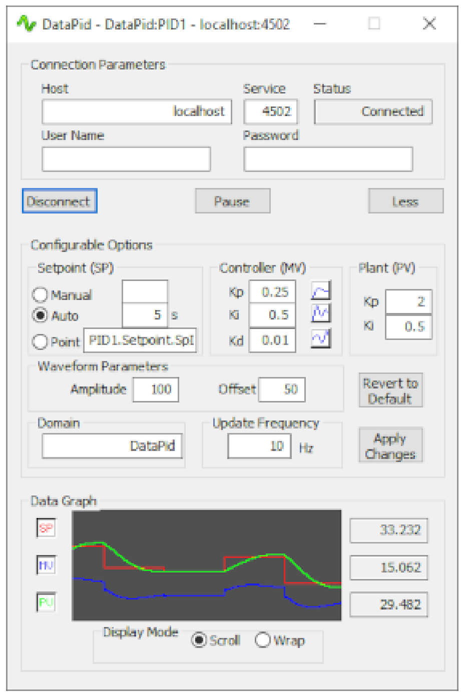
Service

The port number or service name as entered in the **Master service/port** entry box of the DataHub instance.

Status

Displays the attempts to connect, which change to **Connected** when the connection is made.

You can use the **Reconnect** button to reconnect and the **Pause** button to freeze all data generation. Press the **More...** button to view and change some of the data parameters:



Configurable Options

The following options can be set in DataPid, and sent to the DataHub instance. All of the numeric options have a corresponding point in the DataHub instance that contains the value. Thus, these values can be set from within the Data Browser, by selecting the point name and entering a new value for it.

Setpoint (SP)

Manual
A number from `0` to `100` to for the set point. An entry here overrides **Auto**.

Auto
Changes the set point randomly, every *n* seconds, where *n* is the number entered.

Point
Changes the set point according to a point registered in the DataHub instance.

Controller (MV)

Kp	The proportional control factor, sets the speed of adjustment.	The wave form button sets a well-tuned PID loop.
Ki	The integral control factor, reduces error.	The wave form button sets a poorly-tuned PID loop.
Kd	The derivative control factor, provides a damping effect.	The wave form button sets an oscillating PID loop.

Plant (PV)

Kp	The proportional control factor of the plant.
Ki	The integral control factor of the plant.

Waveform Parameters

Amplitude	Not yet documented.
Offset	Not yet documented.

Data Domain

The DataHub data domain name for the data points. Any entry in this box changes the connection **Status** to `IDLE`. You must press the **Reconnect** button to reestablish the connection.

Update Frequency

The number of times per second that data changes and is sent to the DataHub instance.

Apply Changes

Applies any changes that have been entered for these configurable options. This button is greyed out until a change has been entered and can be applied.

Data Graph

SP, **MV**, and **PV**

The toggle button hides or shows the graph display. The numerical value is shown at the right of the graph.

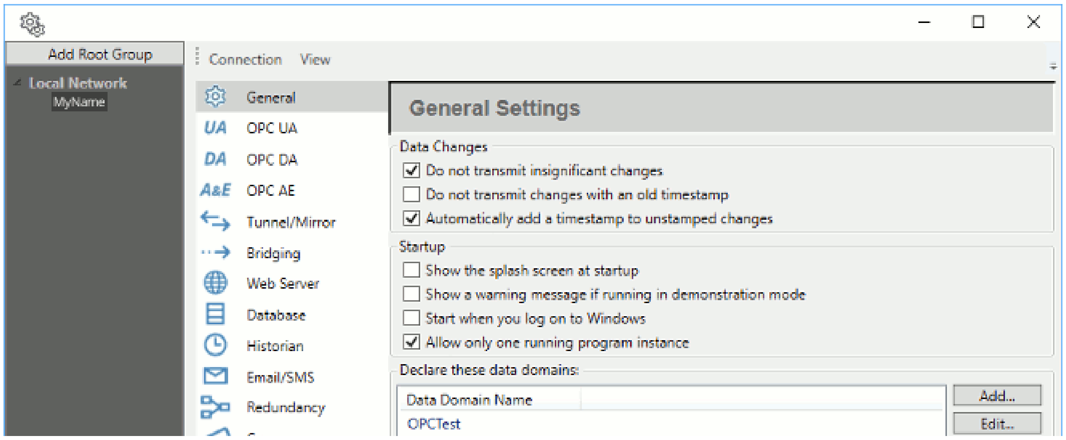
Display Mode

Controls how the data is displayed in the trend display. **Scroll** moves the wave from right to left as the data is generated. Old data scrolls off the left side of the display as new data scrolls in from the right. **Wrap** adds to the wave from left to right, and writes over old data.

Remote Config

The Remote Config tool lets you connect to a DataHub instance while it is running as a Windows service, or when it is running on a different computer on the network.

Click here to watch a video.



When running a DataHub instance as a Windows service it is commonly not possible to access its configuration dialog. Windows services have restricted ability to interact with the Windows desktop. You can use the Remote Config program to conveniently configure the DataHub instance while it is running as a Windows service.

All DataHub installations that are configured to allow remote configuration must also enable the DataHub Web Server. Thus, all DataHub licenses for V9 and above now enable the Web Server for one Remote Config connection, with no additional licenses necessary. The Web Server will not operate for any other purpose without the normal Web Server license, which can be installed separately.

The remote configuration tool includes the ability to store access credentials to many DataHub installations at once. You can now easily manage many DataHub program installations anywhere on your network from a single location.

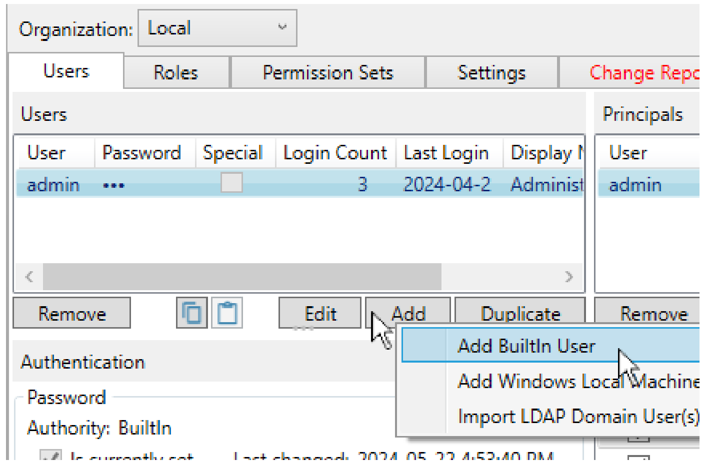
Preparation

Before connecting to a DataHub instance remotely to configure it, you must first run it as a normal program, not a service, and prepare it in two ways:

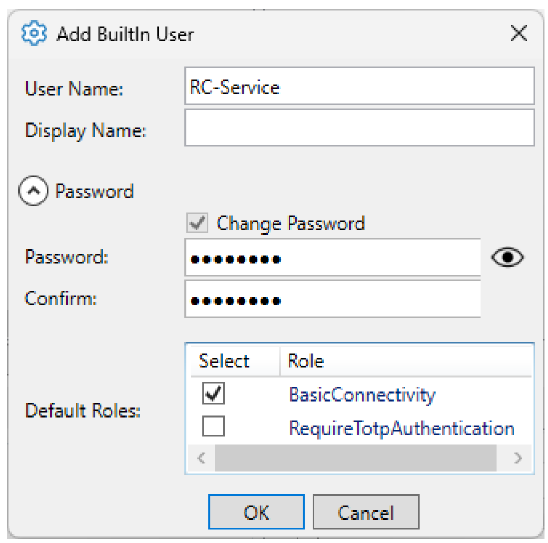
Security

Here is how to enter the basic security settings for Remote Config. To implement TOTP, please see Example: RCUser.

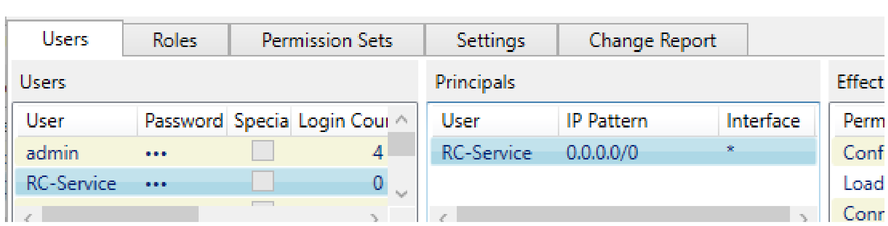
1. In the DataHub Properties window, select the **Security** option and click the **Configure** button.
2. Set the **Organization** to **Local**, and in the **Users** tab, under **Users**, click the **Add** button and select **Add BuiltIn User**.



3. Enter a **User Name** like **`RC-Service`** and an eight-character (letters and digits, upper/lower case) password like `Abcd1234`.

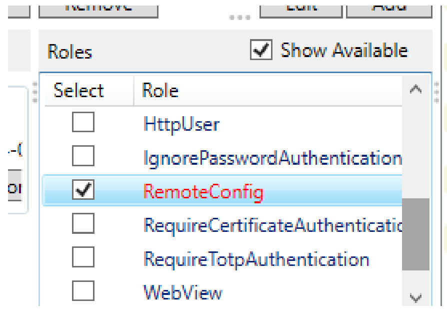


4. In the **Default Roles** section, uncheck the **RequireTotpAuthentication** button because this is an automatic, non-interactive connection.
5. Click the **OK** button. The user name will appear in the **Users** list, as well as in the **Principals** list.



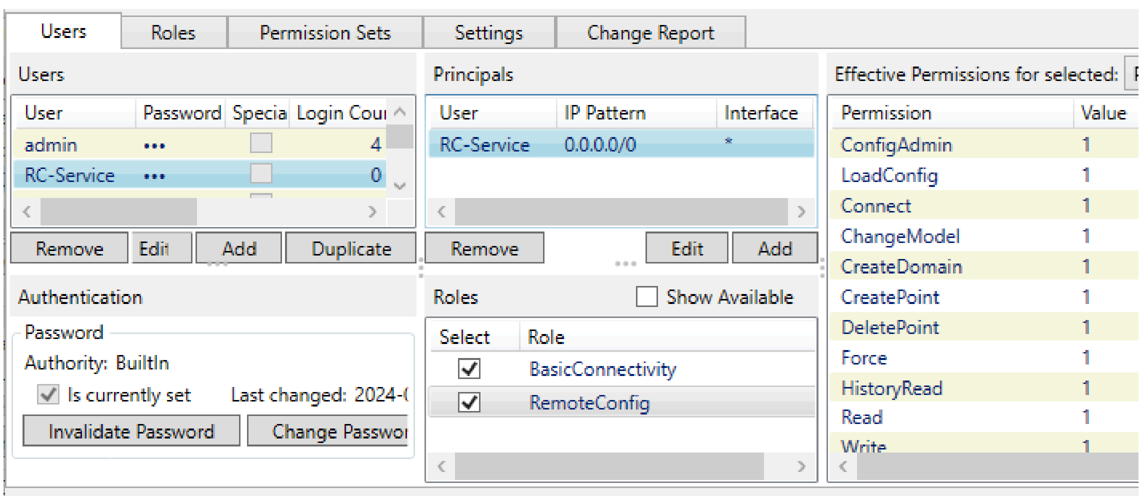
6. With that new user still selected, in the **Roles** section check the **Show Available**

button to display all the available roles. Scroll down to the **RemoteConfig** role and check that box.



Notice that more permissions now appear in the **Effective Permissions** panel, showing what the user can do from the Remote Config app.

7. Click the **Apply** button to apply your changes.

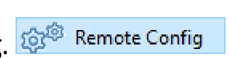


Click **OK** button to close the Security configuration.

For more information about security, please refer to DataHub Security and Using Security.

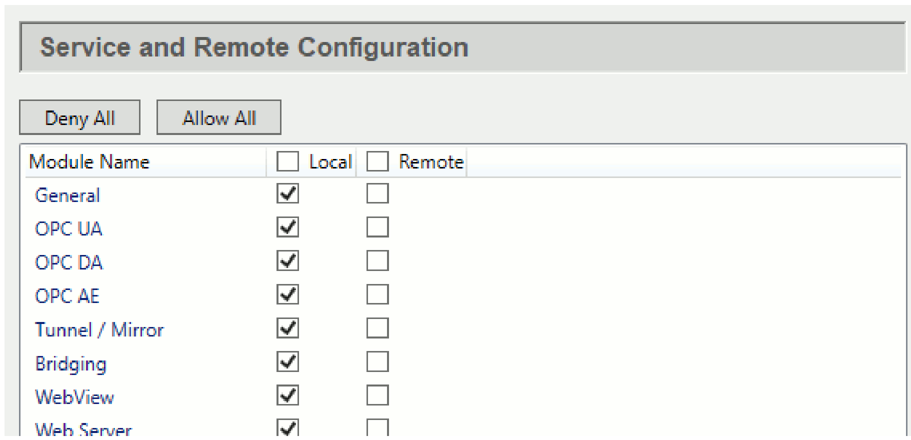
Features

You must configure the DataHub instance to allow remote configuration for any features that you wish to be able to remotely configure. For example, you may want to remotely configure Tunnel connections, but not allow scripts to be configured except from the local computer. You specify the configurable features as follows:

1. In the DataHub Properties window, select **Remote Config**. 

2. Check the boxes of the features you want to be configurable. Checking a box in the **Local** column allows connections only from a DataHub instance running on the

same machine, whereas boxes in the **Remote** column allow connections from a Remote Config instance running on a remote machine. If you uncheck **Local** and check **Remote**, then a user on the local machine will not be able to configure that feature.



Your DataHub instance is now ready to accept connections from the Remote Config program. Now you can go to Configuring a Local DataHub Instance for configuring a local connection, such as when running a DataHub instance as a service, or to Configuring a Remote DataHub Instance for remote connections.

The Remote Config tool can connect to DataHub Version 8 but cannot configure its settings. The only purpose in connection to DataHub V8 would be to remotely view the Data Browser, Event Log, Connection Viewer or Script Log. To make such a connection, use the button **Enter (Ignore Errors)** when authenticating the connection.

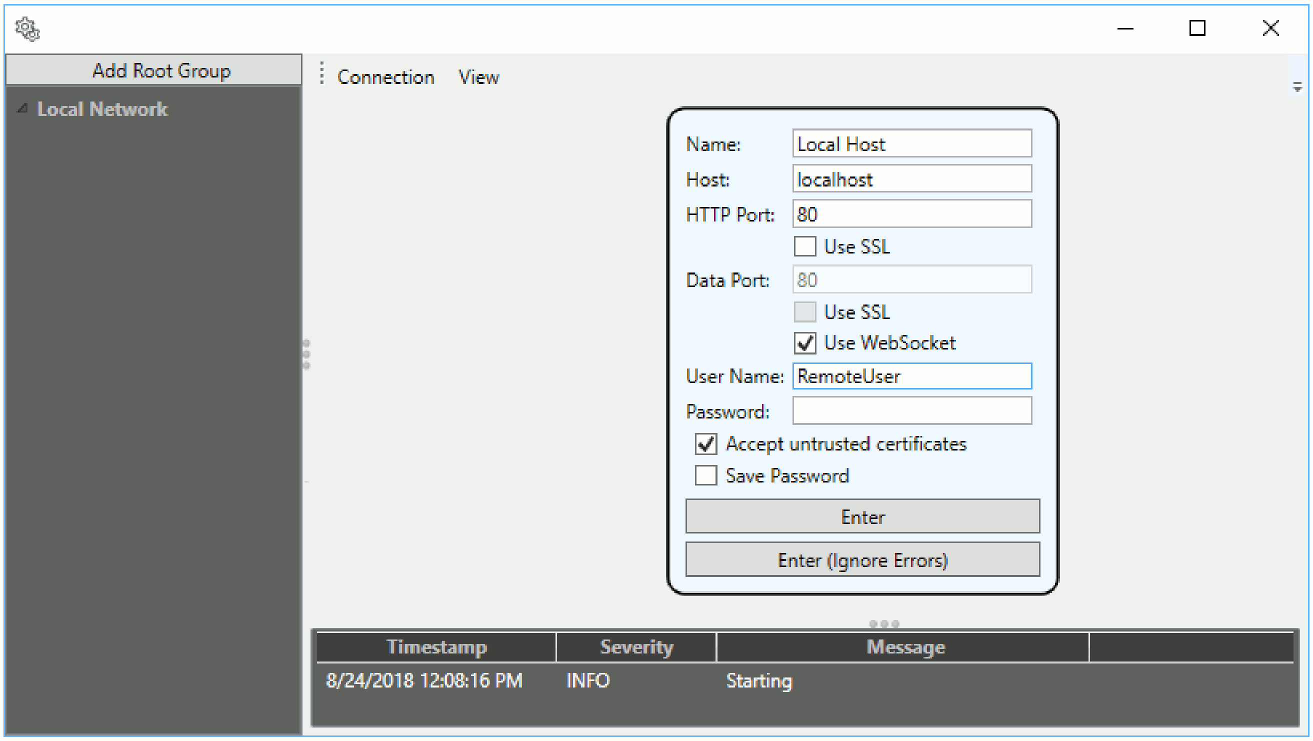
Configuring a Local DataHub Instance

When a DataHub instance is running as a Windows Service, you can use the Remote Config program to interact with it, without having to stop the service. You can reconfigure the DataHub instance, add new connections or view data and Event Log messages using the Remote Config program.

Here is how to start up the Remote Config program to interact with a DataHub instance while it is running as a Windows service on the same computer:

1. From the Start menu, go to the Cogent programs and select the Remote Config program.

This will open the Remote Config program interface.



2. Enter the following information

Name

A name for this connection, any text string.

Host

The URL or machine name of the computer where the DataHub instance is running.

HTTP Port

This port is used to exchange configuration data between the Remote Config program and the DataHub instance, via the DataHub Web Server. Use port `80` for plain text, unless you have changed the default settings on your Web Server. Entries here may need to be correlated with entries for the **Data Port**. See the table below for more details.

When configuring the DataHub Web Server, you must ensure that the port you configure is not in use. Please see the section called “Configuring the DataHub Web Server” for more information.

You do not need a Web Server license on a DataHub instance to connect the rcf; program.

Data Port

This port is used for passing data between the DataHub instance and the Remote Config program. The default and recommended setting is to make a WebSocket connection, which will use the same port as you choose for HTTP. You must use a WebSocket connection for the data port if your DataHub license does not enable the Tunnel/Mirror feature. Here are some of the possible HTTP and data port combinations.

HTTP Type - with - Data Type		HTTP Port	Data Port
Plain text - with - Plain text	configure	80, no SSL	4502, no SSL, no WebSocket
Plain text - with - WebSocket	configure	80, no SSL	80, use WebSocket
SSL - with - SSL, no WebSocket	configure	4503, use SSL	4503, use SSL, no WebSocket
SSL - with - SSL and WebSocket	configure	443, use SSL	443, use SSL and WebSocket

User Name

A name for a DataHub user that has administrative permissions (see Preparation for details).

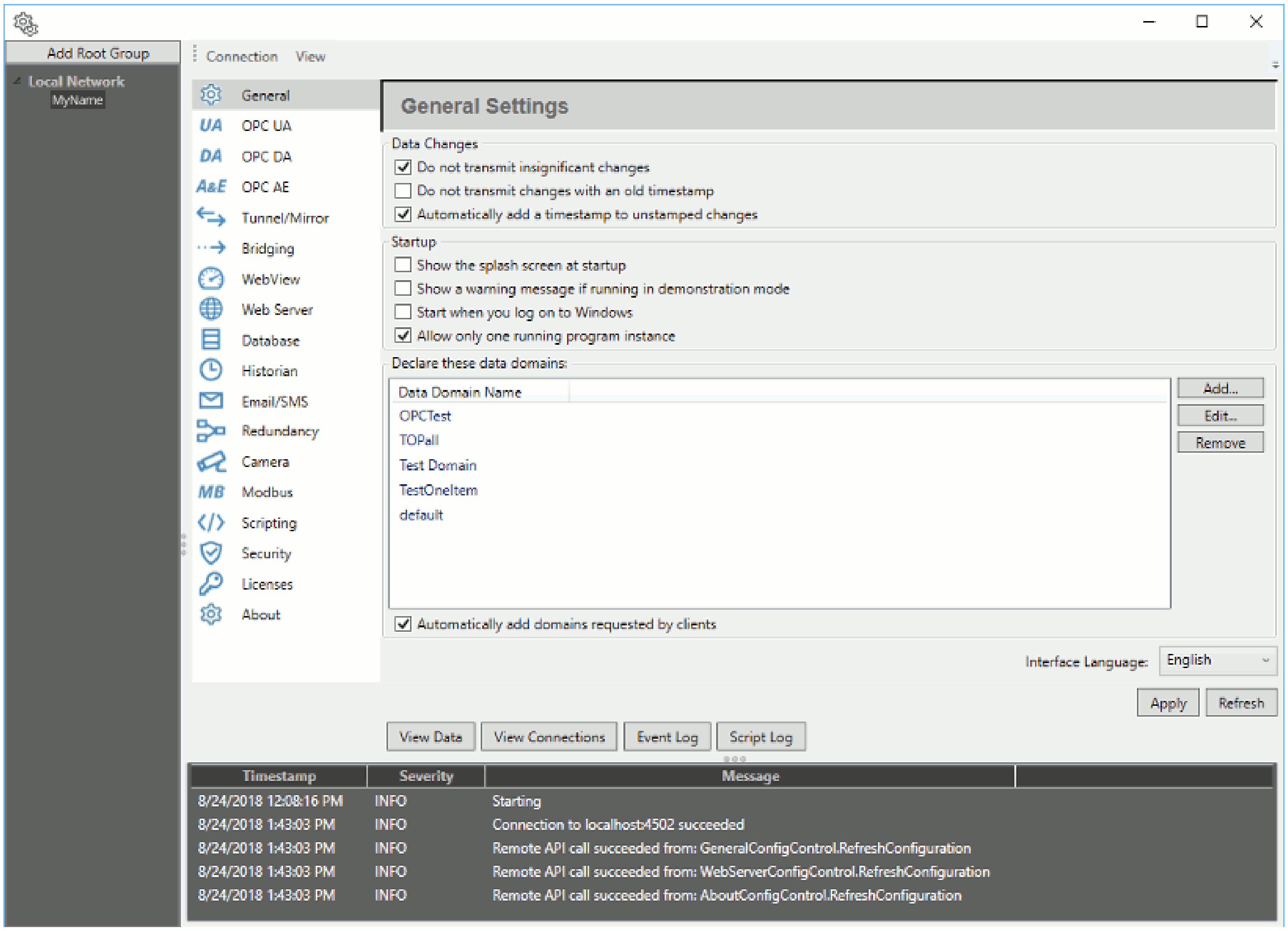
Password

The password for that user. Use the **Save Password** option to avoid re-entering it each time.

Accept untrusted certificates

Checking this box allows the Remote Config program to attempt a connection with a DataHub instance that may be using certificates for secure connections, such as the OPC UA server feature.

3. Press the **Enter** button to make the connection. You should now see a remote configuration version of the DataHub Properties window:



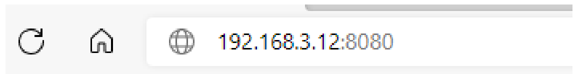
Please refer to the Remote Config chapter of the Cogent DataHub software manual for more information about the Remote Config application.

Configuring a Remote DataHub Instance

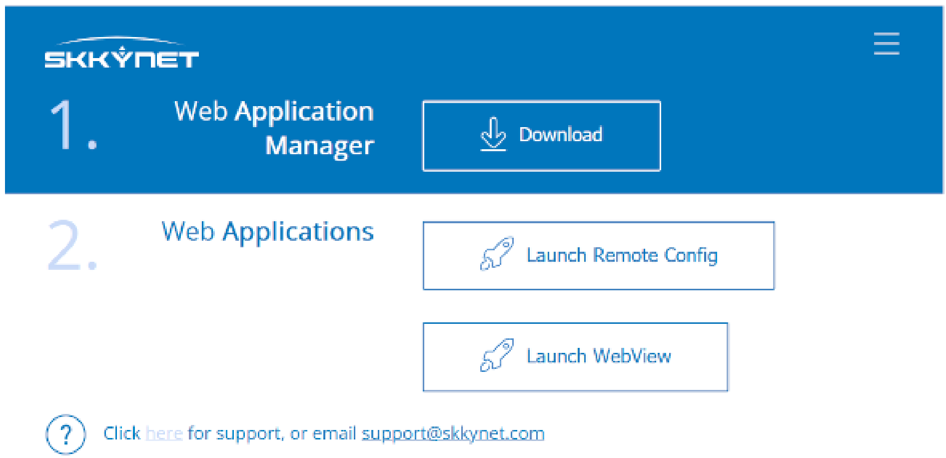
You can configure a DataHub instance from a remote computer with the Remote Config program. A special program, the Skkynet Web Application Manager, that comes with the DataHub program, helps you securely manage the process. Once you have prepared a remote DataHub instance, you can download the Web Application Manager from it, and web launch the Remote Config app, as follows:

1. Ensure that the DataHub instance you want to access is running, and that its Web Server feature is enabled.
2. Open a web browser and type in the IP address or network name for the DataHub computer. If the Web Server feature on that DataHub instance is configured to use a port other than the default port `80`, include that port number in the network address. For example, if the remote DataHub instance is at `192.168.3.12` and its Web Server is configured to use port `8080`, then the network address would be

192.168.3.12:8080.



This opens the launch page.



3. Click the **Download Web Application Manager** button and follow the instructions to download and install the Skkynet Web Application Manager. Now you are ready to launch an application.

   This installation is signed with a valid code signing certificate from Skkynet. If Windows cannot validate the certificate, do not install the software.

Launching the Remote Config application

Having installed the Web Application Manager, you can now follow the steps for Launching Applications to launch the Remote Config application.

Service Manager

The Service Manager is a program that provides access to Cogent software that can be installed to run as a Windows service. With this program you can select and configure how the service runs and change its status.

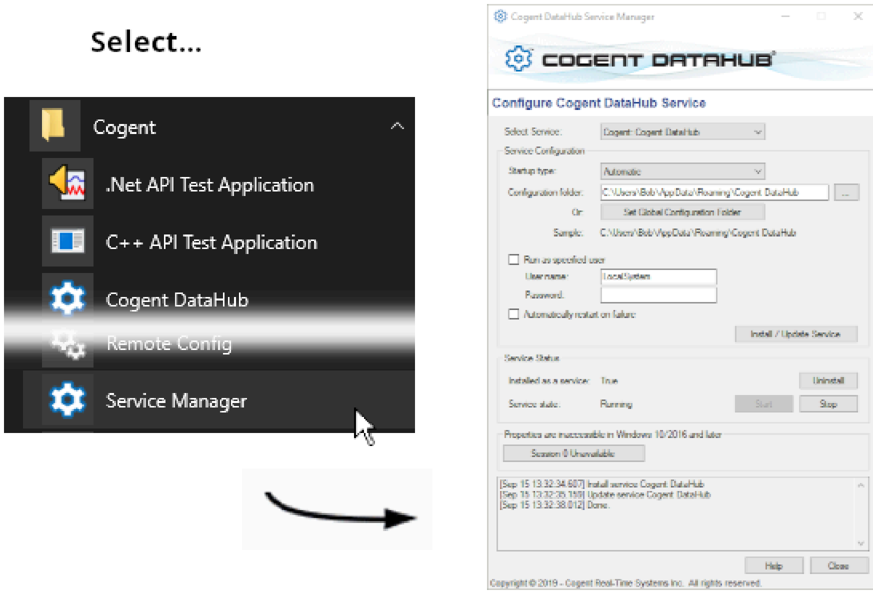
Please see Installing as a Service first if you are not yet running the service.

Please see Remote Config for the most convenient way to configure a DataHub instance while it is running as a service.

If your are upgrading to a newer major version of the DataHub program, please refer to Running a DataHub Instance as a service in Windows 10 and Server 2016 in Known Issues on the Cogent DataHub website for more information.

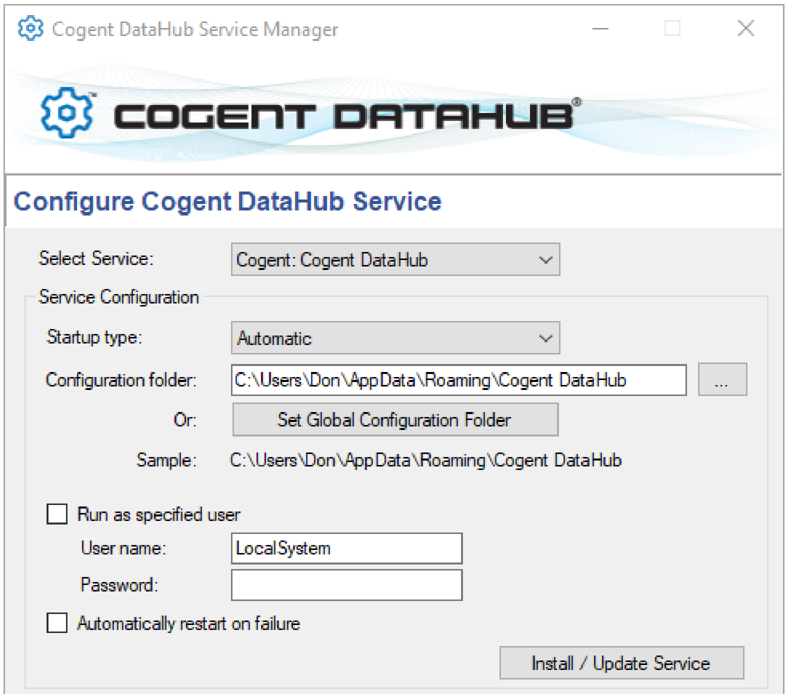
Starting the Service Manager

The Service Manager can be started from the **Cogent DataHub** program group in the **Cogent** entry of the Windows **Start** menu.



Once started, you can choose the service you need to configure from the **Select Service** dropdown list at the top. Then you can configure, install, and check the status of the service, as well as view the DataHub Properties window. The scrolling list at the bottom maintains a record of activities.

Service Configuration



Startup type:

Choose between **Automatic**, **Manual**, or **Disabled** to specify how you want the service to start when Windows starts.

Configuration folder:

Allows you to specify a folder in which to put the configuration files for the DataHub program. Typically this does not need to be changed. If you do change this entry, you must manually move all the files from the existing configuration folder to the new one. Please refer to Configuration Files for more information.

The **Set Global Configuration Folder** button lets you specify the configuration file through the registry. This will override the default configuration folder, but will not override a configuration folder supplied on the DataHub command line with the -H option. You can use environment variables to make this folder dependent on the system and user configuration. The **Sample** field gives an example of what the folder path will likely be, but it is not necessarily accurate. If the DataHub instance is run as a specified user, and the path is dependent on the user, then the **Sample** will display a path based on the current user, not the executing user, and will therefore show an inaccurate path. You can find the true configuration path in the DataHub About panel, by clicking the **About** button in the DataHub Properties window.

Run as specified user

If you run the DataHub instance as the local SYSTEM (`LocalSystem`) user, then you will be able to access the Properties window and make changes to the DataHub instance while it is running as a service. If you run as any other user, then you will need to access the Properties window using the Remote Config option.

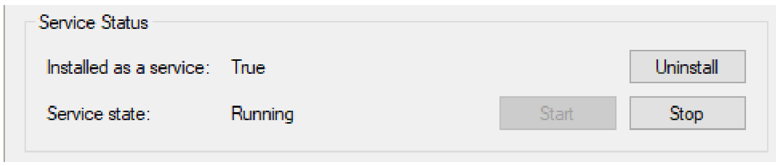
Automatically restart on failure

Have the service restart should it fail or be stopped for some reason.

Install/Update Service

When the above configuration is complete, press this button to install the DataHub program as a service. This will also start the DataHub service, though on some systems the service may need to be started manually if it doesn't start with the install operation. If the service is running and you make changes to the configuration, pressing this button will cycle through a service shutdown and restart to apply your changes.

Service Status



Installed as a service:

Indicates whether the selected program is installed as a service or not (**True** or **False**). The **Uninstall** button allows you to uninstall the DataHub program as a service.

Service state:

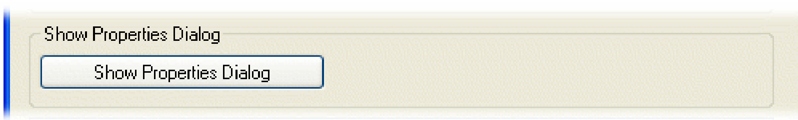
Indicates the run status of the service (**Stopped**, **StartPending**, **Running**, etc.) . The **Start** and **Stop** buttons allow you to start or stop the service.

Show Properties Dialog

This option appears differently for different versions of the Windows operating system:

Windows XP and Windows Server 2003

A **Show Properties Dialog** button allows you to open the Cogent DataHub Properties window.

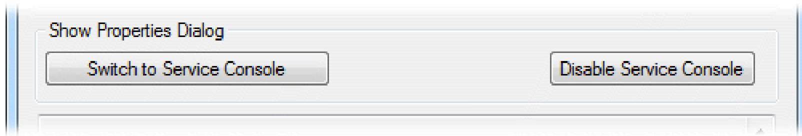


The DataHub Properties window is only visible on the primary console of the computer running the DataHub instance. If you are currently logged in via a remote desktop session, you will see a pop-up dialog indicating that you must be connected to the computer's primary console. You can do this by using the `/admin` or `/console` options on the Microsoft Remote Desktop client.

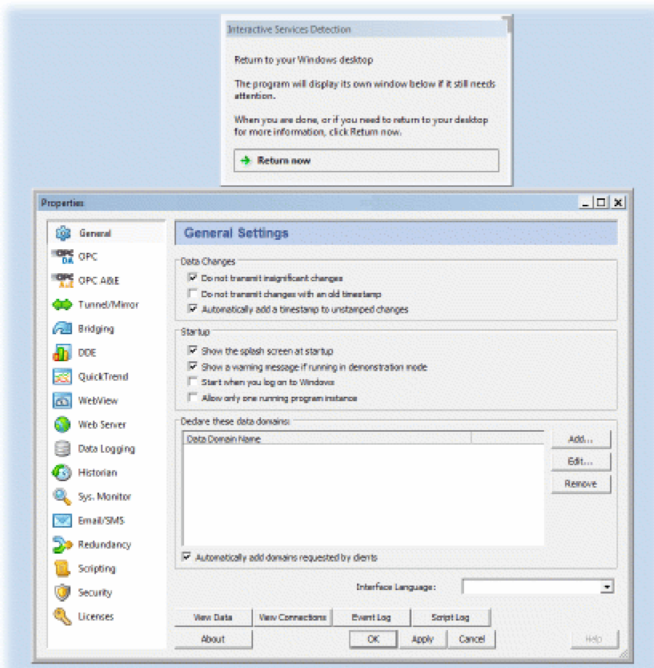
If you are already connected to the primary console, the DataHub Properties window and system tray icon will be displayed when you press **Show Properties Dialog** button.

Windows Vista, Windows 7, Windows 8, Windows Server 2008, and Windows Server 2012

The **Switch to Service Console** button displays the Windows Service Console, which is where the DataHub Properties window appears when running as a service. This allows you to view data and make changes to the DataHub configuration while it is running as a service.



The Service Console is a special display console provided by Microsoft Windows, also known as the "session 0 console". This was introduced in Windows Vista as a security mechanism to limit access to the user interface of high-permission processes. When you switch to the Service Console, your desktop will be hidden and the screen background will change color to indicate the special status of the Service Console.

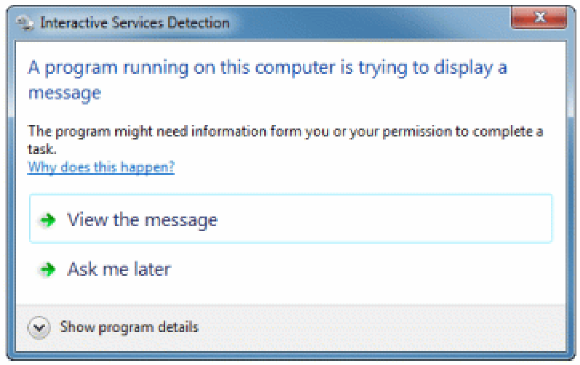


While the Service Console is open, your other applications will continue to run normally, but you will not be able to see or interact with them. A dialog box will be visible while you are viewing the Service Console that will allow you to switch back to your regular desktop at any time. If you have other system services running on your computer that also have user interface windows, those services will also be available to you while viewing the Service Console.

When you have finished viewing or editing the DataHub properties, before returning to the normal user console, you should click the **Apply** and **OK** buttons to close down the DataHub Properties window. Also be sure to close any other DataHub windows. This prevents the Windows Interactive Service Detection program from displaying pop-up messages when you return to the normal user console.

Once all the DataHub windows are closed, you can return to the normal user console by pressing the **Return Now** button in the Interactive Service Detection window.

If you forget to close any of the DataHub windows while working in the Service Console, Windows will begin popping up messages in the user console telling you there is a program requiring attention in the Service Console.



You can stop these messages and close down the Service Console by clicking on the **Disable Service Console** button in the DataHub Service Manager. Clicking this button will not stop the DataHub service.

When you close the Service Manager it will automatically disable the service console. This will stop Windows from periodically displaying the Interactive Services Detection dialog on your system.

Tunnel/Mirror Connections

For data networks, *tunnelling* means to encapsulate one protocol inside another, to allow it to be sent more easily and/or securely across the network. *Mirroring* means to replicate the data from one side to the other, so that both sides have identical data sets. DataHub tunnel/mirroring offers some unique advantage for data networking.

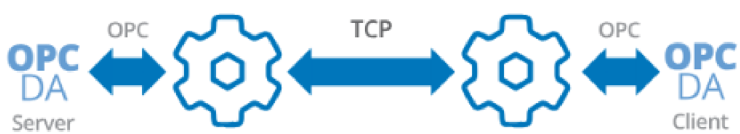
Watch this video to see how to configure Secure Tunnel Mirroring.

Why Tunnelling?

Avoiding DCOM

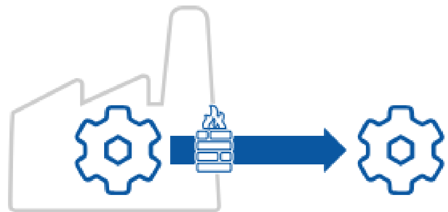
Connecting OPC Classic servers and clients across a network requires DCOM. DCOM has always been difficult to configure, and not very secure. Now, with the mandatory application of the KB5004442 security patch from Microsoft, only the two highest levels of DCOM authorization are permitted. Any connections from OPC clients with lower security settings will fail.

DataHub tunnel/mirroring makes only local OPC connections, and passes the data across the network over TCP, with optional SSL if needed. This eliminates the need for DCOM and solves the KB5004442 security patch problem.



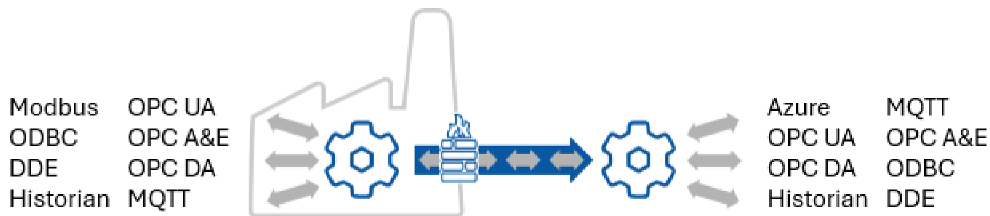
Outbound connections

Unlike most industrial data protocols, DataHub tunnel/mirroring can make outbound-only connections from the plant to the cloud, IT department, or a DMZ. It keeps all inbound firewall ports closed and uses no VPNs, for zero attack surface. SSL is fully supported for all networked protocols.



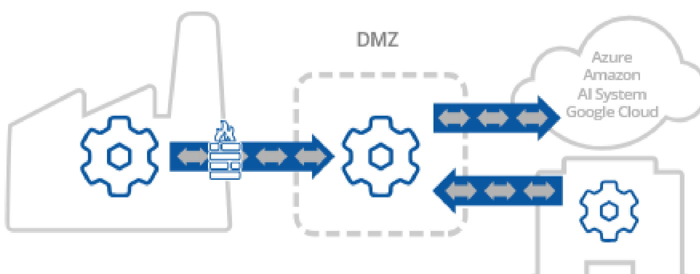
Flexible data flow

DataHub tunnel/mirroring can be configured for one-way or bidirectional data flow. It supports OPC UA, OPC DA, A&E, MQTT, Modbus, ODBC, and external historian connections—converting between them if necessary in real-time within the DataHub unified namespace.



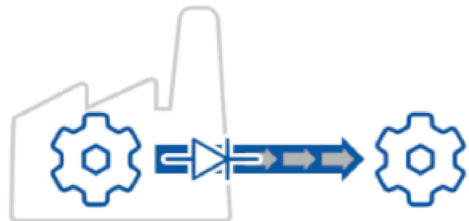
Traversing a DMZ

The NIS2 Directive, NIST CSF 2.0, and leading security experts all agree that network segmentation using a DMZ is critical for securing access to operations data. Unlike OPC UA or MQTT, DataHub tunnel/mirroring can pass data securely along the multiple daisy-chained connections that are necessary for DMZ support.



Data diode mode

Data diode mode provides an extra layer of security, ensuring that absolutely no data passes into the OT system. This feature can be used to support data diode hardware, or as a software-only option.



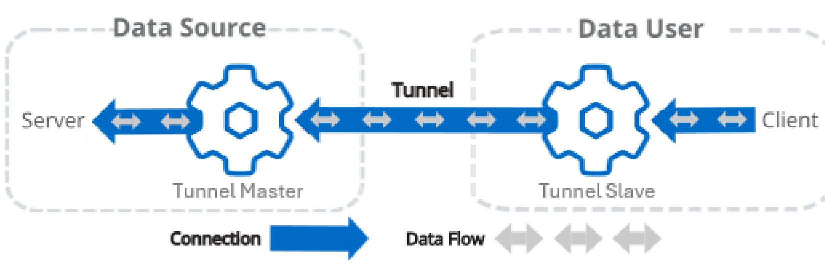
How-To Scenarios

There are three main tunnel/mirror scenarios, depending on how secure a connection you need.

- **Both Firewalls Open, Inbound** Often used for networking OPC Classic DA to avoid DCOM, as well as for OPC A&E or other data. Most effective on a secure, isolated network.
- **One Firewall Closed, Outbound** For securely accessing data from outside the control network, without VPNs.
- **Both Firewalls Closed, with DMZ** The most secure way to transmit data over insecure networks, without VPNs. It uses a DMZ (demilitarized zone) to completely isolate networks, as recommended by the NIS2 Directive, NIST CSF 2.0, and leading security experts worldwide.

Both Firewalls Open, Inbound

Primary Use For connecting OPC DA, A&E or other data over a secure, isolated network, avoiding DCOM.



1. On the Data Source side, connect the DataHub instance to the data source.
2. Still on the Data Source side, configure the DataHub instance as tunnel master.
3. Move to the Data User side and configure the DataHub instance as tunnel slave, making sure to configure these options as follows:.
    - For **Data Flow Direction:** choose **Read-only** for one-way, or **Read-write** for bidirectional data flow
    - For **When Connection Initiated:** choose **Get all values from Master**

• For **When Connection Lost:** choose **Mark data here “not connected”**

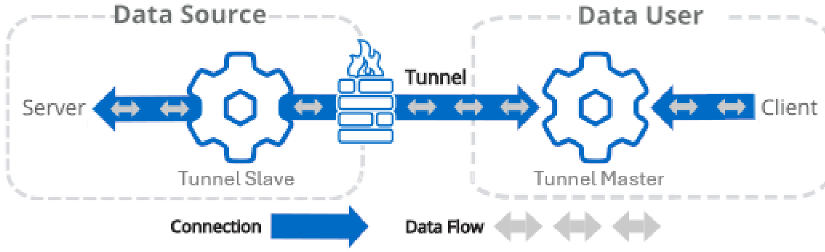
These options are configured this way because the tunnel master acts as the authoritative data source.

4. Still on the Data User side, connect the data user to the DataHub instance.

See also Tunnelling Security - Best Practices.

One Firewall Closed, Outbound

Primary Use Securely access data from outside the control network, without VPNs.



For all DataHub tunnels, the tunnel slave initiates the connection to the tunnel master. So, to tunnel outbound from the data source, you need to first configure the DataHub instance on the Data User side as the tunnel master, and then configure the DataHub instance on the Data Source side as the tunnel slave.

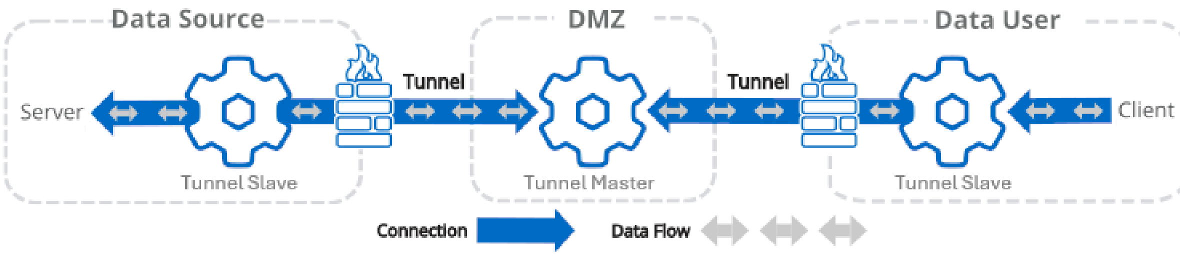
1. On the Data User side, configure the DataHub instance as tunnel master.
2. Move to the Data Source side and connect the DataHub instance to the data source.
3. Still on the Data Source side, configure the DataHub instance as tunnel slave, making sure to configure these options as follows:.
   - For **Data Flow Direction:** choose **Read-only** for one-way, or **Read-write** for bidirectional data flow.
   - For **When Connection Initiated:** choose **Override Master's values with mine**.
   - For **When Connection Lost:** choose **Mark Master's data “not connected”**.

   These options are configured this way because the tunnel slave acts as the authoritative data source.
4. Move to the Data User side and connect the data user to the DataHub instance.

See also Tunnelling Security - Best Practices.

Both Firewalls Closed, with DMZ

Primary Use Securely transmit data over insecure networks, without VPNs.



Since slaves initiate the connection to the tunnel master, the DataHub instance on the DMZ is the tunnel master, and both the other DataHub instances are tunnel slaves.

1. On the DMZ, configure the DataHub instance as tunnel master.
2. Move to the Data Source side, and connect the DataHub instance to the data source.
3. Still on the Data Source side, configure the DataHub instance as tunnel slave, making sure to configure these options as follows:
   - For **Data Flow Direction:** choose **Read-only** for one-way, or **Read-write** for bidirectional data flow
   - For **When Connection Initiated:** choose **Override Master's values with mine**.
   - For **When Connection Lost:** choose **Mark Master's data “not connected”**.

   These options are set this way because for this first part of the tunnel, the tunnel slave acts as the authoritative data source.
4. Move to the Data User side and configure this DataHub instance also as tunnel slave, making sure to configure these options as follows:
   - For **Data Flow Direction:** choose **Read-only** for one-way, or **Read-write** for bidirectional data flow
   - For **When Connection Initiated:** choose **Get all values from Master**.
   - For **When Connection Lost:** choose **Mark data here “not connected”**.

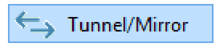
   These options are set this way because for this second part of the tunnel, the tunnel master on the DMZ is the authoritative data source.
5. Connect the data user to the DataHub instance.

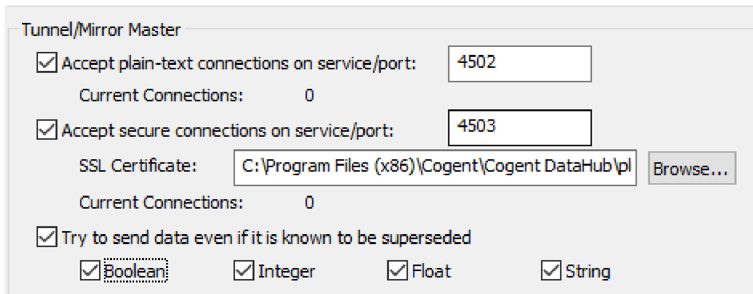
See also Tunnelling Security - Best Practices.

Configuring the Tunnel Master

The tunnelling master DataHub instance receives the initial request from a tunnelling slave to establish the tunnelling connection, initially or after a network break. Once the connection is established the two DataHub instances are indistinguishable from each other; both will send and receive data changes.

You must allow Remote Connections in Security for any incoming connections over the network.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 



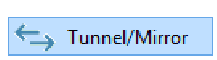
3. In the **Tunnelling Master** section, you can configure plain-text or secure tunnelling. Ensure that at least one of these is checked. If you want to change any of the other defaults, please refer to Tunnel/Mirror in the Properties Window chapter for more information.

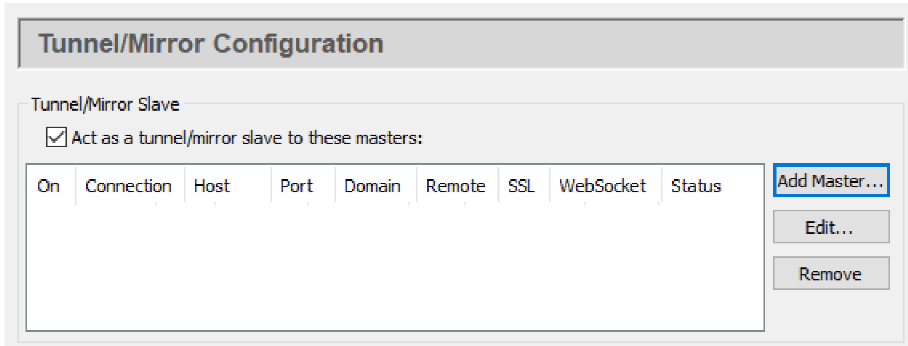
   To optimize throughput, un-check the **Try to send data even if it is known to be superseded** option. This will allow the DataHub instance to drop stale values for points which have already changed before the client has been notified of the original change. The latest value will always be transmitted.

4. To support incoming WebSocket connections from DataHub tunnelling clients, you will need to configure the tunnelling master DataHub instance's Web Server. For WebSocket connections, we recommend using SSL, on port 443.
5. Click **OK** to close the Properties window.

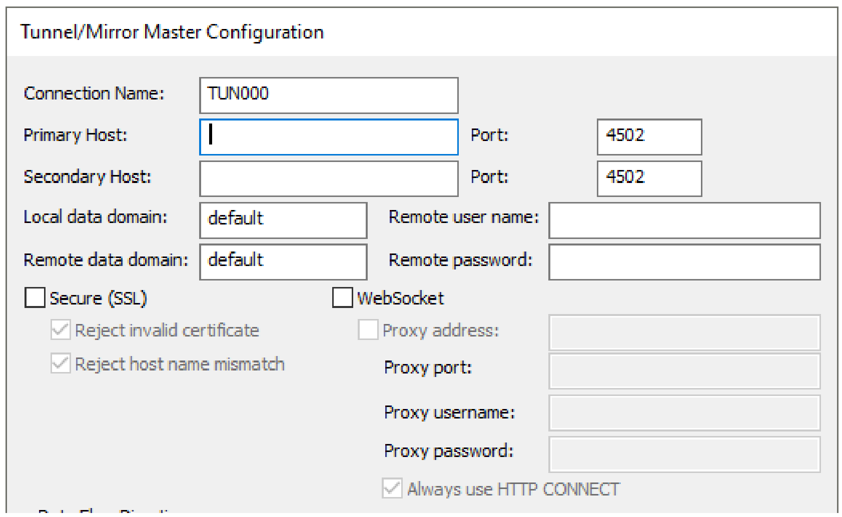
Configuring the Tunnel Slave

The tunnelling slave DataHub instance behaves exactly like the tunnelling master DataHub instance except that the slave establishes the tunnelling connection initially, and reestablishes it after a network break. If there are no firewalls between the server and master sides, the DataHub instance on the client side typically acts as the tunnelling slave, while the DataHub instance on the server side acts as the tunnelling master. If, however, you need to connect across a firewall, we recommend this scenario.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 



3. Check the box **Act as a tunnelling/mirror slave to these masters**.
4. Click the **Add Master...** button to assign a master to this slave. The **Tunnel/Mirror Master Configuration** window will open:



5. Type in the following information:
   - **Connection Name** a name to identify the tunnel. There should be no spaces in the name, and it doesn't matter what name is chosen, but it should be unique to other tunnel names.
   - **Primary Host** the name or IP address of the computer running the tunnelling master DataHub instance.
   - **Port** the port number or service name for this host. You should use default port number (`4502`) unless you have changed the entry in the master DataHub instance.
   - **Secondary Host** gives you the option to have an alternate host and service/port number. On startup or after a network break, the DataHub instance will search first for the primary host, then for the secondary host, alternating between primary and secondary until a connection is made. If no secondary host is specified, the connection will be attempted on the primary host only.

This feature is not recommended for implementing redundancy because it only checks for a TCP disconnect. The DataHub Redundancy feature, on the other hand, provides full-time TCP connections to both data sources, for instantaneous switchover when one source fails for any reason. There is no need to start up the OPC DA server and wait for it to configure its data set. You can also specify a preferred source, and automatically switch back to that data source whenever it becomes available. By contrast, the primary and secondary host in the tunnel can act as a primitive form of redundancy, but will only switch on a connection failure at the TCP level, which is only one sort of failure that a real redundancy pair must consider.

- **Local data domain** The data domain in which you plan to receive data.
- **Remote data domain** the master DataHub data domain from which you plan to receive data. Point names will be mapped from the remote data domain (on the master DataHub instance) into the local data domain (on this DataHub instance), and vice versa.

Unless you have a good reason for making these different, we recommend using the same data domain name on both DataHub instances for the sake of simplicity.

- **Remote user name** The user name for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.
- **Remote password** The password for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.
- **Secure (SSL)** lets you establish a secure connection using SSL tunnelling as long as the tunnelling master DataHub instance you are attempting to connect to has been configured for secure connections. The additional options allow for a connection to be made even if the security certificate is invalid, or the host name does not match. We don't recommend using these options unless absolutely necessary. For more about SSL, please refer to SSL Encryption.
- **WebSocket** lets you connect via WebSocket. This option is applied for both primary and secondary hosts, and allows you to enter a **Proxy address**, and a **Proxy port** number, **username**, and **password** as needed. When tunnelling through a proxy, HTTP uses normal HTTP proxy, and HTTPS uses HTTP CONNECT proxy. You can select the **Always use HTTP CONNECT** to use it for HTTP as well as HTTPS.

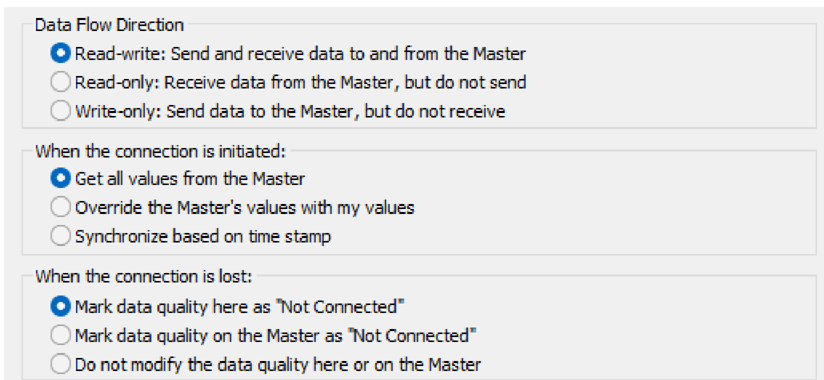
The WebSocket protocol requires a web server to act as an intermediary. So, for this option you will need to use the DataHub Web Server on the tunnelling master DataHub instance (as explained here).

There is a DataHub instance running on a Skkynet cloud server that you can connect to for testing. Here are the parameters you will need to enter for it:

- **Primary Host** `demo.skkynet.com`

- **Port** Will be set automatically by the system, `80` for **WebSocket** and `443` for **Secure (SSL)**.
- **Local data domain** `cloud`
- **Remote data domain** `DataPid`
- **Remote user name** `demo/guest`
- **Remote password** `guest`
- **WebSocket** Must be selected.
- **Secure (SSL)** Must be selected.

6. You now have several options for the mirrored connection.



a. **Data Flow Direction** lets you determine which way the data flows. The default is bi-directional data flow between slave and master, but you can effectively set up a read-only or write-only connection by choosing that respective option.

To optimize throughput, check the **Read-only Receive data from the Master, but do not send** option. Only do this if you actually want a read-only connection. If you do not require read-write access, a read-only tunnel will be faster.

b. **When the connection is initiated** determines how the values from the points are assigned when the slave first connects to the master. There three possibilities: the slave gets all values from the master, the slave sends all its values to the master, or the master and slave synchronize their data sets, point by point, according to the most recent value of each point (the default).

c. **When the connection is lost** determines where to display the data quality as "Not Connected"—on the master, on the slave, or neither.

If you have configured **When the connection is initiated** as **Synchronize based on time stamp** (see above), then this option must be set to **Do not modify the data quality here or on the Master** to get correct data synchronization.

d. **Connection Properties** gives you these options

- **Replace incoming timestamp...** lets you use local time on timestamps. This is useful if the source of the data either does not generate time stamps, or you do not trust the clock on the data source.
- **Transmit point changes in binary** gives users of x86 CPUs a way to speed up the data transfer rate. Selecting this option can improve maximum throughput by up to 50%.

  For more information, please refer to Binary Mode Tunnel/Mirror (TCP) Connections in Optimizing Data Throughput.

- **Run in data diode mode and discard all incoming data** This mode is used for outbound slave connections and outbound data flow. Please see Run in data diode mode... in Tunnel/Mirror Properties for more information.
- **Target is an Embedded Toolkit server** allows this slave to connect to an Embedded Toolkit server rather than to another DataHub instance.
- **Heartbeat** sends a heartbeat message to the master every number of milliseconds specified here, to verify that the connection is up.
- **Timeout** specifies the timeout period for the heartbeat. If the slave DataHub instance doesn't receive a response from the master within this timeout, it drops the connection. You must set the timeout time at least twice the heartbeat time.

  To optimize this setting, please refer to Tunnel/Mirror (TCP) Heartbeat and Timeout in Security.

- **Retry** specifies a number of milliseconds to wait before attempting to reconnect a broken connection.

7. Click **OK** to close the **Tunnel/Mirror Master** window. The fields in the **Tunnelling Slave** table of the Properties Window should now be filled in.
8. Click the **Apply** button in the Properties Window. If the master DataHub instance is running, this DataHub instance should establish the tunnelling connection, and the **Status** should display `Connected`. You can view the data with the Data Browser, or view the connection with the Connection Viewer.

Endpoints - Sources and Users

Supported Protocols

The Tunnel/Mirror feature works with these DataHub-supported protocols:

- OPC UA
- OPC DA
- OPC A&E

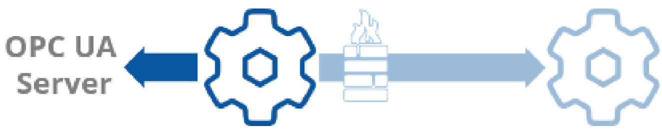
- MQTT
- Modbus
- ODBC
- DDE
- External Historian
- DataHub service for Azure

One end of the tunnel typically connects to a data source, while the other end connects to a data user. Often the data source is a server, like an OPC server, and the data user is a client, like an OPC client. But since the data flow can be one-way or bidirectional, any connected program can act as a data source or data user.

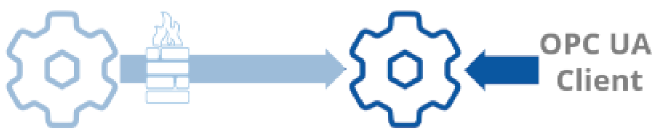
Because each DataHub instance acts as a unified namespace, you can connect with any data protocol at either end of the tunnel. For example, the data source might be an OPC UA server, while the data user could be an MQTT broker.

OPC UA

Connecting to an OPC UA server How-To



Connecting from an OPC UA client How-To



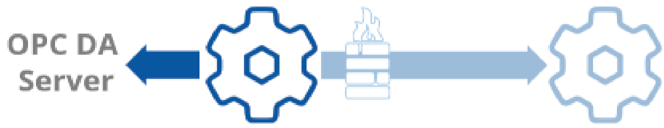
Tunnelling may not seem necessary for OPC UA, since it offers robust networking options. But since OPC UA follows standard industry practice, it requires an open inbound firewall port to connect from the client to the server. Secure tunnelling solves that problem.

You can keep all inbound firewall ports closed on the OPC UA server side by configuring the DataHub instance there as a tunnelling slave. That way the connection is outbound to the OPC UA client side, while the DataHub instance on that side is configured as the tunnelling master. This approach allows you to keep all inbound firewall ports closed on the data source side, for a secure, zero-attack-surface connection.

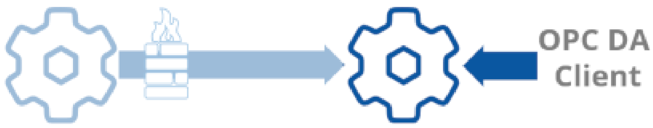
Additionally, a tunnel/mirror connection can traverse a DMZ, while the OPC UA protocol cannot.

OPC DA

Connecting to an OPC DA server How-To



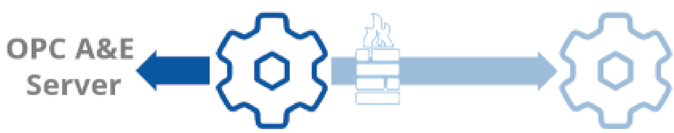
Connecting from an OPC DA client How-To



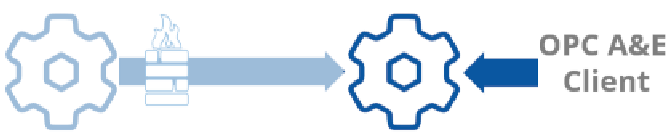
Tunnelling is the best way to network OPC DA. It avoids DCOM, which is difficult to configure and not very secure. For secure, isolated networks, you can make a traditional client-to-server connections, keeping all firewalls open. Over an *insecure*, exposed network, you can make an outbound connection, as shown above. This keeps all inbound firewall ports closed on the data source side, for zero attack surface.

OPC A&E

Connecting to an OPC A&E server How-To



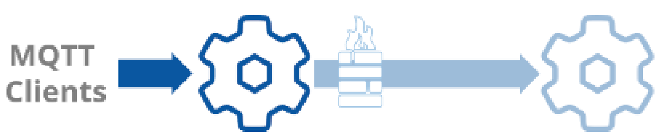
Connecting from an OPC A&E client How-To



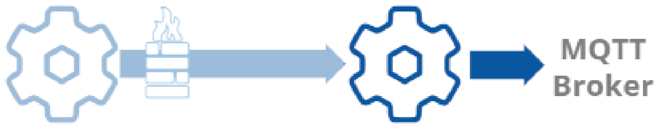
Like OPC DA, OPC A&E Classic relies on DCOM for networking. All of the advantages of tunnelling for OPC DA apply to OPC A&E as well.

MQTT

Connecting Incoming Clients How-To



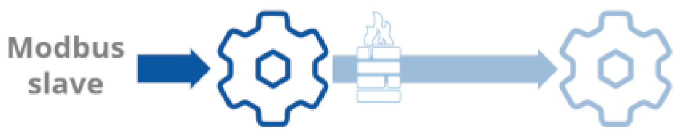
Connecting Out to a Broker How-To



Often used in Industrial IoT for moving data from the field directly to a cloud service, MQTT does not traverse a DMZ very well because it cannot ensure data consistency across daisy-chained servers. Tunnelling solves that problem. The both firewalls closed scenario is typically used.

Modbus

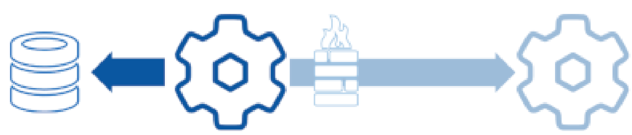
Making Slave Connections How-To



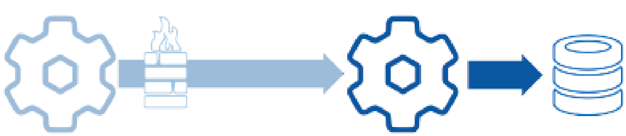
DataHub software provides Modbus master support only. So for tunnelling, the data source can be a Modbus slave, but the data user must be a protocol other than Modbus.

ODBC

Making Read/Query Connections How-To



Making Write Connections How-To

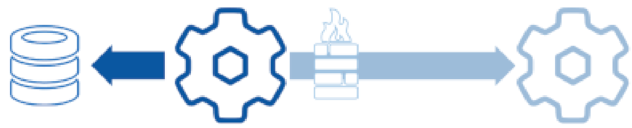


Using the Database Query option, it is possible to read data from an ODBC database and send it via a tunnel to any data user. Likewise, you can tunnel any data source to a DataHub instance that is configured for Database Write, and log the data.

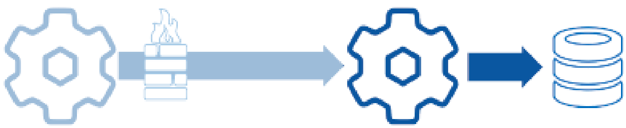
Since ODBC networks well, it is typically more advisable to use the Database Write feature for logging to a database across a network. Doing so allows you to use the built-in Store and Forward feature to recover data during network outages.

DDE

Act as a DDE Client How-To



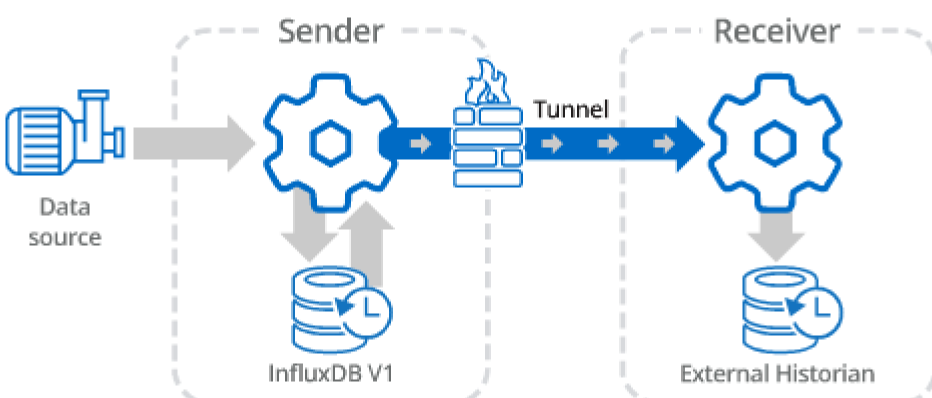
Act as a DDE Server How-To



Tunnelling lets you connect Excel across a network, as well as any other DDE client or server. For more flexible Excel networking, see also DataHub™ Add-in for Microsoft Excel.

External Historian

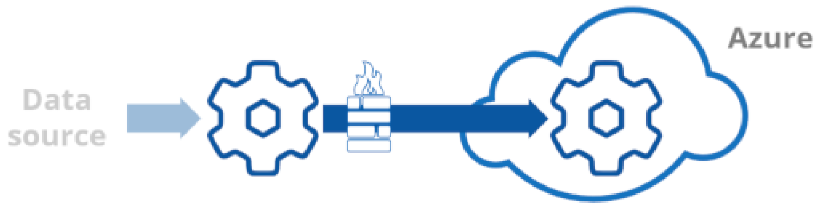
Making Connections



Tunnelling lets you connect to an external historian across a network, and can support store and forwarding of historical data. This kind of tunnel can also traverse a DMZ. Please see Typical Scenarios in Using the External Historian for more information.

DataHub service for Azure

Making Connections



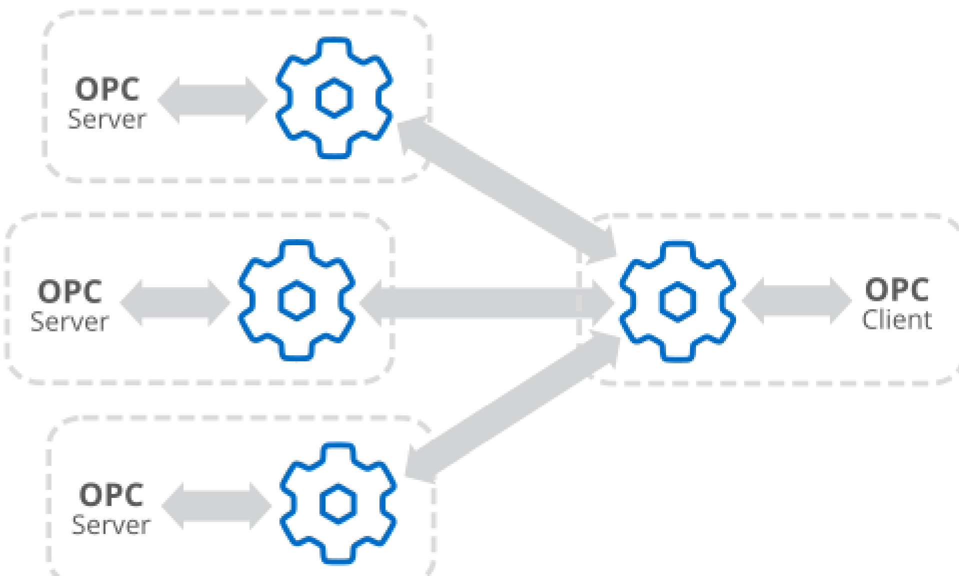
An on-premise DataHub instance can serve as a tunnelling endpoint to send data directly into Azure Event Hubs. This kind of connection is more flexible and reliable than using MQTT to connect to the cloud.

Combinations

Here are some ways to create multiple tunnels, and/or integrate other DataHub features.

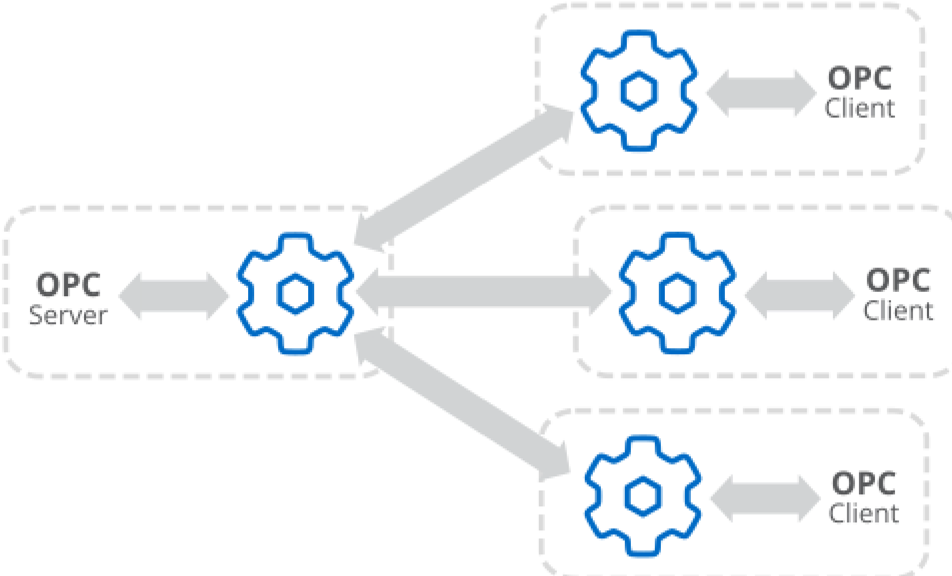
Multiple connections

- You can aggregate data from multiple remote servers into a single DataHub instance, and bring all the data into one client.



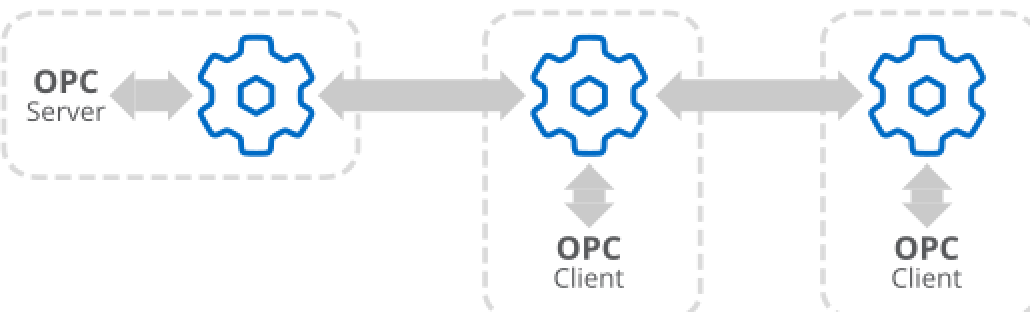
Aggregation takes place on the OPC client machine.

- You can also use tunnelling to bring data from a single server to many remote clients.



Aggregation takes place on the OPC server machine.

- You can link multiple DataHub instances together to form a *daisy chain*.



The middle DataHub instance in this scenario is configured as both a tunnelling slave and a tunnelling master.

- See Typical Scenarios for scenarios that let you tunnel through firewalls and DMZs, keeping all outbound firewall ports closed. That section also covers redundant tunnelling connections.

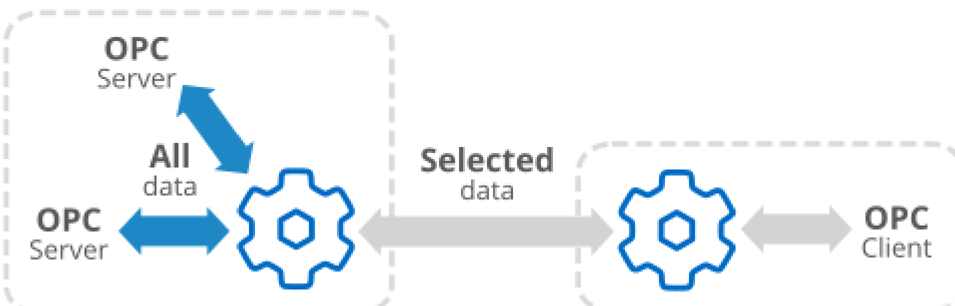
Bridging

Bridging means linking data from one server to another server, usually on a single machine. However, you can also bridge two OPC servers over a network using a tunnelling connection:

This scenario involves setting up the DataHub instances on both machines to act as OPC clients to the respective OPC servers. The DataHub instances then interface with each other over a tunnelling connection. Configure the DataHub instance on the machine with the most uptime to be the tunnelling master and the other DataHub instance to be the tunnelling slave. We recommend that all bridges be configured on just one of the DataHub instances.

Partial data sets

You often don't need to tunnel all of the data from an OPC server across the network. It is faster and takes less bandwidth to transfer only the data you need. The DataHub program allows you to do this by setting up a separate data domain for the tunneled data. In fact, you can aggregate parts of data sets from several servers into a single data domain, and then tunnel that combined data set across the network.



Putting data from one or more servers into a separate data domain is done through bridging. When you configure bridges, just make sure to create target points in a new, separate data domain..

TCP Ports and DataHub Tunnelling

When a TCP socket connection is made (for any socket by any software, not just a DataHub instance), the original connection is made between a (usually) random port on the TCP client side and a published (listening) port on the TCP server side.

In the case of a DataHub tunnel, the tunnelling slave is the TCP client, which makes an outbound connection from a random port. The tunnelling master is the TCP server, which requires an inbound firewall port to be open for its published port number.

When a TCP client connects to a TCP server, it first makes contact through the published port. The server application then allocates a socket associating the client's random port with the server's listening port. More than one socket can be associated with the server's listening port, but the combination of client IP, client port and server port will always be unique. Data on the established socket can flow in either direction if the software is configured to allow it. Any subsequent conversation between a client and the server will again be initiated through the published port.

All modern firewalls understand this mechanism. They maintain "state" information for TCP connections. When a socket conversation is initiated, the client's firewall sees this and updates its tables to allow traffic from the server to the client on the client's randomly selected port, but just for that one socket conversation. When the socket closes, that port is again blocked. While the conversation is open, the firewall will reject any packets to that port that have not originated from the server application. See https://en.wikipedia.org/wiki/Stateful_firewall.

This is the fundamental nature of TCP communication. It is safe. You do not need to open any inbound firewall ports on the DataHub tunnelling slave's firewall. You do need to open one inbound port in your firewall for the DataHub tunnelling master.

If that is too much exposure on the DataHub master computer, you can further isolate it by using a DMZ running a DataHub instance, acting as an isolation layer between the two networks. The DataHub instance on the DMZ becomes the tunnelling master, and each of the connected DataHub instances act as tunnelling slaves. This allows you to communicate between both ends of the tunnel without opening any inbound firewall ports on either end. The only open inbound firewall ports would be on the DMZ itself, where the DataHub tunnelling master is located.

In summary, a simple DataHub tunnel requires:

- One open inbound firewall port on the master.
- Zero open inbound firewall ports on the slave.
- See Tunnelling - One Firewall Closed.

A DataHub tunnel using a DMZ requires:

- One open inbound firewall port on the DMZ, the master.
- Zero open inbound firewall ports on either end of the tunnel, which are both slaves.
- See Tunnelling - Both Firewalls Closed.

OPC UA Connections

Introduction

OPC *Unified Architecture* (*UA*) is the latest standard from the OPC Foundation. Its purpose is to unify the OPC Classic standards of Data Access (DA), Alarms and Events (A&E), and Historical Data Access (HDA) into a single, extensible framework. At the same time OPC UA offers improved networking support, a more sophisticated security model, platform independence, and comprehensive information modeling.

The OPC UA spec allows for implementation across a wide range of hardware platforms and operating systems. The different OPC UA implementations that are possible within this extensible and flexible framework all share a common core OPC UA functionality and interoperability.

The goal of the DataHub program's implementation of OPC UA is to support the functionality most required for industrial process control—secure, real-time data communications. Currently this includes OPC UA Server and OPC UA Client support for Data Access, including Discovery, Address spaces, On-demand, Subscriptions, and Events.

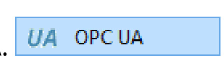
The DataHub program offers its OPC UA Server and OPC UA Client support as fully integrated with all other DataHub features. This allows it to act, for example, as an OPC UA - Classic converter, to connect OPC UA to any SQL database, display and access OPC UA data via DataHub WebView, connect to Modbus or Excel, send emails, and support tunnelling OPC DA, server-to-server bridging, data aggregation, redundancy, and more.

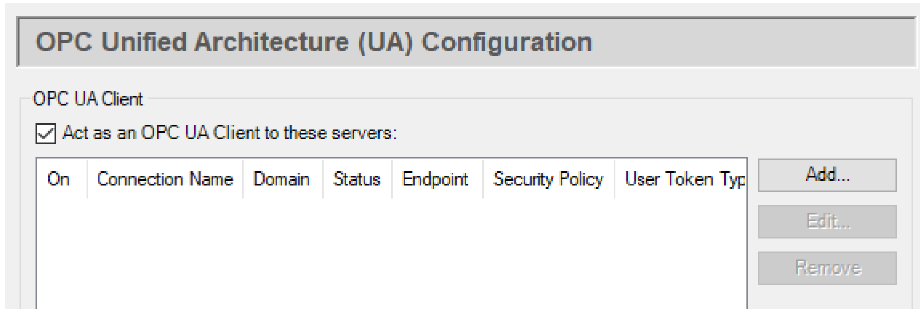
Because OPC UA may be new to some DataHub users, this chapter includes background information on OPC UA, such as concepts related to Endpoints and Discovery, Certificates, and Security, while also providing the necessary instructions for configuring a DataHub instance to connect to an OPC UA server or receive connections from an OPC UA client, along with some troubleshooting tips.

Connect to an OPC UA server

To configure a DataHub instance to act as an OPC UA client to connect to an OPC UA server, you can follow these steps:

Click here to watch a video.

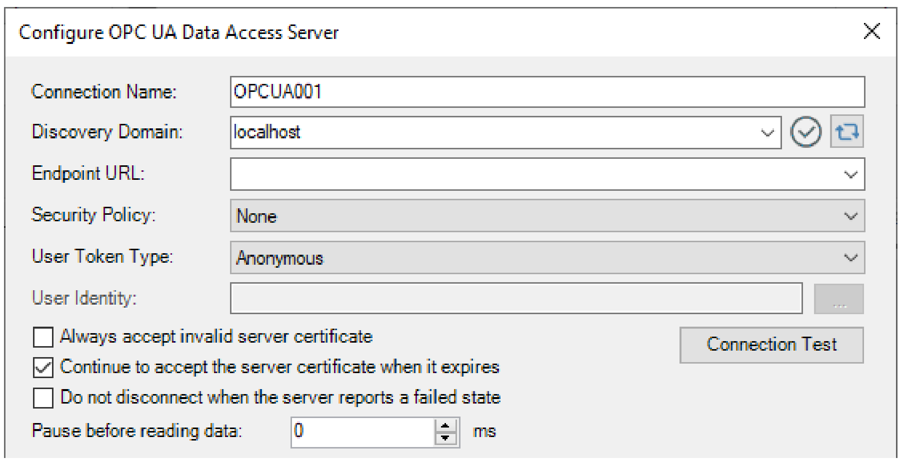
1. **Activating OPC UA**
   a. Right click on the DataHub system-tray icon and choose **Properties**.
   b. In the Properties window, select **OPC UA**. 



c. Check the **Act as an OPC UA Client to these servers** box.

2. **Making the Connection**

   Click the **Add** button and fill in the fields in the **Configure OPC UA Data Access Server** Window:



a. **Connection Name** Choose any name, to be used by the DataHub instance to identify the connection. If you leave this blank, names will be assigned incrementally, starting with `OPCUA000`, `OPCUA001`, `OPCUA002`, etc.

b. For the two next entries there are three different approaches, depending on how this client is able to access the LDS (Local Discovery Server) for the server you want to connect to.

   1. If the LDS appears in the **Discovery Domain** list:

      Discovery Domain Choose the OPC UA Discovery Server to which you want to connect. Click the server refresh button () if necessary. A list of available endpoint URLs will appear below.

      Endpoint URL Choose the appropriate endpoint URL for the protocol that you want to use to connect to the OPC UA Server.

   2. If the LDS does *not* appear in the **Discovery Domain** list:

      Discovery Domain Type in the computer name or IP address of the computer running the OPC UA server to which you want to connect. Click the server refresh button ( ) if necessary. A list of available endpoint URLs should appear below.

Endpoint URL Choose the endpoint URL for the protocol that you want to use to connect to the OPC UA Server. When the LDS returns the endpoint, it will probably contain the computer name instead of the IP address that you typed in, above. If so, you will need to edit it, replacing the computer name with the IP address. If the endpoint URL is not there at all, you can type it in, making sure that you enter the complete name.

3. If there is *no LDS* for the server you need to connect to:

   Discovery Domain Type in the IP address of the computer running the OPC UA server to which you want to connect.

   Endpoint URL Type in the *complete name* of the endpoint URL that you want to use.

Endpoint URL Searches

For each Discovery Domain, the system will attempt to list its endpoint(s), providing feedback as follows:

Indicates that the endpoint discovery is in process.

Indicates that the endpoint discovery has failed.

Indicates that the endpoint discovery has succeeded.

If a connection has already been configured, and the **Configure OPC UA Data Access Server** Window is opened for editing. the **Endpoint URL** will first appear as previously configured. The DataHub instance will then attempt to validate the endpoint, with the status icon changing first to In Process ( ), and then to either Failure ( ) or Success ( ). If at any time you initiate a search by pressing the server refresh button ( ), and the system fails to locate an endpoint URL, then it will leave the **Endpoint URL** entry field empty.

c. **Security Policy** If you are working on an untrusted network, and want to use encryption, then choose a security policy. Otherwise, you can leave this at **None**.

   The security options available for each endpoint URL are determined by the OPC UA server configuration.

d. **User Token Type** If you want to use authentication, then you can choose a User Token Type. Otherwise, you can leave this at **Anonymous**.

e. **User Identity** This will change depending on the **User Token Type** (above), allowing for the entry of a certificate file path or a user name and password, as appropriate.

f. **Always accept invalid server certificate:** This option tells the client to always accept the server certificate, even if the certificate is invalid, or if it changes in the future.

Selecting this option will disable server certificate verification for this connection, exposing the connection to man-in-the-middle attacks. Use with extreme caution.

g. **Continue to accept server certificate when it expires** This allows a UA server certificate to be accepted outside of its valid time window, meaning that expired certificates can continue to be used, and that the UA server and client will stay connected if their system clocks ever get out of synch.

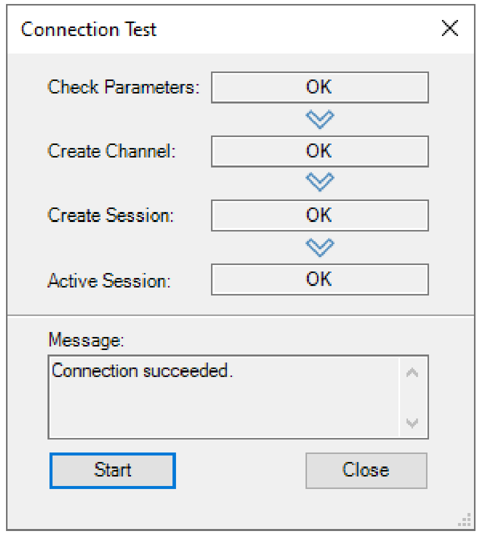
If you are using the http protocol along with a security policy, then the clocks on the UA server and client machine must match within 5 minutes at all times. If this is not possible, you should use either the opc:tcp or https protocol.

h. **Do not disconnect when the server reports a failed state** By default, if the UA server is in a non-`RUNNING` state the DataHub instance disconnects and puts a message in the Event Log. Checking this box lets you override that behaviour and maintain the connection to the server.

i. **Pause before reading data** Lets you specify a time for the DataHub instance to pause before reading the OPC server's data set. Some OPC servers report that they are running, but have not yet constructed their full data set. If the DataHub instance attempts to browse the server immediately after connecting, it might get a partial data set. This option tells the DataHub instance to wait the specified amount of time after a successful connection before it browses the server’s data set.

3. **Connection Test**

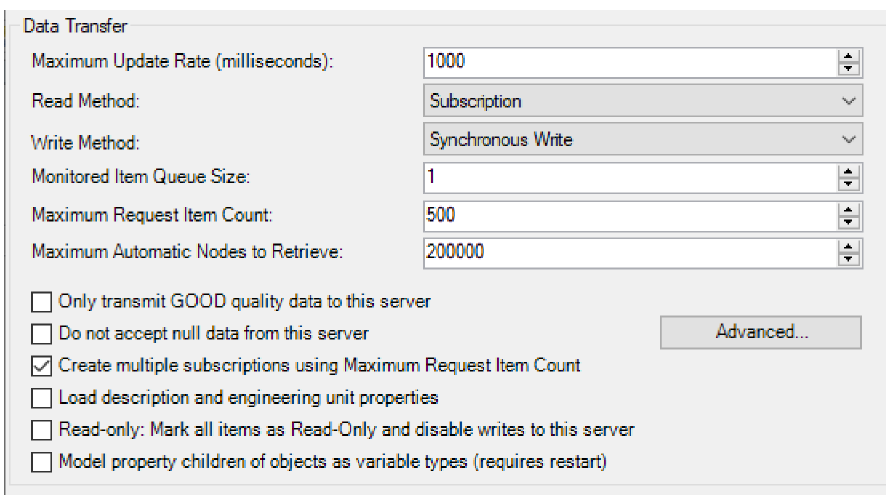
   To test the connection, click the **Connection Test** button. The system will open the Connection Test window, and you can watch as it checks the parameters, then creates a channel and session, and then activates the session.



If there is a problem at any point, the **Message** box will provide some trouble-shooting tips. The **Start** button restarts the test.

4. **Data Transfer**

   There are several options for specifying how the data is to be transferred: If this is the first time you are configuring an OPC UA client connection, to keep things simple you can keep the default settings for now, and move on to the next step, Selecting Items. Otherwise, you can change the data transfer settings as follows:



   a. **Maximum update rate (milliseconds)** lets you specify an update rate, useful for slowing down the rate of incoming data. The minimum value is `10`. This value is also used as the polling time for asynchronous and synchronous reads (see below).

   b. **Read Method** Choose how to read data from the OPC UA server:

      - **Subscription** The DataHub instance registers with the UA server for all configured points, to be received on an event-driven basis. Whenever a point value changes, the new value is sent immediately to the DataHub instance. This option is more efficient than **Synchronous Read** or **Asynchronous Read**, and has lower latency than either of them.

- **Asynchronous Read** The DataHub instance polls the UA server for all configured points on a timed interval (set by the **Maximum update rate**), and does *not* wait for a reply. This option is less efficient than **Subscription**, and has higher latency.
- **Synchronous Cache Read and Synchronous Device Read** The DataHub instance polls the UA server for all configured points on a timed interval (set by the **Maximum update rate**), and this thread waits for a reply. The difference between **Synchronous Cache Read** and **Synchronous Device Read** is the maximum age (maxAge). This mimics the cache and device reads in OPC DA, where a device read requests a new read from the underlying device. A device read can be substantially slower than a cache read.

  Synchronous Cache Read is approximately equivalent to **Asynchronous Read** in terms of efficiency and latency. If you are trying to read data at a rate that is near the limit of the server's capability, **Synchronous Cache Read** is a better choice because it will naturally slow down to what the server can handle, whereas **Asynchronous Read** will generate overlapping requests that could ultimately result in the connection being closed by the server. For this reason, given a choice between these two, we recommend **Synchronous Cache Read**.

c. **Write Method** Choose how to write data to the OPC UA server:

   - **Asynchronous Write** The DataHub instance writes to the UA server and does not wait for a response. This provides the highest overall performance.
   - **Synchronous Write** The DataHub instance writes to the UA server and waits for a response each time. This elicits a quicker response for a given item from the UA server, but results in lower overall performance. This option is useful if the UA server doesn't support asynchronous writes at all, or if it can't handle a large number of them.

d. **Monitored Item Queue Size** The maximum number of items between polls that get stored on this server.

e. **Maximum Request Item Count** lets you reduce the DataHub default of `500` to what the server allows. This may be necessary because the OPC UA spec allows a UA server to specify the number of items it will allow per request, which in some cases can be less than 500.

f. **Only transmit GOOD quality data to this server** restricts point updates from the DataHub instance to the server to only those with "Good" quality.

g. **Do not accept null data from this server** restricts point updates from the server to the DataHub instance to only those with non-null values.

h. **Create multiple subscriptions using Maximum Request Item Count** The **Maximum Request Item Count** (above) specifies the maximum number of nodes per subscription. With the **Create multiple subscriptions...** option checked (the default), the DataHub instance will use this number to decide the maximum number of nodes per subscription. However, if this number is small and the total number of nodes is large then the number of requested subscriptions could exceed the subscription count limit of the server. Unchecking this box will solve that problem by putting all of the nodes into a single subscription.

i. **Load description and engineering unit properties** Checking this box will cause the DataHub instance to load any engineering unit and range information associated with each point. These values are then made available to all DataHub clients, and are displayed in the DataHub Data Browser. Activating this feature will increase the time needed for making the initial connection to the server.

j. **Read-only: Mark all items as Read-Only and disable writes to this server** lets you specify that the connection to the OPC server be read-only, regardless of how individual items are specified. Items in the DataHub instance that originate from such an OPC server will be read-only to all DataHub clients. The DataHub instance will reject any attempt to force the value of a point when the server is marked as read-only.

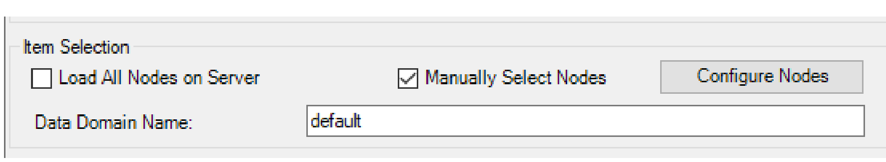
k. **Model property children of objects as value types** Normally an OPC UA property will be modeled in OPC DA as a property. In OPC UA properties can be direct children of either structural nodes, like objects, or value nodes. Similarly in OPC DA, properties can be direct children of branches or leaves. The DataHub program attempts to preserve this structure as much as possible. However, many OPC DA clients cannot subscribe to properties, making the UA properties inaccessible to those OPC DA subscriptions. Selecting this option will promote OPC UA properties that are direct children of structural nodes to become values, which will in turn promote them to leaf items in OPC DA. This option will not have an effect if the parent of the property is a value node in OPC UA, because promoting the property to be a value child of a value would make it unrepresentable in OPC DA.

Changing this option may require restarting the DataHub instance for its effects to apply.

Please see **Advanced** for information about advanced options.

5. **Selecting Items**

You can select all nodes, select nodes manually, or both.

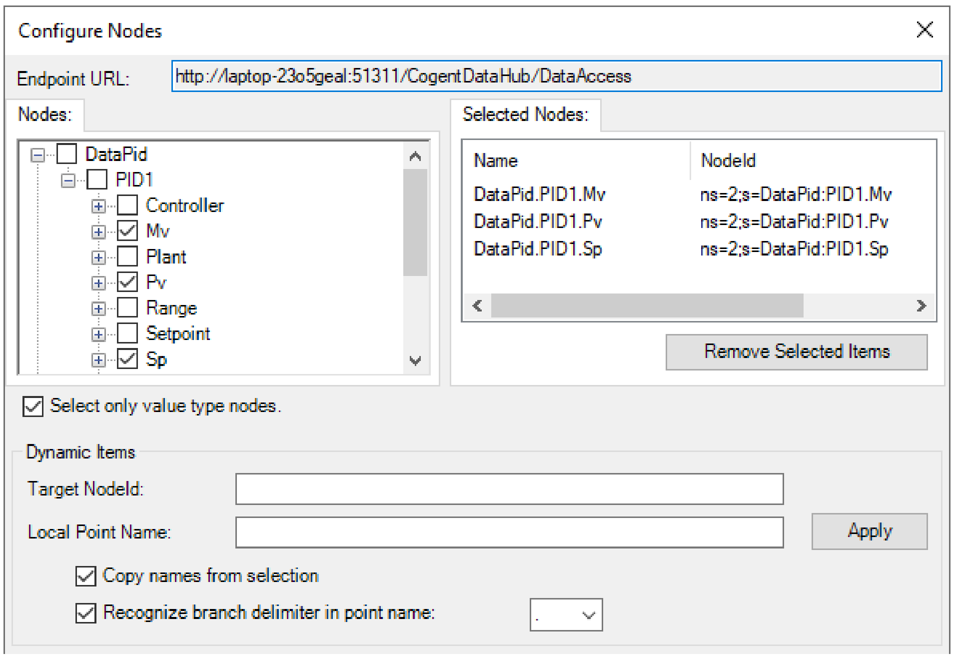


a. **Load All Nodes on Server** With this option you can load all data nodes on the OPC UA server, or filter for groups of nodes.

When you choose this option, the DataHub instance is configured to provide all data nodes, but not the Server nodes. This is done as a convenience, because in most cases few, if any, Server nodes are needed. To additionally get Server nodes, you can select them manually.

b. **Manually Select Nodes** Select the **Manually Select Nodes** option and press the **Configure Nodes** button.

This opens the Configure Nodes window, where you can specify exactly which nodes you wish to use:



You can browse through the tree in the left pane, selecting points as you go. The selections will appear in the right pane. To view sub-branch and leaf items, click the + sign in front of the item to show the children. You can select many items together like this:

a. Expand all of the branches containing points that you want to add.

b. Click the name of the first point (not the check box).

c. Go down to the last point, hold down the **Shift** key and click the name. All of the names should become highlighted.

d. Press the **Space Bar**.

That should select all of the highlighted points. It will not select nodes that are not visible.

Selecting just a branch by itself will not include any of its sub-branches or leaves, but selecting a leaf item will automatically include all of its branches.

In the Remote Config tool, the following options are available:

- Left-click the checkbox to select/deselect only that item.
- Right-click the checkbox to select/deselect all direct children of that item, but not the item itself.
- Control-right-click the checkbox to select/deselect all children of that item recursively, but not the item itself.

Checking the box **Select only value type nodes** will ensure that the only nodes you choose are data nodes.

A + in front of an item does not necessarily mean that the item has children. You must click the + sign to find out.

c. **Dynamic Items** allow you to explicitly map OPC UA nodes to DataHub point names. Use this when you cannot find the node by browsing, or when the OPC UA server supports dynamically created nodes.

   a. **Target NodeId** A text string to identify the node in the OPC UA server.

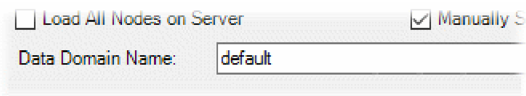
   b. **Local Point Name** The name of the point within the DataHub instance to map to the **Target NodeId**.

   c. **Copy names from selection** When checked, automatically fills in the **Target NodeId** and **Local Point Name** fields whenever you select a node in the **Selected Nodes** list.

   d. **Recognize branch delimiter in point name** When checked, the **Local Point Name** will be split using the delimiter character, and a DataHub point hierarchy will automatically be created. For example, if the point name is `Plant1.Tank2.Temperature` and the delimiter is a dot character, then this will automatically create a root branch named `Plant1` and a sub-branch within `Plant1` named `Tank2`, then add a point named `Temperature` within the `Tank2` branch. When unchecked, the point name will be created without modification in the root of the target data domain.

   Changes in this **Dynamic Items** section are applied to the Selected Nodes list when you press the **Apply** button.

d. **Data Domain Name** lets you specify the name of the DataHub domain into which the data points will be placed.



6. Click the **OK** button to accept the configuration (or **Cancel** to reject it) and close the Configure OPC UA Data Access Server window.
7. Click the **Apply** button in the Properties window to accept the configuration.

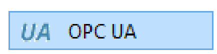
   The configured client connection will appear in the list, and if the **Act as an OPC UA Client to these servers** option is selected, the DataHub instance will attempt to connect to the OPC UA server.

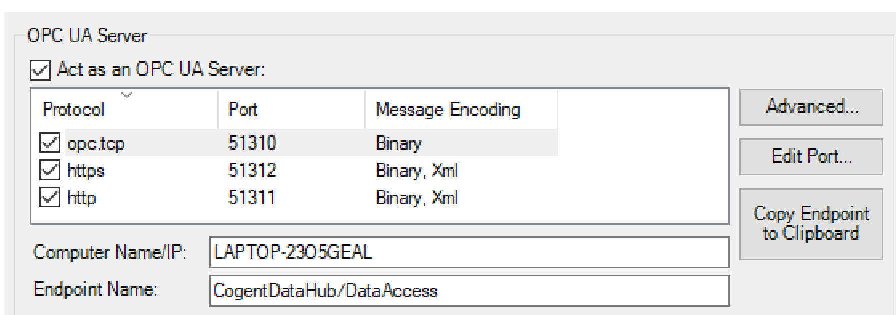
Connect from an OPC UA client

By default, the DataHub program is configured to act as an OPC UA server to receive client connections. To change this or any default settings, you can follow the steps below.

Click here to watch a video.

You must allow Remote Connections in Security for any incoming connections over the network.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **OPC UA**. 



3. Ensure that the **Act as an OPC UA Server** box is checked to enable the OPC UA server, or uncheck the box to disable it.
4. These basic UA server settings can be modified if necessary.

   Any changes made here will restart the OPC UA server when you click the **Apply** button.

   - **Protocol** To disable any of the available protocols, uncheck its box.

- **Port** The port number can be changed by double-clicking it, or by using the **Edit Port...** button.
- **Computer Name/IP** You can change the host name or IP address, which will then be integrated into the server URL visible to a connecting client. The default is the host name.
- **Endpoint Name** You can enter an endpoint name for this OPC UA server. This will be integrated into the server URL visible to a connecting client. The default is `CogentDataHub/DataAccess`.

Some UA clients cannot connect to a UA server unless the server name is left blank. For these cases, the DataHub instance can be configured with a blank server name as follows:

1. Clear the **Endpoint Name** entry field so that it is blank.
2. Uncheck the **HTTP** and **HTTPS** protocols, as these are not supported when the **Endpoint Name** is blank.
3. Click **Apply** to save the changes.

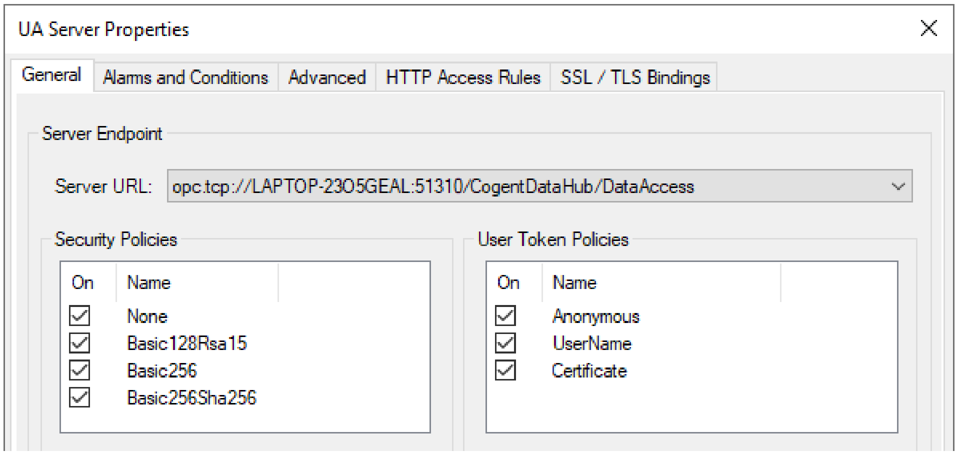
The DataHub UA server will restart with a blank user name, allowing a UA client to connect to it using a simple Endpoint URL, for example:

```
opc.tcp://192.168.1.1:52310/
```

Some UA clients may require some or all of the following information about the DataHub OPC UA server:

- **Namespace** http://www.cogentdatahub.com/DataHub
- **Namespace ID** 2
- **ID type** This information should not be exposed to the user.
- **NodeID syntax** The syntax of NodeIDs in a DataHub instance is `ns=2;s=`*`pointname`*. The namespace is always 2. For example: `ns=2;s=DataPid:PID1.Mv`.
- **Type** Typically the canonical type of the node (ID above) retrieved from the server through a client request.
- **Access to data point** The client application developer will need to provide this information, such as read-only or read-write.

5. To make it easy to get started, the OPC UA server is configured with minimal security settings. If you want to modify or enhance security, click the **Advanced** button to open the UA Server Properties window, shown below. Otherwise, you can skip this step.



a. The **General** tab of the UA Server Properties dialog lets you modify the default **Security Policies** and **User Token Policies** for each **Server URL**.

Security Policies Disabling **None** for `opc.tcp` and `http` will require connecting clients to support encryption for these connections. HTTPS is already encrypted, so **None** need not be disabled for `https`.

User Token Policies Disabling **Anonymous** will require the connecting client to provide a username/password or certificate to log in.

Putting all this together, below are some suggested settings you can use to secure your OPC UA server.

`opc.tcp://...`

Security Policies		**User Token Policies**	
Off	None	**Off**	Anonymous
On	Basic128Rsa15	On	User Name
On	Basic256	On	Certificate

`http://...`

Security Policies		**User Token Policies**	
Off	None	**Off**	Anonymous
On	Basic128Rsa15	On	User Name

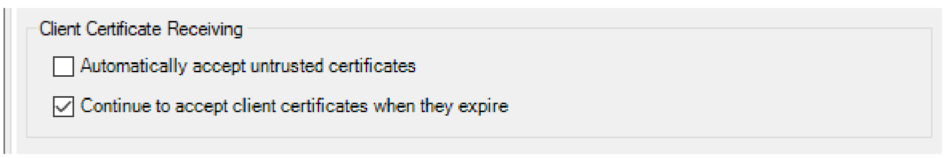
Security Policies		User Token Policies	
On	Basic256	On	Certificate

https://...

Security Policies		User Token Policies	
On	None	**Off**	Anonymous
		On	User Name
		On	Certificate

Any changes made here will restart the OPC UA server when you click the **Apply** button.

b. In the **Client Certificate Receiving** section, ensure that the **Automatically accept untrusted certificates** box is *not* checked.



Otherwise, all clients will be accepted as trusted.

The **Continue to accept client certificates when they expire** option allows expired certificates to be used, and also keeps the UA server and client connected if their system clocks ever get out of synch. For more information, please see the Advanced feature of the OPC UA Server section.

c. Click the **OK** button to accept the revised configuration (or **Cancel** to reject it) and close the UA Server Properties window.

6. You can use the **Copy Endpoint to Clipboard** button to make a copy of this server's endpoint, if necessary.
7. Click the **Apply** button in the Properties window to accept the configuration.

These are the most common changes you might want to make to the default configuration for the OPC UA server. For other configuration options and more details about the OPC UA server, please refer to the OPC UA Server section of the Properties Window chapter.

Endpoints and Discovery

An OPC UA connection is initiated by an OPC UA client contacting an OPC UA server. Each client connection is made to the *endpoint URL* that the OPC UA server makes available. To establish a connection, the OPC UA client must either know the endpoint URL of the OPC UA server in advance, or it needs to *discover* it.

To facilitate discovery, an OPC UA server can offer a Local Discovery Server, or *LDS* connection. The LDS is identified by the computer host name, and it always uses port 4840. Thus, as long as the OPC UA client knows the host name of the computer, it can connect to the LDS. Once connected, the LDS provides the endpoint URL for the OPC UA server. Based on that information, the OPC UA client connects to the OPC UA server.

Of course, if the endpoint URL is known, then that can be entered directly in the OPC UA client configuration, and the connection will be made directly.

Endpoint URL Syntax

The syntax for an endpoint URL is as follows:

```
Protocol://ComputerName:PortNumber/EndpointName
```

`Protocol`
: Defined by the UA Server. The client may only connect using one of the protocols offered by the server. The OPC UA protocols are represented in endpoints as follows:

- **TCP** - `opc.tcp`
- **HTTP** - `http`
- **HTTPS** - `https`

`ComputerName`
: The network name, IP address or fully qualified domain name of the computer you are trying to reach. It is dependent on the client-side computer.

`PortNumber`
: Usually defined by the UA Server, though you may need to change it if your network connection includes a NAT that is remapping the IP address of the UA Server.

`EndpointName`
: Defined by the UA Server.

Examples:

```
opc.tcp://My-PC:4840/MyComputer/MyUAServer
http://AcmeServer:52601/UADiscovery
https://175.252.04.21:443/Rsources/TargetUAServer
```

OPC UA Protocols

OPC UA specifies three data communication protocols. The DataHub program supports all of them:

- **TCP** - Binary protocol, highest performance with the smallest overhead and fewest resources, best chance of interoperability with OPC UA servers. Requires TCP port 4840.
- **HTTP** - Binary and XML protocols, lowest performance, usable in Java and .NET environments, extensive tool support, can use TCP port 443.
- **HTTPS** - Binary and XML protocols, a hybrid of TCP and HTTP. More efficient and less overhead than HTTP, wraps a binary payload in HTTPS, can use port 443.

TCP is envisioned as the primary and normal protocol for OPC UA, while HTTPS was implemented to support special cases such as Internet communications. HTTP can be used when web services are necessary and resources are sufficient.

Security

OPC UA requires every participating server or client to have a certificate. Certificates are authenticated according to one of the four OPC UA Security Tiers:

- **Tier 1 - No Authentication** means an OPC UA client can connect to an OPC UA server with any certificate. Neither the client nor the server authenticates the certificate of the other.
- **Tier 2 - Server Authentication** means that the OPC UA client will check the OPC UA server's certificate against its *trust list* of accepted certificates, and only connect to the server if its certificate in on the list. However, the server does not check its trust list for client connections.
- **Tier 3 - Client Authentication** means that the OPC UA server will check the OPC UA client's certificate against its trust list, and only allow a connection from the client if its certificate in on the list. However, the client does not check its trust list for server connections.
- **Tier 4 - Mutual Authentication** means that both the OPC UA server and OPC UA client will check each other's certificate against their respective trust lists, and the connection will only be allowed if each certificate appears in the appropriate trust list.

The Cogent DataHub program supports all of these. The OPC UA server configuration has a Manage Certificates feature where you can search through client certificates and view, accept, reject, or delete them. The OPC UA client configuration allows you to select a *user token type* (see below), and then enter a username and password, or certificate, as appropriate.

User Token Types (Log-in types)

- **Anonymous** The UA server allows any user to connect.
- **User Name** The UA server requires a user name and password.
- **Another Certificate** The UA server requires a certificate other than your DataHub instance's own certificate.
- **My Certificate** The UA server allows you to use your DataHub instance's own certificate.

Security Policies

A security policy determines how an OPC UA server and OPC UA client sign and encrypt messages. The Cogent DataHub program supports these security policies:

- **None** Supports authentication, but no encryption.
- **Basic128Rsa15** Supports authentication and encryption (AES, key length 128).
- **Basic256** Supports authentication and encryption (AES, key length 256).

- **Basic256Sha256** Supports authentication and encryption (AES, key length 256).

Certificates

OPC UA uses *certificates* to implement security. A certificate is a file that contains identifying information for an OPC server or client, such as the application, machine name, validity period, and so on, along with a private key and public key. When an OPC UA client and server negotiate a connection, they exchange public keys. Each of them uses the key to validate the other's certificate, and if successful, a connection is made.

There are two ways that certificates can be created:

1. Issued by a *Certificate Authority* (CA), an independent administrator or organization that verifies the information in the certificate is correct and hasn't been changed, and provides a digital signature to that effect.
2. Self-signed, where the administrators of the OPC UA servers or clients need to validate the contents of the certificate themselves.

The DataHub program provides a self-signed certificate, which gets created when the software is first installed. This one certificate is used for both the DataHub OPC UA server and OPC UA client implementations. The DataHub program also supports the ability to use a certificate from a CA, if desired.

Certificates are stored on a system in a *certificate store*. In Windows, there is a registry-based store called the Windows Certificate Store, and all systems have a directory that stores certificates in a file called the OpenSSL Certificate Store. In addition to these, the DataHub certificate management feature maintains a private certificate store where you can keep your DataHub-related OPC UA certificates separate from other certificates on your machine.

On the initial connection between an OPC UA client and server, the server checks to see if the client's certificate is available in the certificate store. If not, the server may or may not allow the client to connect. A DataHub instance can allow a client to connect temporarily by flagging its certificate as "Temporary", which can subsequently be changed to "Rejected" or "OPC UA client" (accepted) as appropriate.

OPC UA to DA Conversions

You can use the DataHub program to convert data between the OPC UA and OPC DA protocols. A DataHub instance can connect to any number of OPC UA and/or DA servers or clients, and keeps a copy of all of their registered points in a single, universal data set. Each connected server or client can access that whole data set, and yet sends or receives data value updates in its own protocol.

You can configure OPC UA to DA conversion as follows:

1. Configure the appropriate OPC UA server or OPC DA server connections.
2. Configure the appropriate OPC UA client or OPC DA client connections to access the data from any or all OPC UA or DA servers.

If all of your connections are client-server connections, that may be all that is needed. However, if you need to make server-server connections, one more step is necessary

3. Configure DataHub Bridging for any server-server connections.

OPC A&C to OPC A&E Conversions

You can use the DataHub program to convert data between the OPC UA Alarms and Conditions (A&C) and OPC Classic A&E protocols. A DataHub instance can connect to any number of A&C and/or A&E servers or clients, and keep a copy of all of their registered points in a single, universal data set. Each connected server sends or receives data value updates in its own protocol. The only requirement for this conversion is that you configure each participating client or server feature within the DataHub instance to share the same data domain (by default, OPCAE).

- OPC A&E client and server configuration
- OPC UA A&C client configuration
- OPC UA A&C server confguration

There are a few differences between the two protocols. however. To support conversions, the following guidelines have been used:

- **A&C branched alarms** are not supported by the DataHub program. A DataHub instance will track branched conditions internally but will not expose the branches to client applications. When a primary condition is acknowledged or confirmed, the DataHub instance will apply the same acknowledgement or confirmation to all the associated branched conditions.
- **A&C acknowledge and confirm** are maintained in communication between A&C servers and clients. An acknowledgement from an A&E client will be sent as both an acknowledge and confirm to A&C servers and clients. Either an acknowledge or confirm from an A&C client will be transmitted as an acknowledgement to A&E servers and clients.
- **A&C alarm types** such as Two-State, High-Low, Multi-State, etc. are not supported. The DataHub program converts all of these to generic acknowledgeable alarms.
- **A&E attributes** are converted to A&C properties. A&C properties are selectively converted to A&E attributes.
- **A&E sub-conditions** are ignored in A&C.

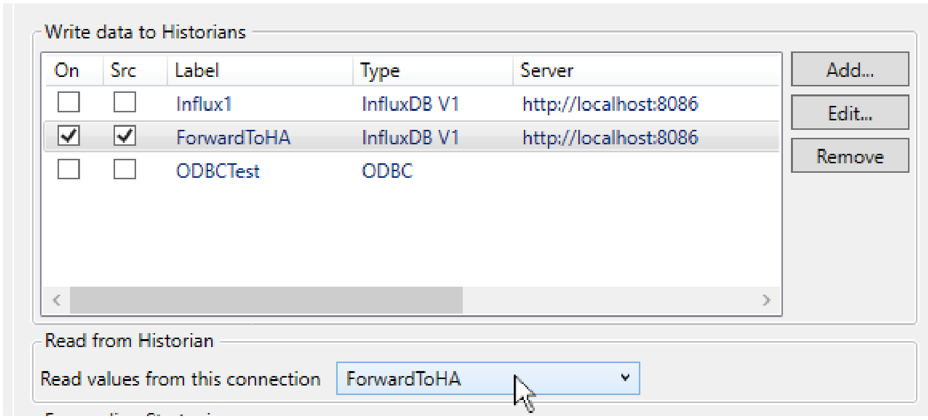
Accessing Historian Data via OPC UA HA

You can make data available in OPC UA HA (Historical Access) that comes from any supported External Historian that can be used as a data source, or the DataHub Historian.

OPC UA HA is an interface to an external data store. It requires a readable External Historian in addition to the OPC UA feature.

Here is an example, using InfluxDB.

1. Start InfluxDB and configure a connection to it from the External Historian feature. Here's how.
2. In the main Historian configuration window, check the boxes **On** and **Src** for the configured connection. The **Src** option tells the DataHub instance that this will be the source historian for your OPC UA HA data.

   Make sure that the **Read values from this connection** dropdown is set to the same connection.
3. Click the **Apply** button to apply the changes.

Now any OPC UA HA client should be able to request historical information on the data points in InfluxDB.

Object Model

Part of the DataHub program's job is to convert OPC UA to OPC DA, DDE, and DHTP tunnel protocols. The OPC UA object model cannot be mapped in general to these other protocols, so some simplification is required. The DataHub program does not support the complete OPC UA object model. Instead, it simplifies the data model by only looking at hierarchical relationships and converting them all to a simple parent/child "organizes" hierarchy.

OPC UA Methods

OPC UA defines a node type called a Method that allows a client application to synchronously execute a predefined function on the server. The client calls the OPC UA method with zero or more arguments and waits for it to complete. OPC UA servers may use methods as an alternative to executing their internal functions in response to a data value change.

OPC UA methods are synchronous, and normally cannot be executed through a DataHub tunnel, because data flow through a tunnel is always asynchronous. You can, however, use a DataHub script to convert an asynchronous data change into a synchronous OPC UA method call. Please see Calling OPC UA Methods from DataHub Scripts for details.

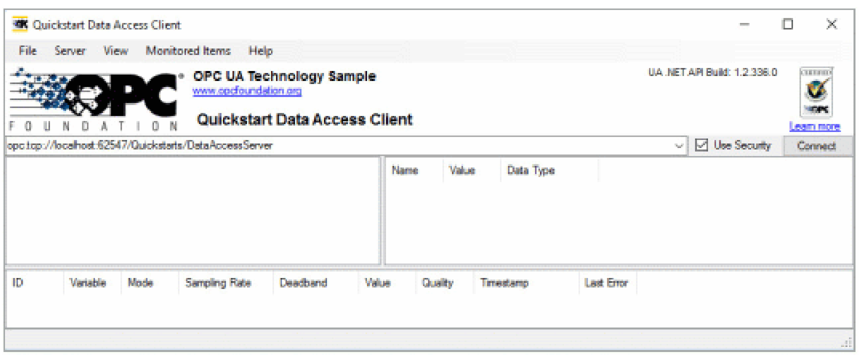
OPC UA Test Client and Server

Using a Test Client

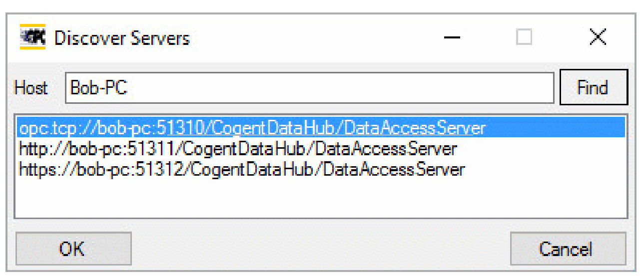
To test the DataHub OPC UA Server using the OPC Foundation's OPC UA Quickstart Data Access Client, follow the steps below.

You must allow Remote Connections in Security for any incoming connections over the network.

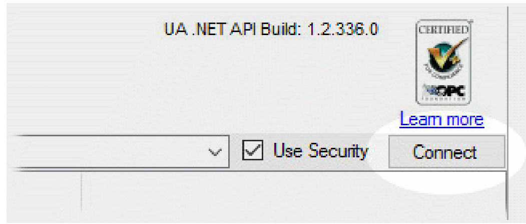
1. Ensure that a DataHub instance and DataPid are running.
2. Download the OPC Foundation software package from here:
```
http://cogentdatahub.com/assets/
opc-ua-1.02-.net-sample-applications-setup-336.0-20150630.zip
```
3. Open the `.msi` archive to install the software.
4. From the Windows **File** Menu, go to **OPC Foundation**, and open the **DataAccess Client**. This should open the Quickstart Data Access Client:



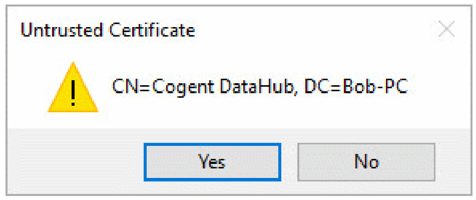
5. From the **Server** menu, select **Discover**, and then press the **Find** button.
6. Select the address that starts with `opc.tcp`.



7. Press **OK**.
8. Click the **Connect** button in the client window.

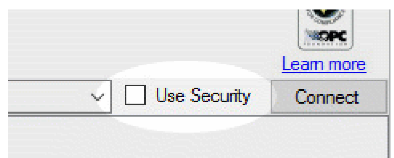


You will get an **Untrusted Certificate** message.

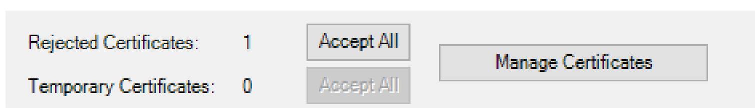


9. Click **Yes**. You will see an error message, telling you that the connection was not successful. This is normal. The DataHub instance has rejected the client's certificate, and placed it in the rejected certificate store. At this point you have two options:

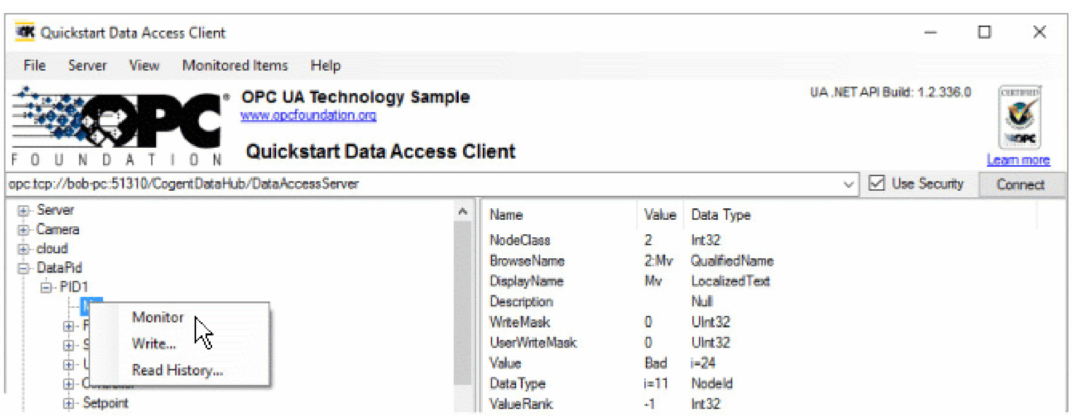
   1. You can uncheck the **Use Security** option in the Quickstart client.

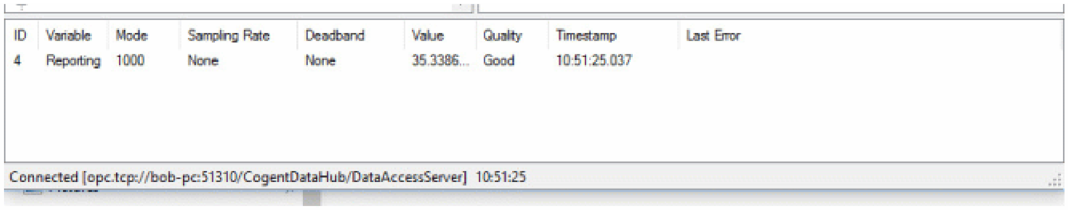
   2. You can go to the DataHub instance and accept the client certificate by clicking the **Accept All** button in the **OPC UA Server** section of the Properties window.

10. Once you have done either or both of these, click the **Connect** button again. You should now see the DataHub data hierarchy.



To test monitoring, right-click a data point, for example `DataPid:PID1.MV`, and select **Monitor**. You should see the point and its data appear in the list at the bottom:



11. Do the same for `DataPid:PID1.PV` and `DataPid:PID1.SP`. To test writing to the DataHub instance, right-click a writeable data point like `DataPid:PID1.SP`, select **Write** and enter a value between 0 and 100. You should see the SP value in DataPid change. Note that if DataPid is running in Auto mode, the value of that point changes automatically every 5 seconds.

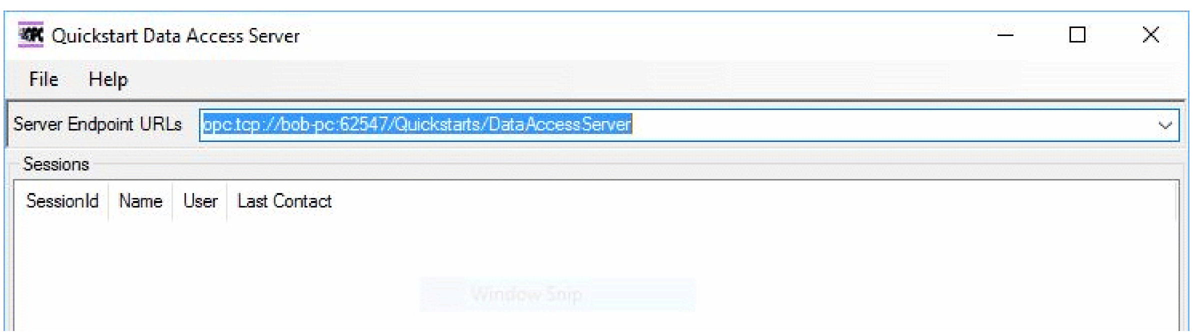
Using a Test Server

To test the DataHub OPC UA Client using the OPC Foundation's OPC UA Quickstart Data Access Server, follow these steps:

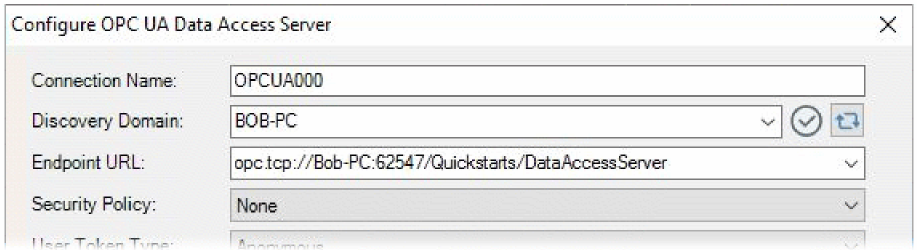
1. Ensure that a DataHub instance is running.
2. Download the OPC Foundation software package from here:

```
http://cogentdatahub.com/assets/
opc-ua-1.02-.net-sample-applications-setup-336.0-20150630.zip
```

3. Open the `.msi` archive to install the software.
4. From the Windows **File** Menu, go to **OPC Foundation**, and open the **DataAccess Server**. This should open the Quickstart Data Access Server:



5. Copy the **Server Endpoint URL** that starts with `opc:tcp`.
6. In the DataHub instance, go to the **OPC UA** option in the **Properties** window, and click the **Add** button.
7. Choose the **Discovery Domain** for your system, and paste the **Server Endpoint URL** that you copied from the Quickstart Data Access Client into the **Endpoint URL** field.



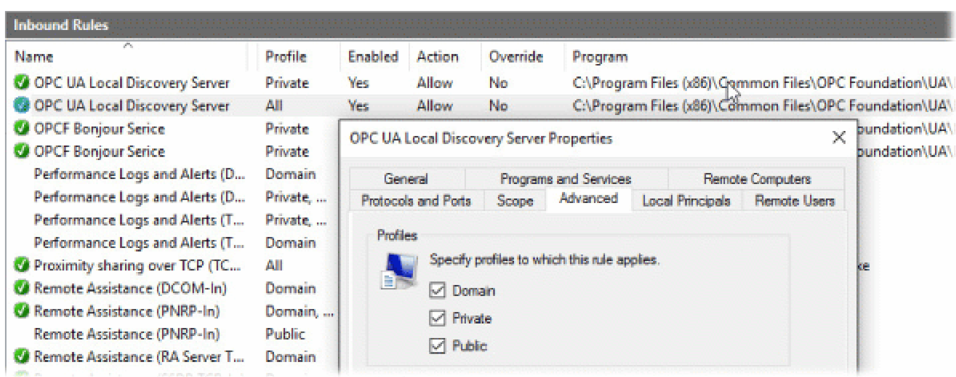
8. Continue configuring the connection as documented in the section called “Connect to an OPC UA server”.

Troubleshooting

Endpoint URLs

What if the LDS doesn't report back the Endpoint URLs?

1. Check to ensure that the LDS is running on the server.
2. Check that all firewalls between client and server are allowing access to the LDS port.
   a. Look in the DataHub Event Log for any messages like this that show you the port number of the LDS you are trying to connect to:
   ```
   UA Client: Could not fetch servers from url:
   http://myPC:52601/UADiscovery.
   ```
   b. On the UA server, check the firewall rule. Look for OPC UA Local Discovery Server and make sure it is allowing Inbound connections on that port number and that the firewall rule is set to allow all Profiles (Domain, Private and Public).



3. If you can't change anything, then you need to resolve this by typing in the Endpoint URL manually.

How do I know what the Endpoint URL is for the UA server?

The syntax for an endpoint URL is as follows:

```
Protocol://ComputerName:PortNumber/EndpointName
```

Protocol

Defined by the UA Server. The client may only connect using one of the protocols offered by the server. The OPC UA protocols are represented in endpoints as follows:

- **TCP** - `opc.tcp`
- **HTTP** - `http`
- **HTTPS** - `https`

ComputerName

The network name, IP address or fully qualified domain name of the computer you are trying to reach. It is dependent on the client-side computer.

PortNumber

Usually defined by the UA Server, though you may need to change it if your network connection includes a NAT that is remapping the IP address of the UA Server.

EndpointName

Defined by the UA Server.

Examples:

```
opc.tcp://My-PC:4840/MyComputer/MyUAServer
http://AcmeServer:52601/UADiscovery
https://175.252.04.21:443/Rsources/TargetUAServer
```

Please see the section called “Endpoints and Discovery” for more information.

Error Messages

Errors related to Endpoint URL

- `Error: A requested configuration was not found.`

  Possible cause: Endpoint Name defined in the Endpoint is incorrect.

- ```
  Error: BadTcpInternalError:
  Error establishing a connection.
  ```

  Possible cause 1: The server is not running.

  Possible cause 2: The port number defined in the Endpoint is incorrect.

- `Error: No such host is known.`

  Possible cause: The computer name, IP address or domain name defined in the Endpoint is incorrect.

- ```
  Error: BadTcpEndpointUrlInvalid:
  The Server does not recognize
  the QueryString specified.
  ```

  Possible cause: The protocol defined in the Endpoint is incorrect or mistyped.

- `Error: No such host is known.`

  Possible cause: The IP address (or computer name or domain name) defined in the Endpoint is incorrect. This error can also occur if you are using an IP address in the Discovery Domain field to return the list of Endpoint URLs from the server. The endpoints returned by the server will include the server's computer name rather than the IP address, so you need to edit the endpoint URL to replace the computer name with the IP address like this:

  ```
  opc.tcp://192.168.3.151:51310/OCS4DDataLink/DataAccess
  ```

  The Endpoint URL is made up of these parts:

  ```
  protocol://computer name:port number/endpoint name
  ```

Errors related to Security Policy (Encryption)

- ```
  Error: BadSecurityChecksFailed:
  An error occurred while verifying security.
  ```

  Configuration: Protocol = `opc.tcp`, **Security Policy** = `Basic128Rsa15` or `Basic256`, **Token Type** = any.

  Possible cause: This means your connection succeeded but the certificate being used to enable encryption has been rejected by the server. The UA Server needs to accept this certificate in order for this connection to succeed.

- ```
  Error: An unsecured or incorrectly secured
  fault was received from the other party.
  See the inner FaultException for the
  fault code and detail.
  ```

  Configuration: Protocol = `http`, **Security Policy** = `Basic128Rsa15` or `Basic256`, **Token Type** = any.

  Possible cause: This means your connection succeeded but the certificate being used to enable encryption has been rejected by the server. The UA Server needs to accept this certificate in order for this connection to succeed.

Errors related to User Token Type (Authentication)

- ```
  Error: 'CN=Cogent DataHub Data Access Server,
  DC=WIN10VM' is not a trusted user certificate.
  ```

  Configuration: Protocol = any, **Security Policy** = any, **Token Type** = certificate.

  Possible cause: This means your connection succeeded but the certificate being used to authenticate has been rejected by the server. The UA Server needs to accept this certificate in order for this connection to succeed.

- ```
  Error: BadIdentityTokenRejected:
  The user identity token is valid but the server
  ```

```
has rejected it. Possible cause, the user token
is not supported on the server or my certificate
is not trusted on the server.
```

Configuration: Protocol = any, **Security Policy** = any, **Token Type** = certificate.

Possible cause: This means that you have successfully connected to the server and your certificate has been passed to the server for authentication. However, the server does not accept your certificate, or does not find it in its trusted store. You need to ensure that the server accepts your certificate, or load it into the trusted store. Then try your connection again.

- ```
  Error: BadUserAccessDenied:
  User does not have permission to
  perform the requested operation.
  ```

  Configuration: Protocol = any, **Security Policy** = any, **Token Type** = `User Name`

  Possible cause: This means the user name or password used to authenticate is incorrect.

Errors related to possible network problems

These will typically involve a long timeout delay before the error message is displayed.

- ```
  Error: There was no endpoint listening at
  http://win8vm:51311/OCS4DDataLink/DataAccess/discovery
  that could accept the message.
  This is often caused by an incorrect address or SOAP action.
  See InnerException, if present, for more details.
  ```

  Configuration: Protocol = any, **Security Policy** = any, **Token Type** = any.

  Possible cause: This may be caused by a firewall between the client and the server not allowing access through the specific port used by the protocol you have chosen. Add new firewall rules as needed to allow access.

- ```
  Error: The underlying connection was closed:
  A connection that was expected to be kept alive
  was closed by the server.
  ```

  Configuration: Protocol = any, **Security Policy** = any, **Token Type** = any.

  Possible cause: This may be caused by a firewall between the client and the server not allowing access through the specific port used by the protocol you have chosen. Add new firewall rules as needed to allow access.

- ```
  Error: BadCommunicationError:
  A low level communication error occurred.
  ```

Configuration: Protocol = any, **Security Policy** = any, **Token Type** = any.

Possible cause: This may be caused by a firewall between the client and the server not allowing access through the specific port used by the protocol you have chosen. Add new firewall rules as needed to allow access.

Other errors

- `Error: BadInvalidTimestamp: The timestamp is outside the range allowed by the server.`

  Cause: The system clock on the client computer is outside the acceptable range defined by the UA server

Expired LDS certificate

If your LDS (Local Discovery Service) certificate has expired, you can renew it as follows:

1. Delete the certificates in `C:\ProgramData\OPC Foundation\UA\Discovery\pki\own`. But do not delete the own folder.
2. Stop your DataHub instance.
3. Restart the UALDS service.
4. Start your DataHub instance.

You may have to also stop and restart any other OPC-UA servers that register with the LDS.

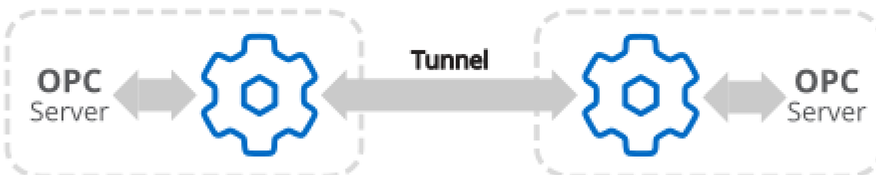
Bridging

Introduction

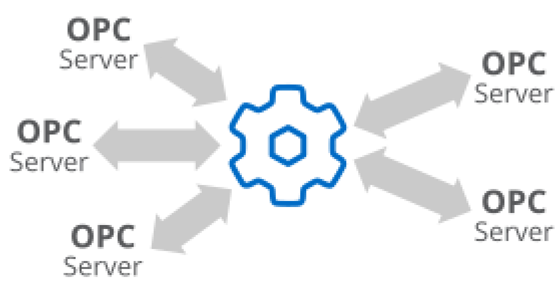
Bridging means connecting two data servers together so they can access each other's data, even when neither of them can act as a client.

In addition to bridging two servers on a single computer, the DataHub program offers advanced bridging capabilities that let you:

- Bridge servers over a network connection, by tunnelling.



- Bridge between any number of servers, through aggregation.



- Scale, convert, or normalize the data as it is bridged from one server to the other, with built-in linear transformations.
- Define even more complex relationships between points in code using DataHub Scripting.

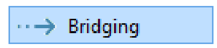
You can configure the bridges you need using the Bridging option in the Properties Window.

Configuring Bridges

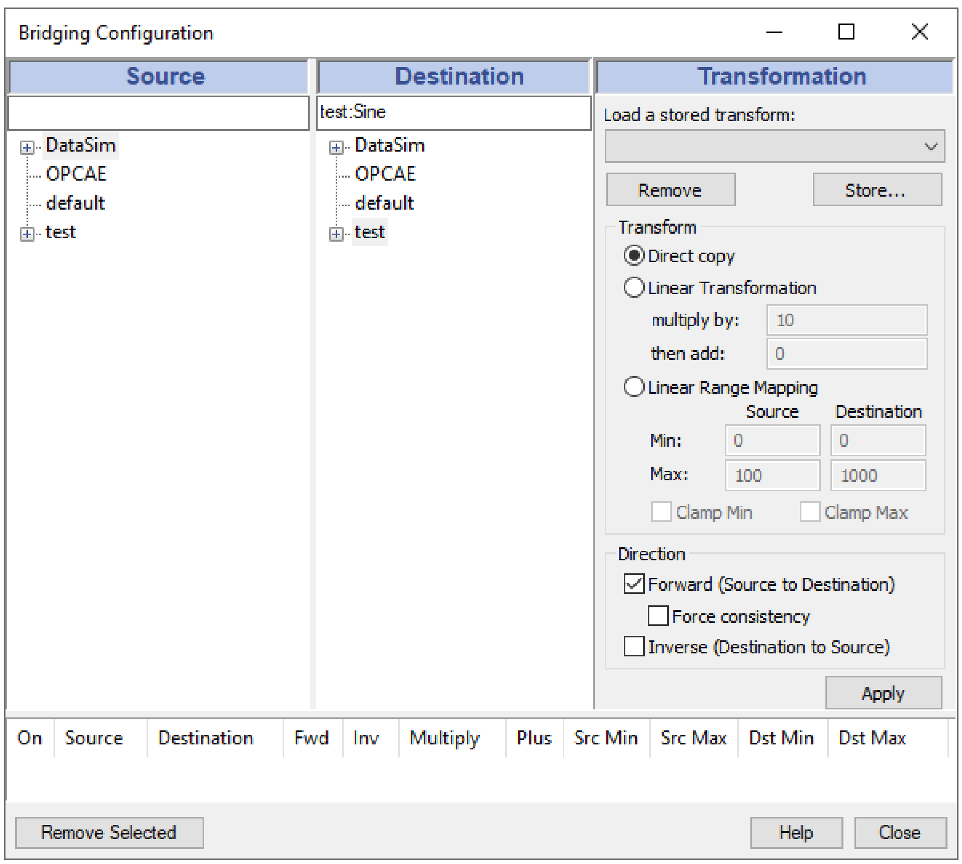
It is easy to configure the DataHub program to bridge existing points—just point and click. If necessary, you can quickly configure linear transformations and specify the direction of data flow of the bridge. And should you want to create a new point for a bridge, it's just few more clicks of the mouse. All configuration and any changes are done on the fly, taking effect as soon as you click the **Apply** button.

Click here to watch a video.

Point-to-point configuration

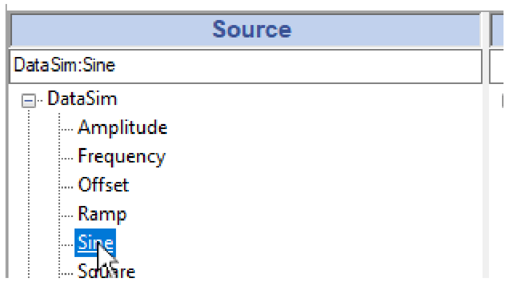
1. With a DataHub instance running, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Bridging**. 

3. Click the **Configure Bridges** button. The Bridging Configuration window will open.



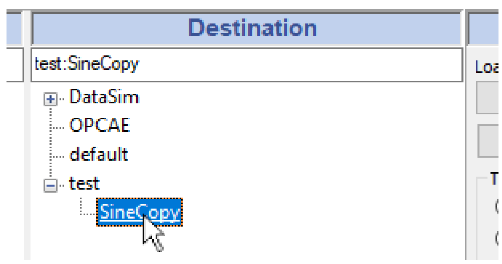
The three top panes in this window correspond to the three basic steps in making the configuration: specify a source, a destination, and any desired transformations. The horizontal pane across the bottom shows the bridges that exist on the system.

4. From the tree diagram in the **Source** panel, select a source point that you want to bridge.



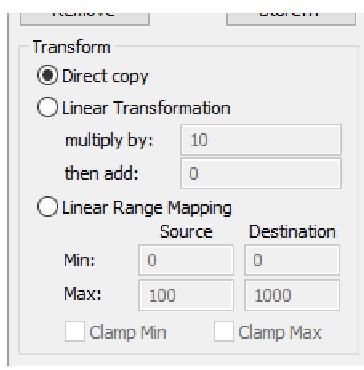
For example, if you have the DataSim program running, you can select the point **Sine** in the **DataSim** data domain. The name of the point gets automatically entered in the field at the top of the panel. Alternatively, you can type the name of the point in the entry field.

5. In the tree diagram in the **Destination** panel, select a destination point.



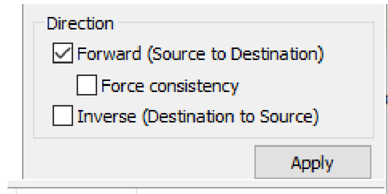
When you select a destination point, its name gets automatically entered in the field at the top of the panel. Or you can type the name of a point in the entry field.

6. Specify direct copy or transformation.



To make a direct copy, just leave the default **Direct copy** selected. To make a linear transformation, select **Linear Transformation** or **Linear Range Mapping** and enter the appropriate data, as explained in the section called “Making transformations” below.

7. Determine which direction you want the bridge to apply.

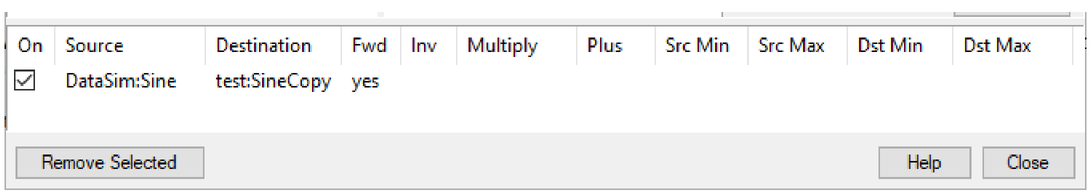


- Select **Forward** to change the destination point when the source point changes, but not change the source when the destination changes. If you select **Force consistency** with this option, and if the destination point gets changed for some reason, then the DataHub instance will attempt to force its value to be consistent with the source point value.
- Select **Inverse** to change the source point if the destination point changes, but not vice-versa.

  Selecting **Inverse** will apply the inverse of the transformation, as explained below.

- Select *both* **Forward** and **Inverse** for a bidirectional bridge, where either point changes whenever the other point changes. This combination will deselect **Force consistency** to eliminate the possibility of conflicting behavior.

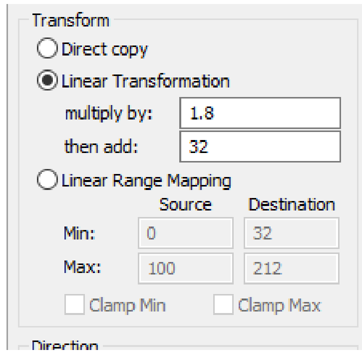
8. Click the **Apply** button to create and activate the bridge. The DataHub instance will create the bridge and update the bridged points immediately.
9. In the bottom panel you can see all the bridges that exist in the system, and the significant information about them.



If you click on a transformation, the source point, destination point, and transform information get displayed in their respective panels. Use the check box at the front of each bridge to activate or deactivate it.

Making transformations

1. Specify the type of transformation by clicking one of the three radio buttons:



- **Direct copy** makes no transformations. It just copies the point.
- **Linear Transformation** lets you multiply by one value and add another value, such as in the equation `y = mx + b` where the destination point is `y`, the source point is `x`, the **multiply by** value is `m`, and the **then add** value is `b`. For example to transform a Celsius source point to a Fahrenheit destination point, you would multiply by `1.8` and add `32`, or

  ```
  Fahrenheit = (1.8 X Celsius) + 32
  ```

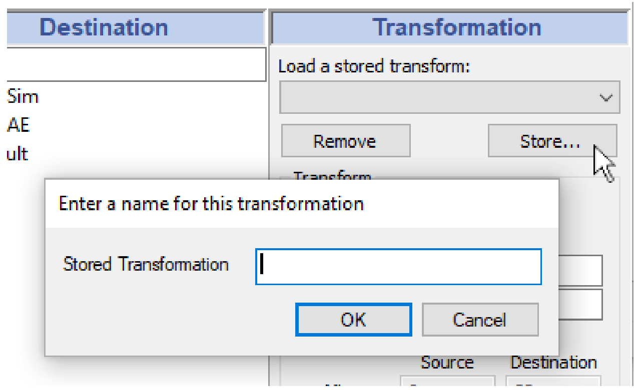
  If you have selected the **Inverse** direction for a transformation, you will get the inverse of the transformation. In this example, you would get a conversion from Fahrenheit to Celsius, or the results of this equation:

  ```
  Celsius = (Fahrenheit - 32) / 1.8
  ```

  As an alternative to entering transformation values, the DataHub program also offers **Linear Range Mapping**.
- **Linear Range Mapping** lets you enter a range for the source and destination, and the DataHub program automatically calculates the corresponding linear transformation. For example, to create the same Fahrenheit to Celsius transformation, you could use the defaults of `0` and `100` for the **Min** and **Max** of the source point. Then you would enter `32` and `212` for the **Min** and **Max** of the destination point. As soon as you make these entries, the correct values get entered automatically in the **Linear Transformation**.

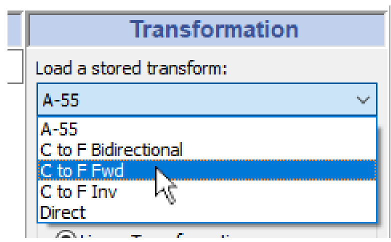
  When you use linear range mapping, you can limit the transformed value to the maximum and minimum by checking the **Clamp** boxes. The clamps get applied to the point being changed, i.e.. to the destination point for forward direction, to the source point for inverse direction, and to both points for bidirectional bridges.

2. If you want to save this transformation for future use, click the **Store...** button at the top of the Transformation panel, and enter a name in the box that pops up.



Once stored, the transformation will become available by name in the drop-down list.

3. To load a transformation, simply select its name from the drop-down list.

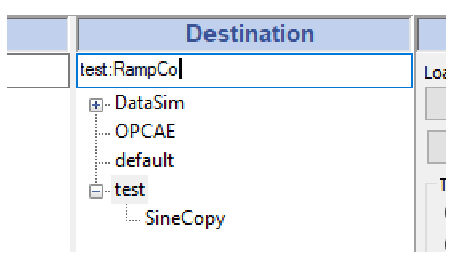


Creating New Points

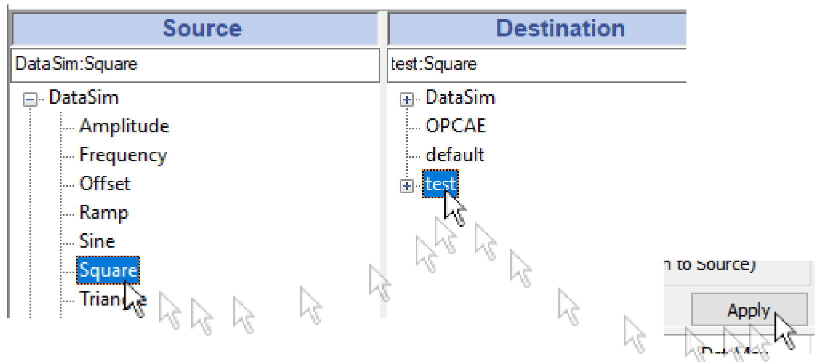
A special feature of the DataHub program allows you to create new points. Combined with the ability to create new data domains, this lets you create:

- **Personalized data sets** for different users or groups.
- **Aggregated data sets** that combine selected data points from different servers and serve it up from a single OPC server (i.e. the DataHub program).
- **Scaled data sets** that apply one or more transformations to a subset of the data.
- **Temporary data sets** for testing and demonstration purposes.
- **Any combination** of the above.

You can create a new point in the **Source** or **Destination** panel of the Bridging Configuration window by typing in a new point name in the entry field.



And with a few mouse clicks you can quickly create bridges to new destination points.



Just click on a source point, click on a data domain, and then click **Apply**. A destination point with the same name as the source point gets created automatically in the data domain you chose, with the current transformation applied.

You might want to create special data domains for holding sets of destination points. For more information about data domains, please refer to the section called “Data Domains”.

Configuring Many Bridges

If you only have a few data points to bridge, then using the Bridging option in the Properties window, as described in the section called “Configuring Bridges” works very well. However, there is a faster way to configure many bridges, using a custom configuration file. Here's how:

1. First configure at least one bridge using the Bridging interface so you can see the syntax used in the DataHub configuration file.
2. When that's done, open the `Cogent DataHub.cfg` file, found here:

   ```
   C:\Users\{username}\AppData\Roaming\Cogent DataHub\Cogent DataHub.cfg
   ```

   Find the section of the file that looks like this:

   ```
   ;;; Point-to-point Bridging
   (bridge "domain:pointname" "domain:pointname" 257 1 0 0 100 0 100)
   ```

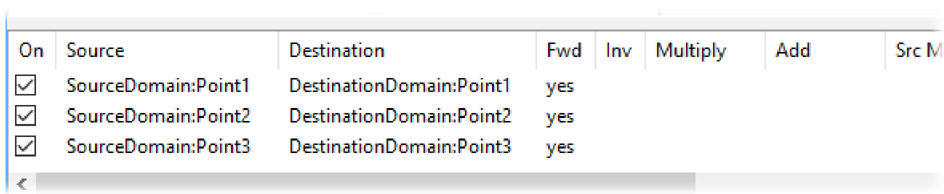
   This is how each bridge gets stored in the DataHub instance's configuration file, as a **bridge** command that gets called when the DataHub instance starts up. Your custom configuration file needs to contain one line like this for each bridge that you configure.
3. Create a custom configuration file, as described at the end of the section called “Configuration Files”. The content of the file should look like this:

   ```
   ;;; My Point-to-point Bridging List
   (bridge "SourceDomain:Point1" "DestinationDomain:Point1"
    257 1 0 0 100 0 100)
   ```

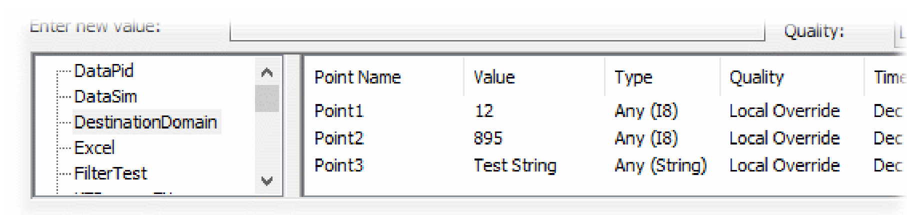
```
(bridge "SourceDomain:Point2" "DestinationDomain:Point2"
 257 1 0 0 100 0 100)
(bridge "SourceDomain:Point3" "DestinationDomain:Point3"
 257 1 0 0 100 0 100)
...
```

You should not try to edit the `Cogent DataHub.cfg` file. Put all of your custom bridge configuration into the custom configuration file.

4. Configure the DataHub instance to load your custom configuration file from the Scripting option in the Properties window, as described at the end of the section called "Scripting".
5. Restart the DataHub instance.
6. Open the Bridging option in the Properties window, and click the **Configure Bridges** button. You should see all of the configured bridges.



7. Check the Data Browser. You should see all of the configured bridged points.

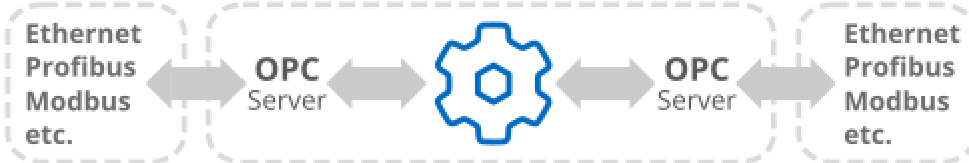


Bridging Scenarios

Here are some of the most commonly used bridging scenarios.

Bridging Local Servers

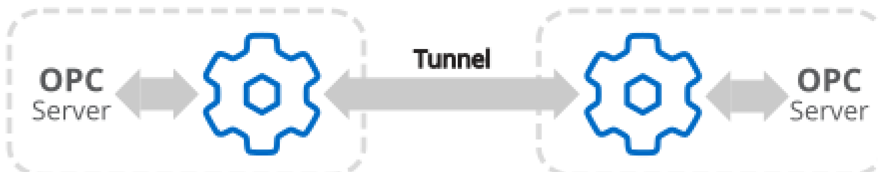
The most common scenario for OPC bridging is connecting OPC servers on a single machine. This can be used to create connections over various fieldbus protocols. Any fieldbus connected to an OPC server can be bridged to any other.



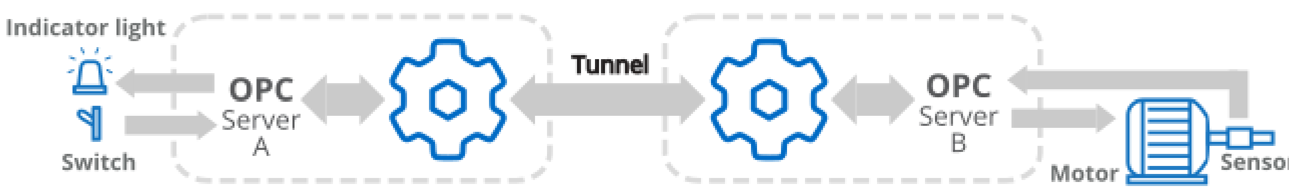
The bridge is configured as a direct link, or it might incorporate linear transformations. It can have a forward or inverse direction, or be bidirectional.

Bridging Remote Servers

A special bridging application that the DataHub program makes possible is to bridge remote servers. This is effectively bridging combined with tunnelling.



You can use this to create a software bridge between remote pieces of hardware. For example, consider this situation:



Suppose you need to control a motor remotely. An on/off switch and status indicator light are connected to PLC "A" in one location. The motor itself and a rotational sensor are connected to PLC "B" in another location. Both PLCs have OPC servers connected to DataHub instances.

To make the connection, you would need to program the PLCs for these data points:

Point	Function
`A.switch`	- Changes value to `1` when switch is on, `0` when switch is off.
`A.indicator`	- Turns on light when value is `1`, switches off light when value is `0`.
`B.motor`	- Starts motor when value is `1`, switches off motor when value is `0`.
`B.sensor`	- Changes value to `1` when shaft is turning is on, `0` when shaft is not turning.

then bridge them in the DataHub instances like this:

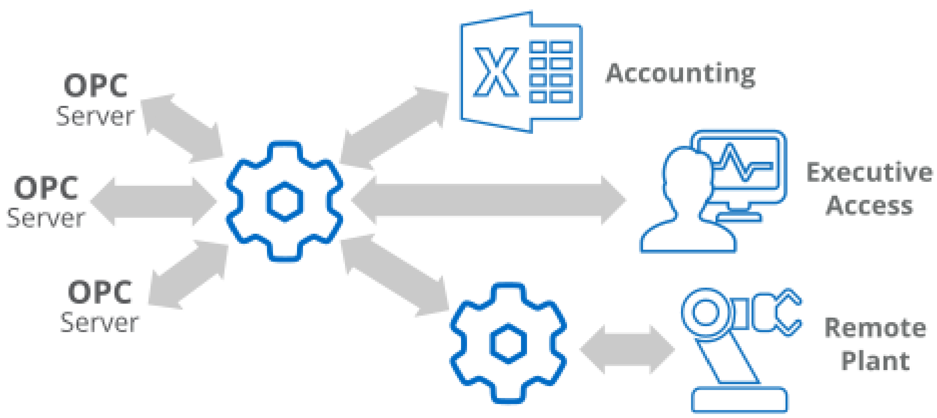
On	Source	Destination	Fwd	Inv	Multiply	Plus
☑	A:switch	B:motor	yes			
☑	A:indicator	B:sensor		yes		

As when bridging local servers, bridging remote servers can also bridge different fieldbus protocols.

Creating Data Sets

A third common application for DataHub bridging is creating custom data sets. You can select certain data points from several OPC servers and group them into different data domains depending on the user. This has two advantages:

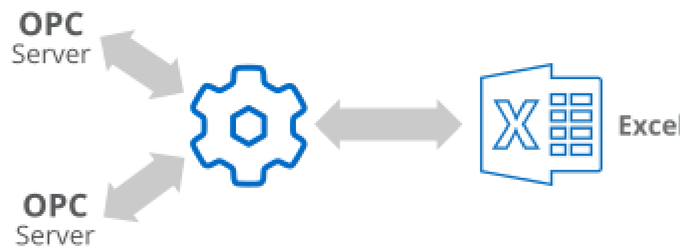
- It simplifies configuration and use.
- It reduces bandwidth across the network.



For example, suppose you needed to get OPC data to three sets of users: accounting department staff, executives on the road, and an OPC server at a remote plant. You could declare three new data domains, such as `Accounting`, `Executive`, and `Remote`. For each data domain, you would then create new points specific to the needs of those users. With this approach, you can limit the data set and customize it for each recipient.

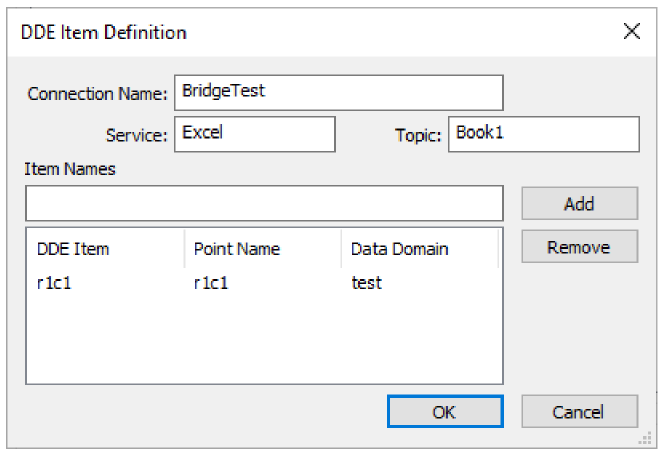
Bridging to Excel

The DataHub program makes it easy bridge data from an Excel spreadsheet to an OPC server.

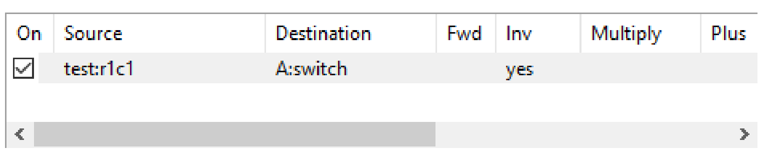


Simply connect a DataHub instances to Excel, then configure the bridges. To get Excel data into an OPC server without changing any names in Excel or any OPC point names, follow these steps:

1. Define a DDE Item in the DataHub instance for the Excel point. For example, the cell A1 in a spreadsheet would become DDE Item `r1c1` (Row 1, Column 1).



2. Configure a point-to-point bridge using the Excel point as the source and the OPC point as the destination. If we used our OPC server A and the point name `switch` from the example above, the bridge would look like this:



On	Source	Destination	Fwd	Inv	Multiply	Plus
☑	test:r1c1	A:switch		yes		

This bridge would allow you to turn the switch on and off (and thus control the motor) from an Excel spreadsheet.

Bridging and Tunnelling

OPC bridging with tunnelling OPC means linking OPC servers across a network. Here's how it's done:

1. **Bridging two OPC servers** over a network requires a tunnelling connection.

This scenario involves setting up DataHub instances on both machines to act as OPC clients to the respective OPC servers. The DataHub instances then interface with each other over a TCP tunnelling connection. Configure the DataHub instance on the machine with the most uptime to be the tunnelling master and the other DataHub instance to be the tunnelling slave. For simplicity sake, we recommend that you configure all bridges on one machine.

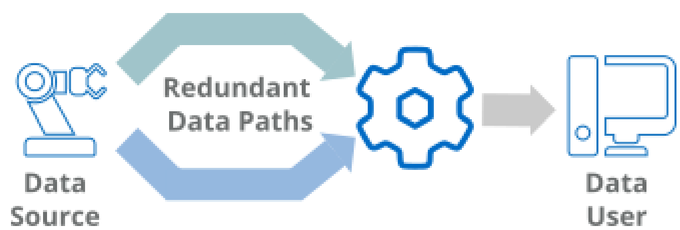
2. **Bridging two OPC clients** over a network also requires a tunnelling connection.

This scenario involves setting up DataHub instances on both machines to act as OPC servers to the respective OPC clients (see above). The DataHub instances then need to interface with each other over a TCP tunnelling connection. Configure the DataHub instance on the machine with the most uptime to be the tunnelling master and the other DataHub instance to be the tunnelling slave. For simplicity sake, we recommend that you configure all bridges on one machine.

Using Redundancy

Redundancy in a process control system means that some or all of the system is duplicated, or redundant. The goal is to eliminate, as much as possible, any single point of failure. When a piece of equipment or a communication link goes down, a similar or identical component is ready to take over.

For data communications, redundancy means sending data from a single data source over two separate paths, and presenting it to a user as a single data set. The two paths may include redundant PLCs, redundant OPC servers, redundant networks, and so on. The data flow is typically from data source to data user.

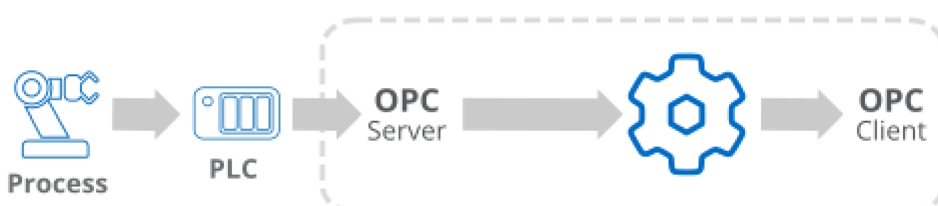


The DataHub Redundancy feature operates at the point where the two data paths meet. It monitors both data streams, and determines which of them should be used from that point onwards. The choice between data stream depends on Redundancy criteria that you configure. Data from the two incoming streams and the outgoing stream is maintained in three separate DataHub data domains.

Configuring the Redundancy feature is explained in the Redundancy section of the Properties window chapter of this book. This Using Redundancy chapter will help you get the most out of this DataHub feature.

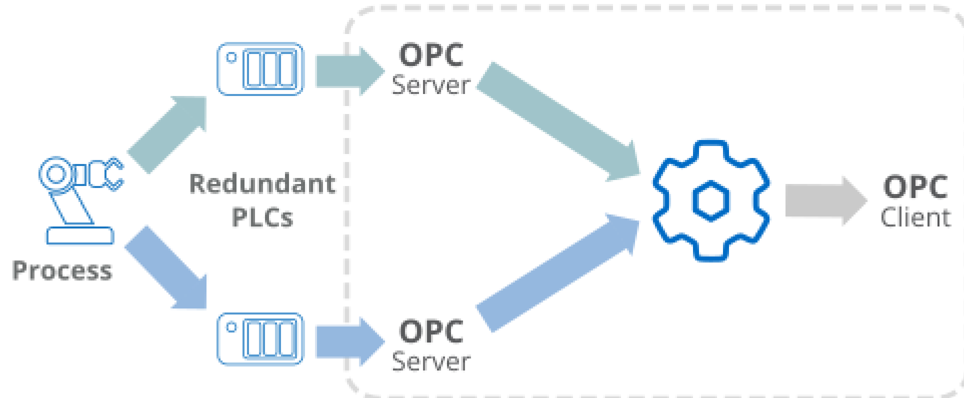
Typical Scenarios

Redundancy Scenario 1 - No redundancy



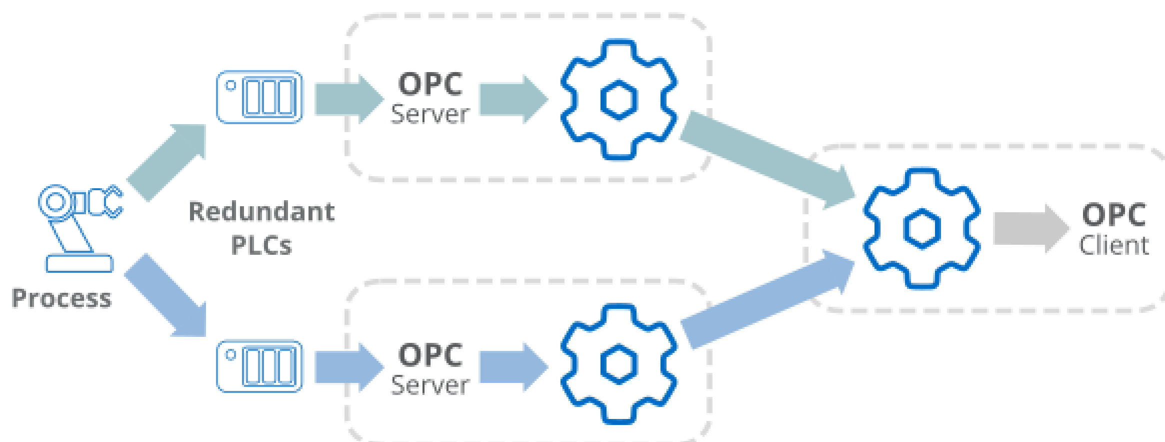
- One process, one client, one computer
- Single data path (PLC and OPC server)

Redundancy Scenario 2 - Redundancy with one computer



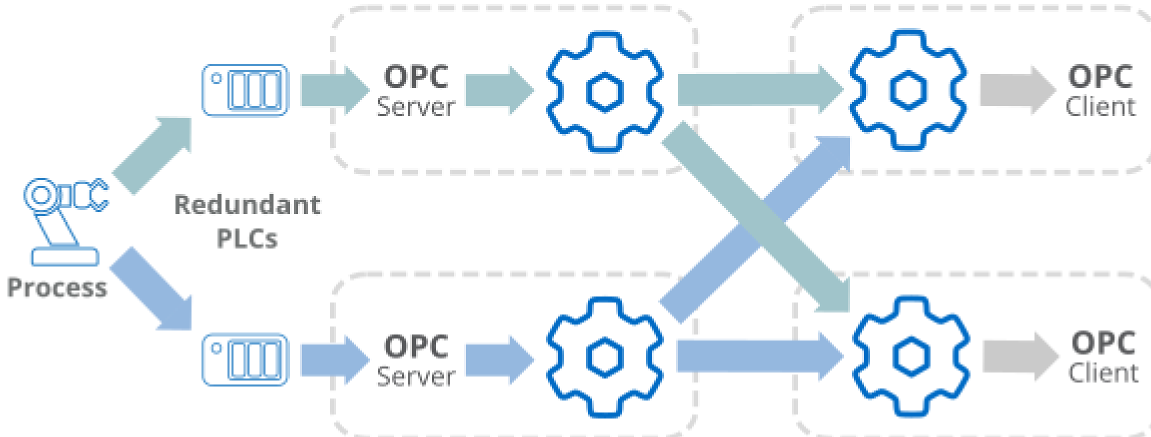
- One process, one client, one computer
- Redundant data paths: 2 PLCs and 2 OPC servers

Redundancy Scenario 3 - Networked redundancy



- Redundant data paths
- Tunnel connections
- Two OPC server machines, one OPC client machine

Redundancy Scenario 4 - Networked, multiple client redundancy

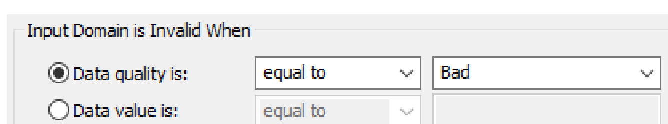


- Redundant data paths
- Tunnel connections
- Two OPC server machines, two OPC client machines

Configure the Switch

Switching Criteria - Domains

Generally speaking, the criteria for switching between redundant data streams should reflect expectations from the plant or process. The criteria for an invalid domain apply to identical points in each of the two input data domains. When that criteria is met in one domain, it is no longer considered valid, and the DataHub instance makes the switch.

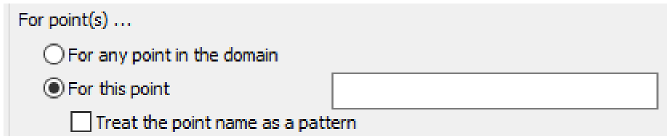


Key concepts:

- **Test criteria are for the whole input domain.** Whenever the criteria you enter are met, then the whole domain is considered invalid. For example, your OPC connection status may be `Running`, but if the data quality for your test point(s) meets your criteria for invalid data, then that entire domain will be considered invalid, triggering a switch to the other domain.
- **Whenever both input domains are invalid** then the DataHub instance sets the quality of the points in the redundancy output domain to `Not Connected`.

Switching Criteria - Points

For any point in the domain means that your entire data set is considered invalid if even one data point meets your test criteria. Instead, consider using a sentinel point or pattern.



For this point lets you choose a connection status point or specify a pattern to act on behalf of the whole domain.

- **Sentinel Point:** A sentinel point is a single data point that acts as a representative, or "sentinel", on behalf of the entire data domain. This can be useful if you want to allow some bad quality data in the input domain, but where one point in the domain will always have good quality whenever the data connection is valid. A sentinel point can also be used to test for connectivity, by testing for the `Not Connected` status of OPC.

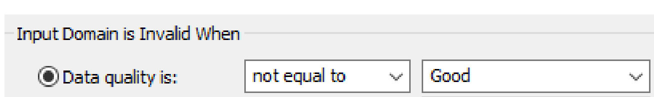
  To configure a sentinel point, choose **For this point** and name one data point that you trust (perhaps a point generated by a PLC rather than a device). This point needs to exist in both of your input domains. The point name should be entered with no domain prefix.

  For OPC A&E or A&C, a connection status point is available for monitoring the connection. Please see A&E / A&C Connection Status Point for more information.

- **Pattern matching:** If you select **Treat the point name as a pattern** then the point name acts as a *globbing* pattern, using matching rules. For example, if you specify a pattern of `*.Setpoint` then you would be indicating that the data domain is invalid if any data point ending with `.Setpoint` is invalid.

Valid and Invalid OPC Qualities

The OPC spec has two general categories for valid and invalid qualities, where only `Good` and `Local Override` are valid. The rest of the OPC qualities, such as `Initializing, Out of Service, Sensor Failure, Not Connected, Bad`, and so on are considered invalid for different reasons. If you want to test for all of these, and switch whenever there might be an interruption to the data stream, or a change in data quality, you can choose **not equal to** and **Good** for **Data quality is** in the **Input Domain** configuration.



There are two things you'll need to consider:

1. If a point's quality changes to `Local Override` it will cause the system to switch.

This rarely happens unless someone enters a value for a point in the DataHub Data Browser.

2. If you choose this setting for *all* points, then the system will switch whenever *any* of the points on the current source is not `Good`. Consider instead testing a sentinel point or pattern, as explained above.

Checking value AND quality

The interface does not allow for checking both the value of a point and its quality. You can use this script to create a synthetic point that reacts to both, and lets you check them.

Example Script `RedundancyState.g`

```
/* Creates a state point that combines both quality and value to
 * produce a single output value that can be used by a redundancy
 * pair to determine input domain validity.  The computeState method
 * can be as complex as you like, so long as it finally writes
 * a 0 or 1 to the state point.
 */

require ("Application");

class RedundancyState Application
{
 // The state point to be used for configuring the redundancy pair
 statePoint = "RedundancyState";

 // The point in the input data set to check for quality and value
 sentinelPoint = "WinAC1500.Memory.master";

 // The names of the input domains.
 domains = [ "HPC_1", "HPC_2" ];
}

method RedundancyState.computeState (pointSymbol)
{
 local info = PointMetadata(pointSymbol);
 local isBad = (info.quality != OPC_QUALITY_GOOD || info.value == 0);
 datahub_write(string(info.domain, ":", .statePoint), isBad ? 0 : 1);
}

method RedundancyState.constructor ()
{
 local pointName, pointSymbol;
 with domain in .domains do
 {
  pointName = string(domain, ":", .sentinelPoint);
```

```
  pointSymbol = symbol(pointName);
  datahub_command(format("(create %s:%s 1)", domain, .statePoint), 1);
  datahub_command(format("(create %s:%s 1)", domain, pointName), 1);

  .OnChange(pointSymbol, `(@self).computeState(#@pointSymbol));
  .computeState(pointSymbol);
 }
}

/* Start the program by instantiating the class. */
ApplicationSingleton (RedundancyState);
```

Troubleshooting

A good first step in troubleshooting redundant DataHub connections is to check the Event Log. There you may see error messages related to a configured redundancy pair. In addition to this, the Redundancy feature offers some useful troubleshooting options.

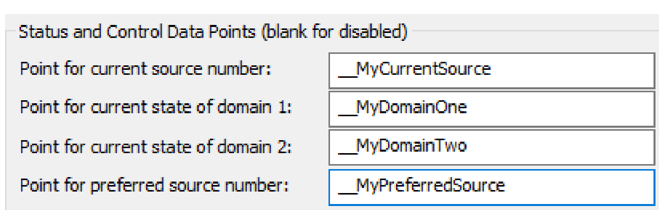
Diagnostic Points

In the Redundancy Configuration dialog you can specify diagnostic points that will get added to the root of the output data domain. These points let you monitor the status of the redundancy pair.

These points will continue to update even when redundancy is disabled. This gives you a way to examine the control bits to determine that the redundancy pair is not currently enabled.

There are two kinds of diagnostic points.

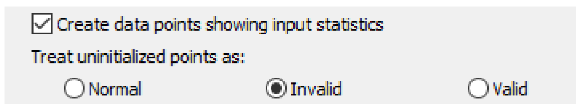
1. **Status and Control Data Points:** Assigning names to these points will add them to the root of the output domain. If you start each name with a unique character or two, like a double underscore (__), the points will all sort together at the beginning or end of the point list, making them easier to find and view together.



   - **Point for current source number:** When set, this point indicates which source domain is currently in use. Its value will be one of these:
     - **0** for none (neither input domain passes the validity check).
     - **1** for source domain 1.
     - **2** for source domain 2.

- **Point for current state of domain 1:** This point's value will be one of:
  - **0** if the data in domain 1 is not valid, according to the validity settings.
  - **1** if the data in domain 1 is valid.
- **Point for current state of domain 2:** Same as above.
- **Point for preferred source number:** This point's value will be one of:
  - **0** if there is no preferred source.
  - **1** if input domain 1 is the preferred source domain.
  - **2** if input domain 2 is the preferred source domain.

2. **Input Statistics Data Points:** In the Options section of the Redundancy Configuration is an option to **Create data points showing input statistics**, which is off by default.



If this is turned on it will create the following data points in the output data domain:

- **Input1ValidCount** shows the number of valid points in input domain 1.
- **Input1InvalidCount** shows the number of invalid points in input domain 1.
- **Input1UninitializedCount** shows the number of uninitialized points in input domain 1. Uninitialized points are ones that have not yet received a value from any source. Changing the radio-button selection from **Invalid** to **Valid** tells the redundancy engine to ignore such points when evaluating the validity of the domain. Selecting **Normal** treats them like all of the other points in the domain.

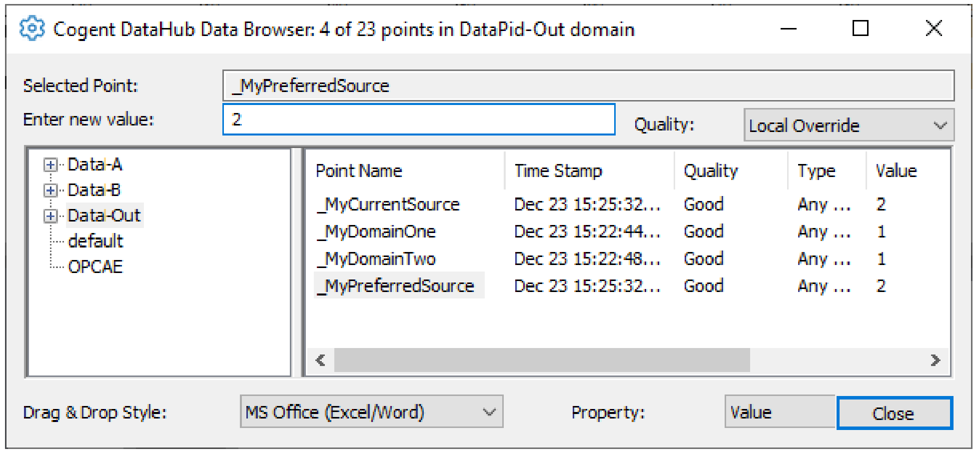
Similar points are created for Input2.

In addition to these, for OPC A&E or A&C connections a connection status point is available for monitoring the connection. Please see A&E / A&C Connection Status Point for more information.

Forcing a Switchover

The DataHub Redundancy feature will always attempt to maintain a valid output domain by selecting one of the valid input domains. This means that you cannot force a switchover to an invalid input domain. You can *request* a switchover by changing which input domain is preferred, and the DataHub instance will comply if that preferred domain is valid.

You can change the preferred input domain by changing the value of the **Point for preferred source number** control point (see above) between `1` and `2`. For example, if you have named that point `_MyPreferredSource`, simply change its value through the Data Browser, an attached DataHub client like a GUI, or a script. If the preferred source is domain 1, enter the value of 2 to change the preferred source to domain 2. The DataHub instance will immediately switch to domain 2, as long as that domain is valid.



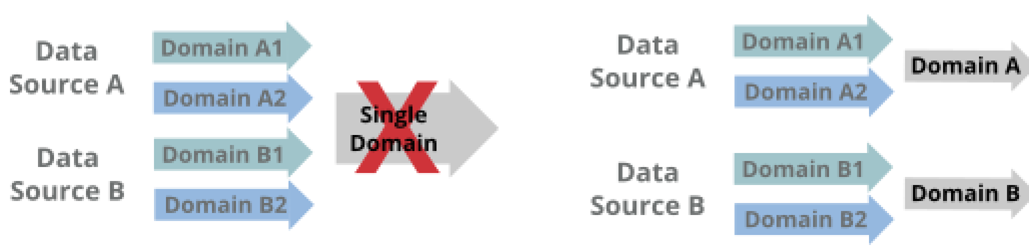
Changing the preferred source in this way does not alter your DataHub configuration file. Also, using a value other than 1 or 2 may lead to unexpected results.

Switchover Pause

Any pause during switchover is the time it takes to confirm that the current source domain has become invalid. Normally this is the connection timeout period. Until that timeout occurs, the DataHub instance still considers that domain to be valid. The status for those points won't change to `Not Connected` until the DataHub instance is aware that the connection has been lost. To reduce the time of the switchover pause you can reduce the connection timeout on the sources, or configure **Data Flow Detection** for this redundancy pair.

Multiple Redundant Pairs

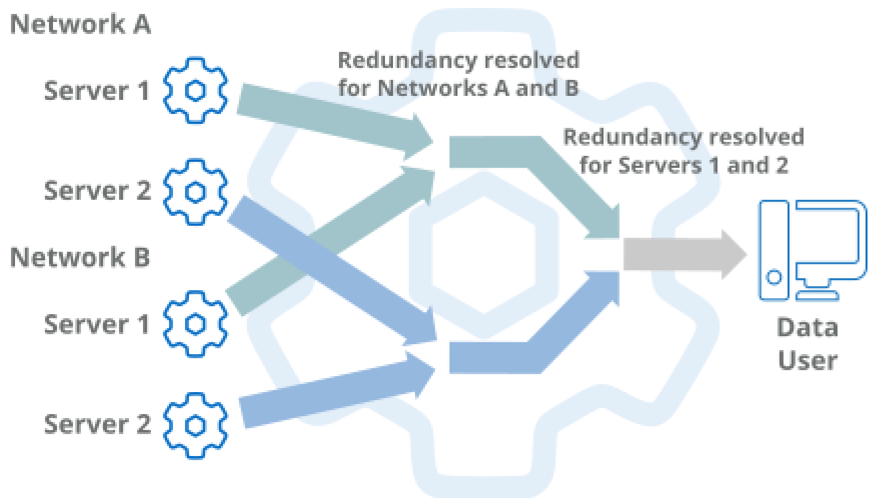
The Redundancy feature can accommodate any number of redundant pairs. Typically this means separate pairs, like A1/A2, B1/B2, C1/C2, and so on where A, B, and C are the data sources for the redundant pairs. To do this, each redundancy pair must have a unique output domain. You cannot send data from multiple redundancy pairs into a single output domain.



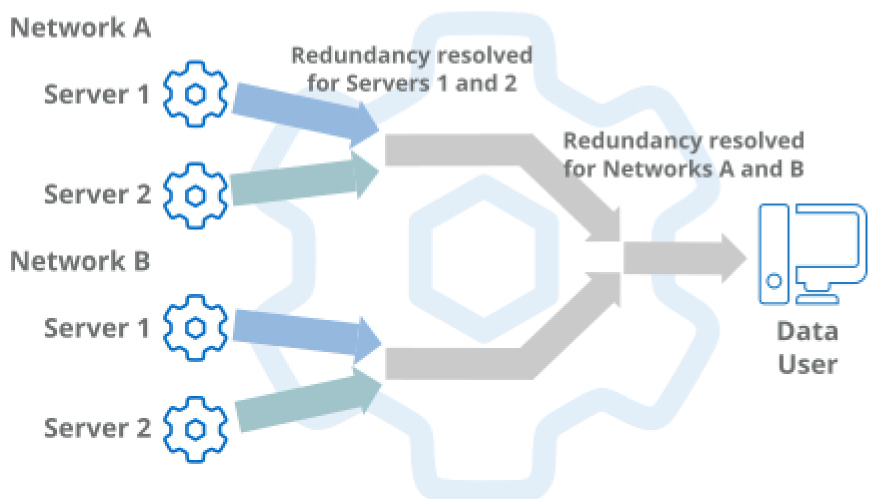
It is also possible to configure redundancy for multiple identical redundant sets coming from a single source of data. For example, you may want to configure redundancy for

4 data paths from a single source, where you have 2 redundant servers running on 2 redundant networks. Redundancy in this scenario would need to be resolved in two stages.

- In the first stage you could resolve the redundant networks into a pair of outputs, one for each server. At the second stage you would resolve the redundant servers to a single output.



- Alternatively, you could resolve the redundant servers to one output for each network, and then resolve the redundant networks into a single output.



Memory Limitations

There are no programmed-in limits on the number of domains or redundancy pairs. The practical limit is typically the number of data points that the DataHub instance can handle before running out of memory. The total data point count is the sum of the data points counts in each domain.

The number of domains is the total of all input and output domains on the DataHub instance resolving the redundant connections. On the simplest redundant system that would be 2 inputs and 1 output, for a total of 3. This means you need to ensure you have enough memory for 3 times the number of points as are in one of the source domains.

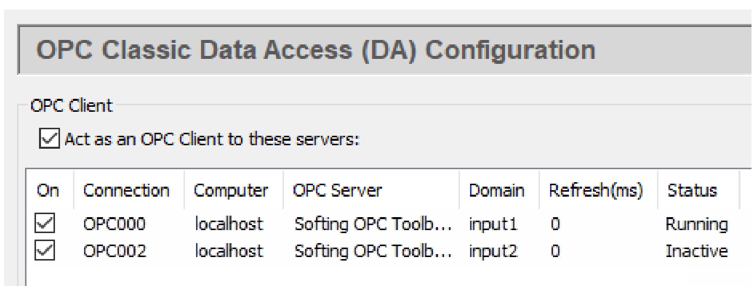
In the more elaborate scenarios shown above, at the first level you have 4 inputs and 2 outputs, or 6. At the second level the two input domains have already been counted (as outputs on the previous level). You just need to add the final output domain for a total of 7. So on the DataHub instance that is resolving the redundancy, you need 7 times the amount of memory that a single domain would require.

Warm Standby

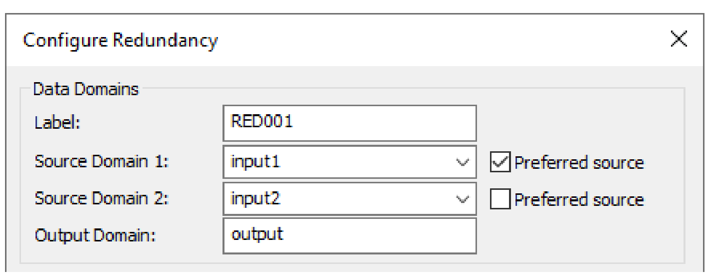
It is possible to use the DataHub Redundancy feature to support warm standby, by using a DataHub script. Since we perform redundancy at the data level instead of the connection level, the DataHub instance does not naturally know which connections to start and stop when it switches input domains. Consequently you need a script that will watch the redundancy state and turn on or off the connections based on separate knowledge about how the connections match up with the data domains.

Below is an example script that shows how to set up warm standby redundancy. It requires you to first configure redundancy through the interface, and then re-enter some of the same information again. For example, here is an OPC configuration, showing two connections named `OPC000` and `OPC002` feeding data into domains `input1` and `input2`:

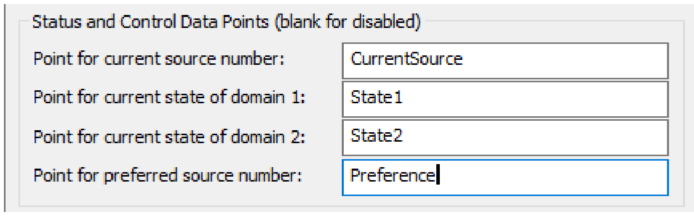
1. Configure the OPC servers.



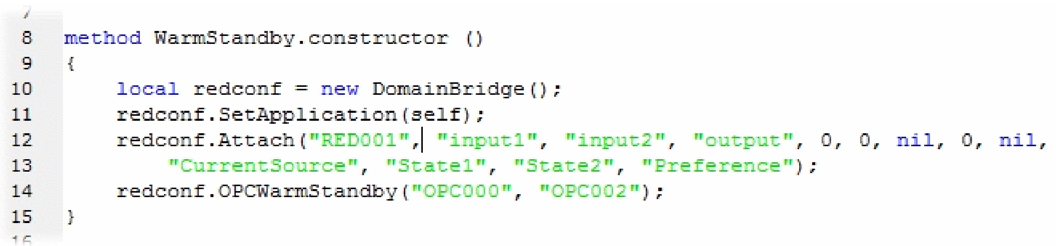
2. Configure a redundancy pair labeled, for example, `RED001`.



3. This redundancy pair *must* include configuration for the four status points. You can name them whatever you like:



4. The script needs to be edited so that it contains the configured information about the redundancy pair, including the **Label**, **Source Domain 1**, **Source Domain 2**, **Output Domain** name as well as all four **Status and Control Data Point** names.



The rest of the information in the `Attach` call will be ignored. Once we have attached to the redundancy pair, we can tell the script which OPC connections correspond to the input domains. These are provided as the OPC connection label corresponding to each input domain.

When you run the script, it will watch the status points and determine which OPC connection should be active and which should be inactive based on the status of the data.

Example Script `WarmStandby.g`

```
require ("Application");
require ("DomainBridgeSupport");
require ("Quality");

class WarmStandby Application
{
}

method WarmStandby.constructor ()
{
    local redconf = new DomainBridge();
    redconf.SetApplication(self);
    redconf.Attach("RED001", "input1", "input2", "output",
     0, 0, nil, 0, nil,
        "CurrentSource", "State1", "State2", "Preference");
    redconf.OPCWarmStandby("OPC000", "OPC002");
}
```

```
ApplicationSingleton (WarmStandby);
```

Special Cases Q&A

Different data sets

Q: Will the Redundancy feature work properly if one of the two input domains has points that the other input domain doesn't have? If that is the case, will it throw some kind of error message?

A: Redundancy will work. If there are points in input 1 that are not in input 2 then they will appear in the output when input 1 is active, and get marked as Not Connected when input 2 becomes active. If both input 1 and input 2 become active at some point in a session then the output will be the union of input 1 and input 2, with the points that only appear in the inactive input marked as Not Connected.

If you want to use redundancy, then you need to ensure that the two input domains contain points with identical names. If the point names are not the same from the two sources then you need to create a synthetic input domain and bridge all of the points from one of the source domains into it, changing the point names as part of the bridge.

Writing back to redundant sources

Q: Writing to the output domain only updates the currently active redundancy connection. Why not both?

A: In general there is no expectation that both pathways are always available. The inactive source should be receiving updates to its points from the underlying process, not the DataHub instance.

If both input domains are available, writing to both of them would cause two write events to the data source, which can produce strange results. Consider a boolean value in a PLC that acts as a rising edge trigger. If the PLC responds to the write by resetting the boolean then writing to both connections will cause the trigger to run twice. This is considered undesirable behaviour.

This has special implications for OPC A&E. If you are reading from two different A&E servers then you have to accept that one of the two servers will not receive an acknowledgement from the A&E client. This is because it may not be connected, or that it is connected but not active. If the inactive A&E server becomes active, the A&E client may see some acknowledged events become unacknowledged as part of the fail-over and will need to re-acknowledge them. Both A&E servers should show the A&E conditions to be in the same state (aside from ACK) as they should be receiving their state information from the same underlying process.

Replicating a tree hierarchy

Q: How can I get the data hierarchy in my input domains into my output domain?

A: A hierarchy in the output domain is created when an input domain becomes valid. There are two settings in the redundancy configuration:

- **Never copy the data model to the output domain**
- **Always copy the data model when switching**

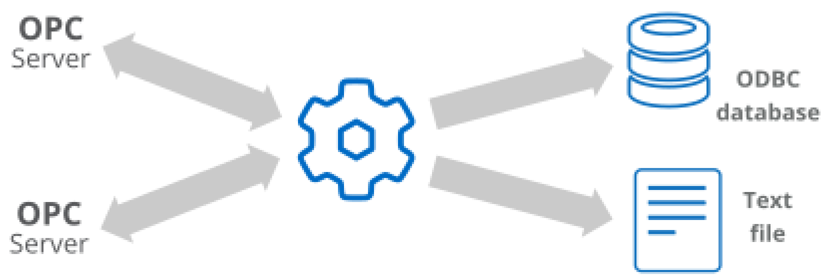
If neither of these options are checked (the default) the data hierarchy gets copied to the output domain whenever the input domains switch. If neither input domain becomes valid then all points in the output domain will have bad quality and will be in a flat organization.

If the first option is checked then the hierarchy will not appear in the output domain.

Write to a Database

Introduction

The DataHub program can write data to any ODBC compliant database or text file[1].



With this feature of the DataHub program you can:

- Log data to any ODBC-compliant database, such as MS Access, MS SQL Server, MySQL, Oracle, and many more.
- Log from any data source connected to a DataHub instance.
- Log to existing database tables, or create new tables as necessary.
- Log data to a text file using the `LogFile.g` script.

To write data from a database into a DataHub instance, please see *Query a Database*.

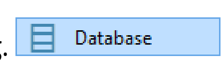
The DataHub ODBC Data Logging interface provides an easy way to connect to a DSN, create or select a table, assign data point properties to table columns, and assign a trigger and conditions for logging points. The fastest way to learn how to use the interface is by watching the web-site video or by using the Quick Start.

Quick Start

Here's how to configure a DataHub instance to write data to a database of your choice. We use a data point from the DataSim program in this example but you can just as easily use your own data point.

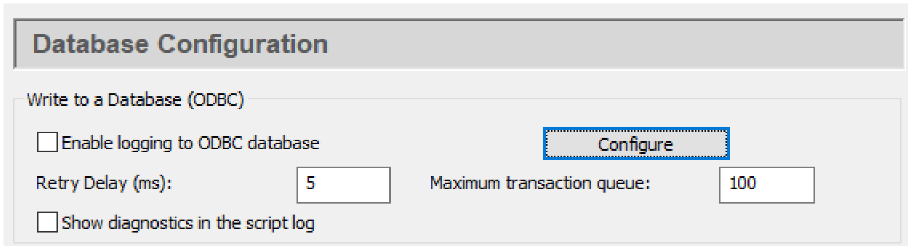
Click here to watch a video.

Open the ODBC Data Logging window

1. In the DataHub Properties window, select **Data Logging**. 

[1]Text logging can be configured through DataHub scripting.

2. Click the **Configure** button.

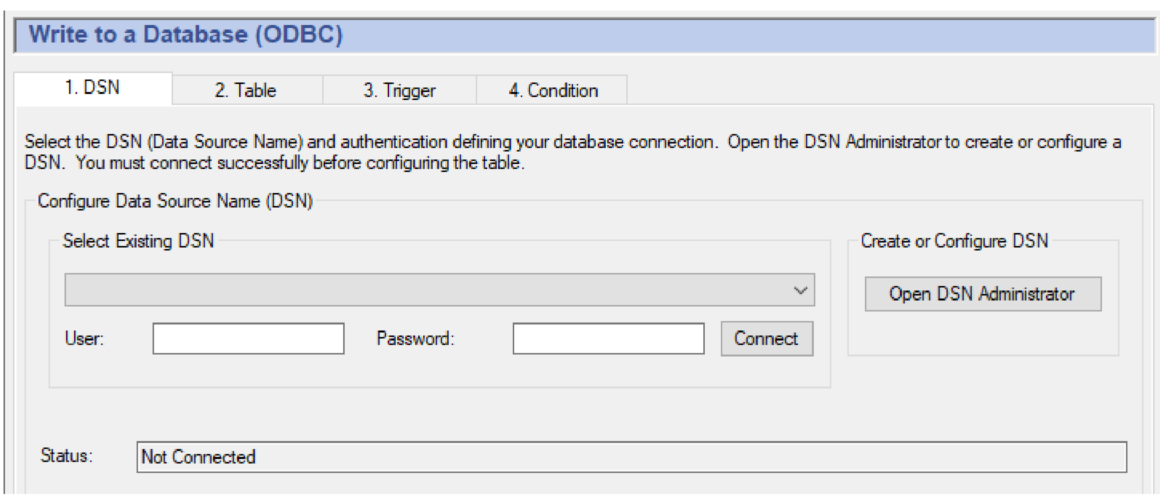


This opens the ODBC Data Logging window, shown below.

The **Data Logging Configuration** interface is explained in detail in the section called “Configuring the Queue, Store and Forward”. For now, you can use the defaults.

Connect to the Database

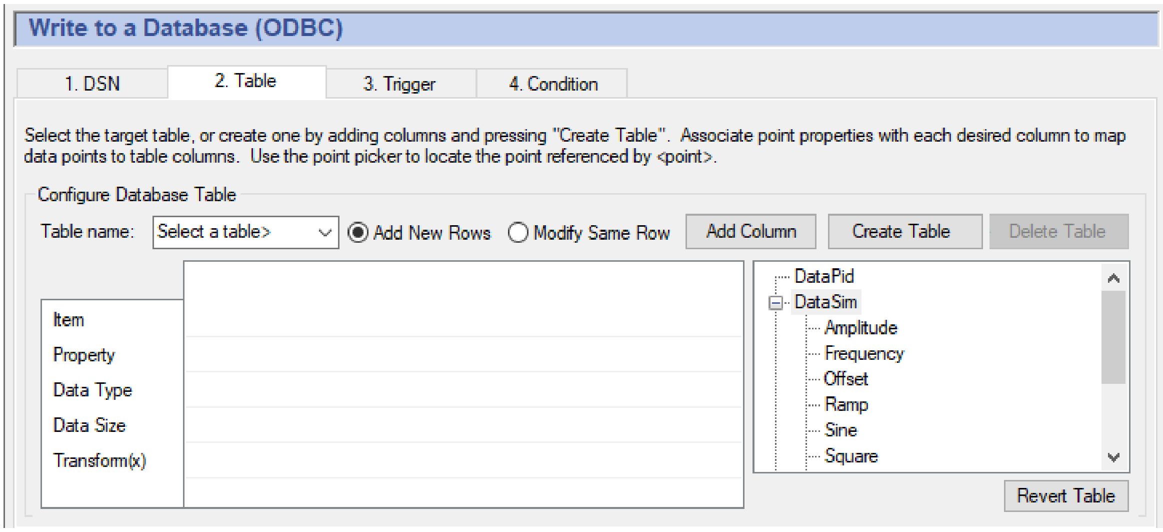
1. Select the **1. DSN** tab. A *DSN* is a Data Source Name. Windows uses this name to identify the database you want to connect to.



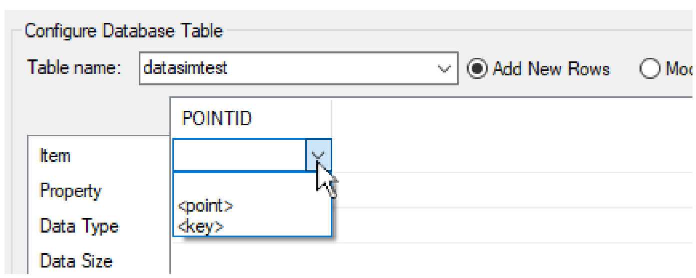
2. From the drop-down box, select a DSN. If you do not have any DSNs, or you wish to create a new DSN, you can do this by opening the DSN Administrator. Please refer to Setting up a DSN for more details.
3. Enter the user name and password (if required), and click the **Connect** button. A "`Connected to ...`" message should appear in the message box. If you get an error message in the box, consult your system administrator.

Configure a Table

1. Select the **2. Table** tab.



2. Start the DataSim program if it isn't already running, and ensure that it is connected to a DataHub instance.
3. In the **Table name** field type: `datasimtest`.
4. Click the **Add Column** button, type: `POINTID` in the pop-up dialog, and then click **OK**.
5. Click under the **POINTID** label in the **Item** row.

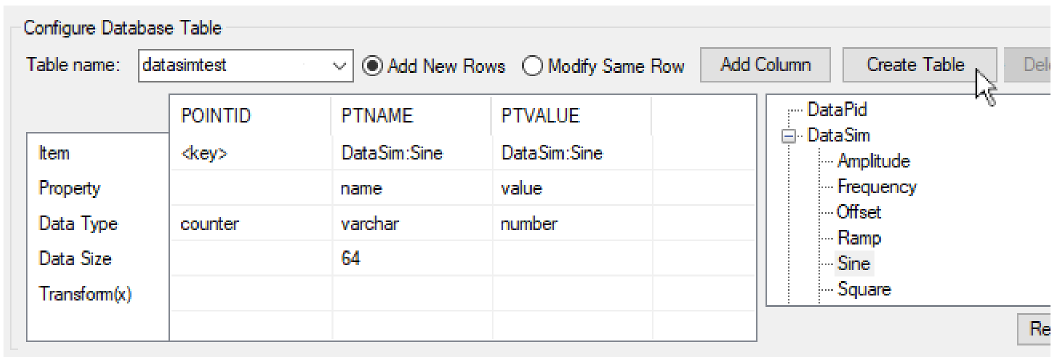


6. Select **<key>** from the drop-down list. Notice after you make your selection that the word `counter` gets entered automatically for the **Data Type**.
7. Click the **Add Column** button and enter the name `PTNAME`.
8. In the point-picker list on the right, expand the `DataSim` data domain and select the point named `Sine`.
9. In the **PTNAME** column, click in the **Item** row and select `<point>`. The full name of the point, `DataSim:Sine`, should appear.

   for **Property** in that column select `name`.
   for **Data Type** select `varchar` (or the equivalent).
   for **Data Size** the system might have entered a value for you. If not, type in a value like 64 and click **Enter**.
10. Click the **Add Column** button again and add the column name `PTVALUE`. Then make these entries:

for **Item** select `<point>`. (The point name, `DataSim:Sine`, should appear.)
for **Property** select `value`.
for **Data Type** select `number` (or the equivalent).
for **Data Size**, depending on your database, you might not be able to enter anything. If you are able to make an entry, you can type in a number of bytes and click **Enter**.

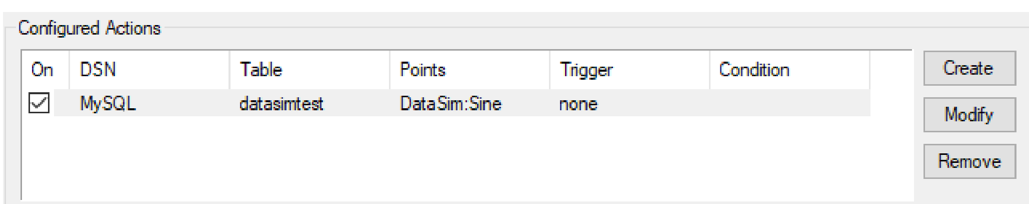
The entry fields should now look similar to this:



11. Click the **Create Table** button. If successful, you have now created a new table in the database specified by your DSN. You can open your database program and view it to verify. If you get an error message, check your entries above carefully to ensure they are compatible with your database. For example, some databases will not allow spaces or special characters in table and column names.

    Once the table is created, you cannot add any more columns. However, you can delete the table using the **Delete Table** button. This will delete the table from the database, but all of your entries will remain in the entry fields. You can then add more columns if you wish, and recreate the table. You can easily rename, insert, or delete a column by right-clicking on the column name for a pop-up menu. For more information about creating and modifying tables, please refer to the section called “Configuring a Database Table”.

12. When you have the table the way you want it, go down to the **Configured Actions** box and click the **Create** button.



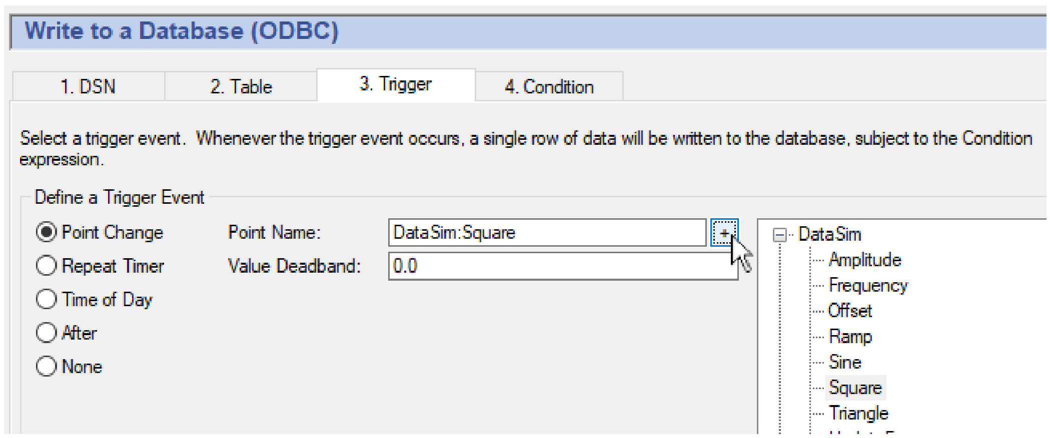
    A new configured action should appear in the list. For more information about configured actions, please refer to the section called “Configured Actions”

    Next, to get the DataHub instance to write the data, you need to assign a trigger.

Assign a Trigger

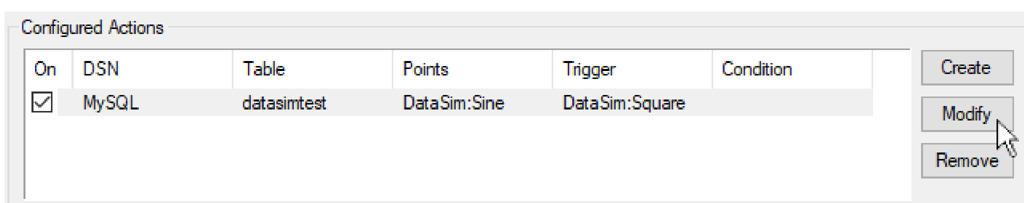
For this example, we will trigger the action whenever the `DataSim:Square` point changes value.

1. Select the **3. Trigger** tab.
2. From the point selector, expand the `DataSim` data domain and select the point `Square`.
3. Click the **+** button to the right of the **Point Name** field. The point name `DataSim:Square` should fill in for you.



You can choose any point for the trigger, including the point that gets written, such as `DataSim:Sine` in our example. For more information about triggers, please refer to the section called “Assigning a Trigger”.

4. In the **Configured Actions** box, make sure that the configured action you just created is highlighted. If not, click on it to highlight it. Then click the **Modify** button.



   Your configured action should now display the `DataSim:Square` point as your **Trigger**.

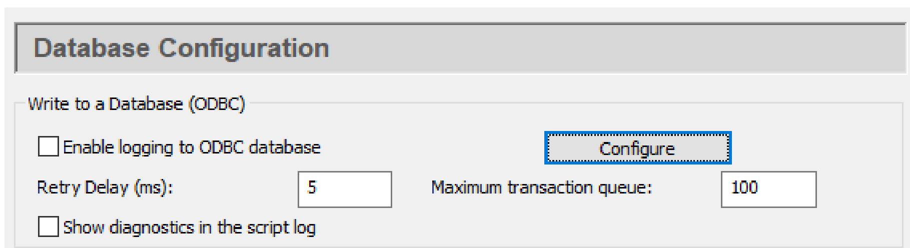
5. Click the **Apply** button to activate the configured action.
6. Open the Script Log to check for error messages and ensure that your data is being written successfully. Each write action to the database gets logged here. You can also verify the writes by querying the database itself.

You have just configured an action that logs the name and value of the `Sine` point in the `DataSim` data domain whenever the value of the `Square` point changes. Now you can create tables to log your own data, with triggers based on points or timers.

The remaining sections in this chapter explain the interface in more detail, and introduce the option of setting specific conditions for logging, if desired.

Configuring the Queue, Store and Forward

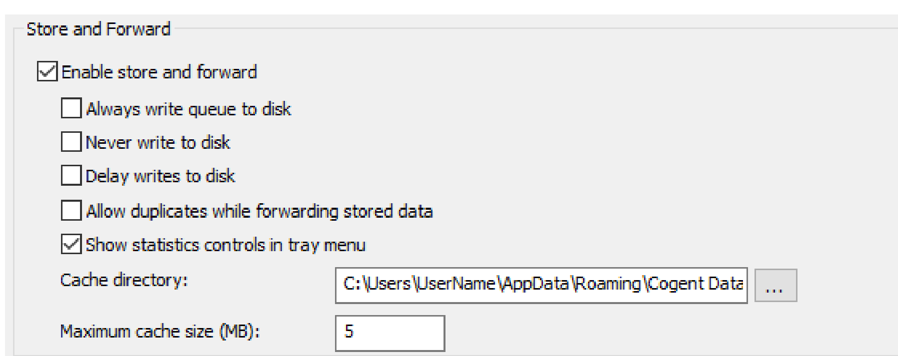
The DataHub program maintains an in-memory *transaction queue* of pending operations. This queue helps to avoid writing to disk during busy periods or during short database or network outages. The **Maximum transaction queue** option lets you modify the depth of this queue, with a default of 100 messages. The **Reconnection delay (s):** option specifies the number of seconds before a reconnect is attempted if the ODBC connection is broken. And the **Show diagnostics in the Script Log** option lets you view messages about the connection in the Script Log.



Store and Forward

The term *store and forward* refers to a type of database connection where the data is stored locally to disk and then later forwarded to the database. The DataHub program performs an advanced form of store and forward that only writes to disk if the database is not connected, or has been paused. If the database is available, the data will be transmitted directly to the database. This means that there is no penalty for using store and forward during normal operation. The DataHub store and forward mechanism uses two levels of disk caching to ensure that all data gets logged, and nothing is lost.

When the database first becomes available after an outage, the DataHub instance starts writing cached values to the database, and continues writing new values to the cache. In this way, the values are inserted into the database in the order in which they are generated by the system. Once the cache is cleared, the DataHub instance then starts writing new values directly to the database.



Enable store and forward

Activates the store and forwarding feature.

Always write queue to disk

Data in the transaction queue will be written to disk cache first, and from there to the database. The safest protection against a crash is to check this box, and uncheck **Delay writes to disk** (below).

Never write queue to disk

The data in the transaction queue will be only stored in memory, and never written to disk.

Delay writes to disk

Data in the transaction queue will be written to disk at the most opportune times. The safest protection against a crash is to uncheck this box, and check **Always write queue to disk** (above).

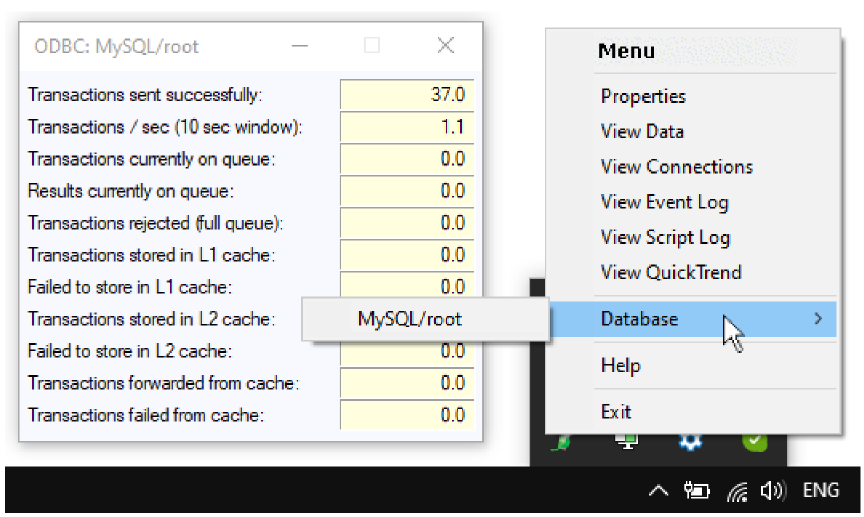
Allow duplicates while forwarding stored data

If the network breaks while transmitting data from a cache, the DataHub instance needs to know how to handle any already-sent data when it reconnects. Leaving this box unchecked will require the DataHub instance to track its cache position at all times, and modify that information each time a value is sent. This will impact the speed of every transmission, but it will ensure that no values get transmitted twice.

Checking this box will cause the DataHub instance to simply start from the beginning of the queue or cache on each reconnect, and retransmit some data. This significantly reduces data-handling complexity and decreases transmission rates. This option is particularly useful if network breaks are frequent and some duplication of logged data is acceptable.

Show statistics in tray menu

Adds a **Data Logging** entry to the DataHub instance's system tray menu, which lets you open a statistics window:



Transactions sent successfully:

The number of transactions that were sent, either directly to the database, or to the disk cache.

Transactions / sec (10 sec window):

The sending rate for transactions, calculated over the past 10 seconds.

Transactions currently on queue:

The number of transactions in the queue.

Results currently on queue:

Not yet documented.

Transactions rejected (full queue)

The number of transactions that were rejected from the queue because it was full.

Transactions stored in L1 cache

The number of transactions taken off the queue and put into the first-level cache. An internal algorithm determines which of the two caches is most appropriate for storing a given transaction.

Failed to store in L1 cache

The number of transactions that were not able to be stored in the first-level cache.

Transactions stored in L2 cache

The number of transactions taken off the queue and put into the second-level cache. An internal algorithm determines which of the two caches is most appropriate for storing a given transaction.

Failed to store in L2 cache

The number of transactions that were not able to be stored in the second-level cache.

Transactions forwarded from cache

The total number of transactions forwarded from both caches. This number should be the sum of L1 and L2, once all transactions have been forwarded, and as long as the DataHub instance was started up with no cache on disk.

Transactions failed from cache

The number of transactions attempted from cache, could not be successfully delivered, and were stored for later transmission. This phenomenon may occur the first time that the DataHub instance learns that the database is not available. For example, you'll see this for every network break if you've checked **Always write queue to disk**.

Cache directory:

The path and directory name for the cache.

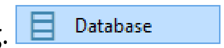
Maximum cache size (MB):

The amount of disk space to allocate for the cache, in megabytes.

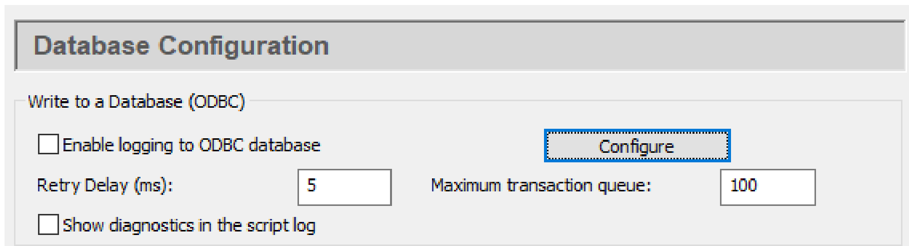
Setting up the DSN (Data Source Name)

A *DSN* is a Data Source Name. Windows uses this name to identify the database you want to connect to. This tab lets you select an existing DSN, or create a new one if necessary.

Open the ODBC Data Logging window

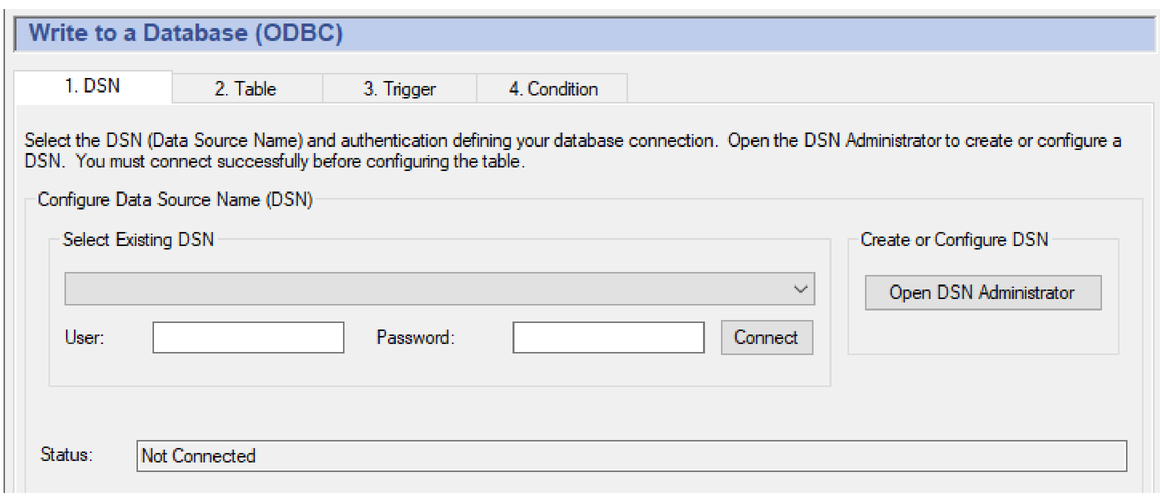
1. In the DataHub Properties window, select **Data Logging**. 

2. In the **Configure Database (ODBC) Data Logging** section click the **Configure** button.



The **Data Logging Configuration** interface is explained in detail in the section called “Configuring the Queue, Store and Forward”.

3. Configure your DSN as explained below.



Selecting a DSN

1. To select a DSN, choose one from the drop-down box, and then enter the user name and password, if applicable.

   If your DSN is using Windows Authentication, leave the **User** and **Password** fields blank.

2. Click the **Connect** button. A "`Connected to ...`" message should appear in the message box. If you get an error message in the box, consult your system

administrator.

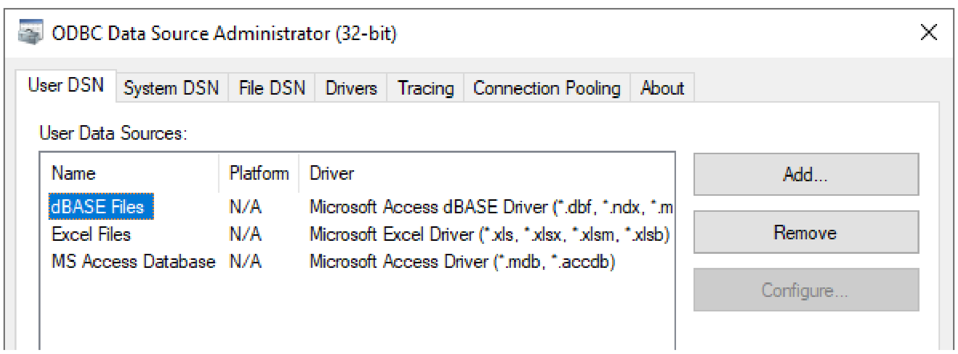
Creating or Configuring a DSN

Windows has different configuration programs for 32-bit and 64-bit DSNs. You need to use the 64-bit DSN administrator with 64-bit DataHub program, or you need to use the 32-bit DSN administrator with 32-bit DataHub program. The application name, `odbcad32.exe`, is the same for both the 32-bit version and the 64-bit version of the DSN Configuration tool. The difference is which folder it is in:

- The 32-bit version is in C:\Windows\SysWow64
- The 64-bit version is in C:\Windows\System32

Despite the apparent mismatch of folder names, those are correct. The DataHub instance will automatically choose the correct version when you select the **Open DSN Administrator** button.

1. To create or configure a DSN, click the **Open DSN Administrator** button. This opens the ODBC Data Source Administrator window.



2. Select the **User DSN** or **System DSN** tab, depending on how you plan to access your database.
   A user DSN is only available to the current user account, while a system DSN is available to any user account on the computer.
3. Now you can add a new database or configure an existing one.

   Add a new database

   1. Click the **Add** button. The Create New Data Source window will open, displaying a list of data source drivers.
   2. Select the data source driver that corresponds to your ODBC database. A data source setup window will open. Each data source setup window is different, but you should be able to find the appropriate entry fields easily enough.
   3. Enter the data source name and select the database.
   4. Enter any other required or optional information such as login name, password, etc. What entries need to be made and where they are entered depends on the

particular data source setup window you are using.

5. Click **OK** to return to the ODBC Data Source Administrator window. You should be able to see the new database and driver listed. If you need to make any changes, you can configure an exiting database, as explained below.

Configure an existing database

1. Select a data source name and click the **Configure...** button. This takes you to the data source setup window (explained above) where you can make changes to the configuration.
2. Make your changes and click **OK** to return to the ODBC Data Source Administrator window. Any time you need to make a change, you can go to this window.

4. When you are satisfied everything is correct, click the **OK** button to exit the ODBC Data Source Administrator.

Once you have created a DSN, you can select it as explained above.

Configuring a Database Table

After you have set up a DSN you can create a table or select an existing one, and then assign points and properties to the columns of the table.

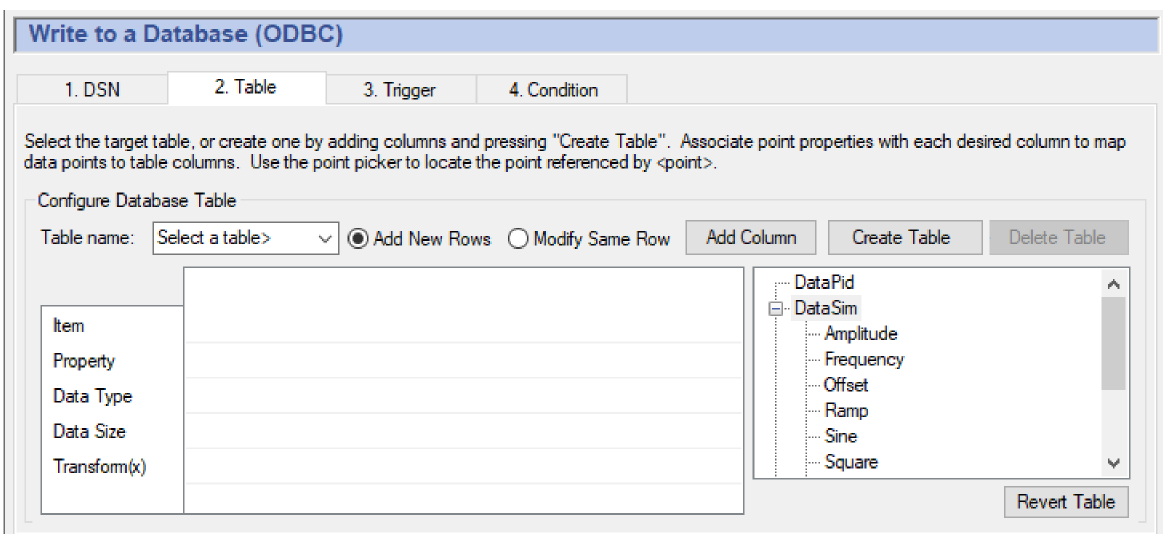


Table Selection or Creation

You need to either select an existing table, or create a new one.

- **Selecting a table** allows you to use a table that you have created in your database program. When you select an existing table, you cannot add columns or change column names. To select a table, choose a table name from the drop-down list. After choosing a table, you can use the **Revert Table** button under the data point list to undo the choice and return to the previous table definition.

- **Creating a table** provides a way to design and create a table from within this interface.
  1. From the **Table Name** drop-down list, select `<Create a new table>`.
  2. In the dialog box, type in a table name and click **OK**.

     Now you will have to add at least one column.
  3. Click the **Add Column** button to create a column.
  4. In the dialog box, type in a column name and click **OK**.

     At this point you can add more columns, or you can assign points (as explained below). You can easily rename, insert, or delete a column by right-clicking on the column name and selecting **Rename Column**, **Insert Column**, or **Delete Column** from the pop-up menu.
  5. When all of your columns have been created and named, you can create the table in the database. Once created, you cannot add columns to the table. To create the table, click the **Create Table** button.

     If, after creating the table, you need to make changes to it, and it has no data in it that you need, you can click the **Delete Table** button. This will delete the table from the database but will leave all of the configuration you've done intact in this window. You can then add more columns or make changes to points and properties and recreate the table. This can be done as often as you need to.

Add New Rows or Modify the Same Row

For any given table, whether existing or newly-created, you will need to decide whether you are going to add new rows, or modify the same row with new data each time it changes.

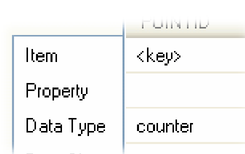
- **Add New Rows** creates a new row in the table each time data is logged.
- **Modify Same Row** writes to the same row in the table each time data is logged.

Assigning a Key

You have the option to make one column, often the first column in a table, a key column.

- **An auto-incrementing key** is commonly configured for **Add New Rows**. A key column is optional for adding new rows, but if you choose to have one, it **must** be auto-incrementing. Please refer to the section called “Key Columns” for more details. An auto-incrementing key can be configured as follows:

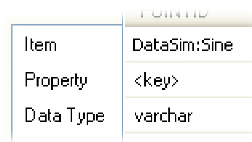
  Item: Choose <key> from the drop-down list.
  Property: (none)
  Data Type: The appropriate auto-incrementing integer type for your



database.

- **A single key column** is required for **Modify Same Row**. The DataHub instance uses the key value to determine which row to modify. Please refer to the section called “Key Columns” for more details. The key can be configured as follows:

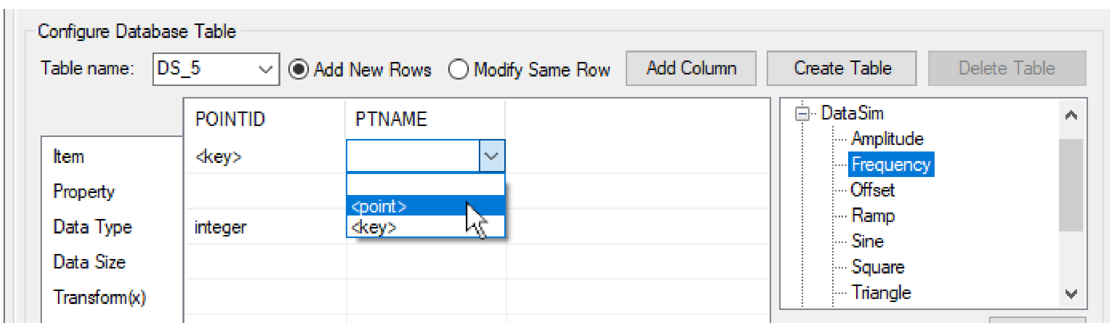
  Item: Type in a DataHub point name, or any other value.
  Property: <key>
  Data Type: The appropriate type for your database (typically VARCHAR, NVARCHAR or CHAR).



Due to a Windows bug, in the first column the interface won't respond unless you click directly below the text of the column name. We are working to resolve this.

Assigning points and properties

When you have selected a table, or you have at least one column in a table you are creating, you can assign points and their properties to the various columns.



Item

First, choose a point from the point-picker list on the right. Then click in the **Item** row and select `<point>` from the drop-down list. Optionally, you can type in the name of the point. Leaving the **Item** blank allows you to choose the **Property** of `clock` to display the system time, or `clockms` to display the number of milliseconds after the second of the system time.

Property

Select which property of the point you want written to the database in this column:

`name`
: The name of a the point shown in the **Item** field.

`value`
: The value of the point shown in the **Item** field.

`quality`
: The quality of the point shown in the **Item** field.

`timestamp`

The time stamp of the point shown in the **Item** field. This will include the milliseconds, but many databases, such as MS Access, ignore the milliseconds and store only the seconds. Other databases such as MySQL and MS SQL Server include the milliseconds in a time stamp. For example:

- Databases like MySQL and MS SQL Server:

	Column A
Enter for **Property**	`timestamp`
Enter for **Data Type**	`datetime` or `timestamp` or `date`

- Databases like MS Access:

	Column A	Column B
Enter for **Property**	`timestamp`	`timems`
Enter for **Data Type**	`datetime`	`number` or `integer`

`timems`

The millisecond component of the `timestamp`, generally used in conjunction with `timestamp`. You only need this if your database cannot store the millisecond component of `timestamp`.

`timestampUTC`

The same as the `timestamp`, but in UTC time. You can use `timems` in conjunction with this as well.

`clock`

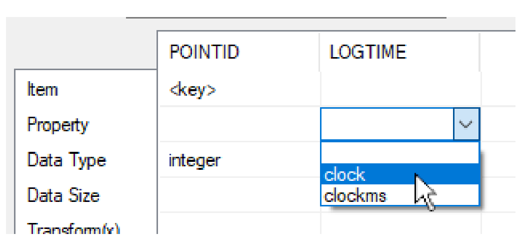
The current system time. This will include the milliseconds, but like `timestamp` (above) many databases ignore the milliseconds and store only the seconds.

`clockms`

The millisecond component of `clock`, generally used in conjunction with `clock`. Like `timems` (above), you only need this if your database cannot store the millisecond component of `clock`.

Using `clock` and `clockms` some tips:

- You must leave the `Item` field blank to select either of these options.



- **Example** If the time is `12:34:56.789`, `clock` will be written as `12:34:56.789` in databases that accept milliseconds, and as `12:34:56` in databases that do not. A `clockms` property will be written as `789` in all databases.
- The `clock` and `clockms` properties allow you to log the system time as a column in the table, so that your record can contain the system time along with a number of different point values, for example:

```
System Time       Point1       Point2       Point3
08:12:56.000      43.883        3.727      213.905
```

Data Type

The data type that the database should associate with the property.

Data Size

In some cases this is entered automatically, in other cases it is not used, but sometimes it is possible or necessary to enter a size, such as the number of characters in a text string, or the number of bytes.

Transform(x)

This allows you to modify the entry or to insert a text string. For example:

- `(x * 100) + 25` could be used to multiply a point value by 100 and add 25 to the result.
- `"Tank Level"` would insert the string `Tank Level` instead of, say, the point name.

Any valid Gamma expression can be used.

Key Columns

A database table can have a special column (or set of columns) that is designated as a *key*. Every value in the key column(s) is unique. By designating a key in a table, you are providing the database engine with a guarantee that any search on the key will produce either zero or one row. Effectively, when a search matches a value in the key column, the row containing that key is guaranteed to be unique in the table.

A database table does not require a key. The key is effectively a hint to the database engine to improve efficiency and to guarantee uniqueness. You can still search and modify a table that has no key.

When working with the DataHub Data Logging interface, you have the option of specifying a key column. The interface will only allow single-column keys. You will not be able to specify more than one key column, and if you choose an existing table with multiple key columns, the interface will fail.

Your choice of key will depend on whether you have chosen **Add New Rows** or **Modify Same Row** for your database table.

Adding New Rows

If you choose to add (insert) new rows into your database table, you do not require a key column. Each new logging event will create a new row and populate it with the data that you have configured. Since you are continually adding rows to the table, there is no data that can be guaranteed to be unique within a column. Any one of point name, quality, value or timestamp may be repeated.

Consequently, if you do wish to have a key column in your table, it must have one important property: it must be automatically generated and guaranteed to be unique. The key value cannot be derived from a DataHub point. Most database engines support the concept of a *counter* or an *auto-increment* numeric value. If you choose to use a table containing a key, the key column must be of the appropriate auto-incrementing integer type for your database.

You can designate a key by choosing the `<key>` option for the **Item** entry of the database table when configuring a table through the Data Logging interface. If you are using an existing table that already contains a key, you must specify in the Data Logging interface that the column is a key column.

Modifying the Same Row

If you choose to modify a row in the database, such that any new data will overwrite the existing data in the row, you must be able to uniquely identify that row. This means that you **must** have a key column.

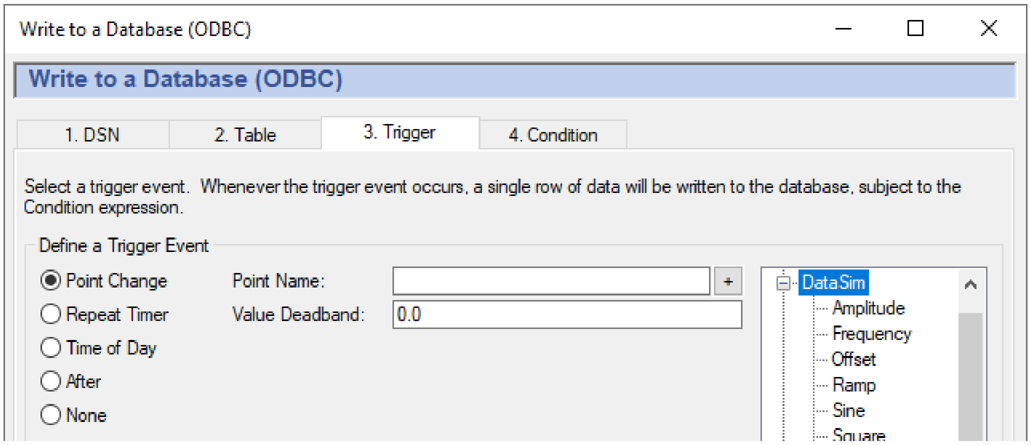
The key column can be any type, and does not need to be auto-incrementing. Since the row is overwritten whenever new data is available, no new key value is generated. It is common to supply the DataHub point name as a key, with the key field defined as a string type (typically `VARCHAR`, `NVARCHAR` or `CHAR`). You can do this by selecting a point in the point picker tree, then choosing the `<point>`; option for the **Item** entry of the database column, and `<key>` for the **Property** field.

If you wish to specify a key value other than a point name, type your own value into the **Item** entry instead of using the point name. You must then choose `<key>` for the **Property** entry.

The key value you enter here is evaluated in the Gamma engine as an expression or symbol. If it is a string, it must be written inside quotes to prevent causing an undefined symbol error. Also, if you are using the Remote Config interface, the expression will appear in the DataHub point list.

Assigning a Trigger

A trigger is an event that causes a row of data to be written to your database table. A trigger event can be either a point value change, a timer event, or a calendar event. You can assign a different trigger for each row, or an identical trigger to any number of rows. An action can be configured to execute on every trigger event, or you can assign trigger conditions that are evaluated whenever a trigger occurs, to determine if the action should be executed.



The three kinds of triggers are:

- **Point Change** fires whenever a specified trigger point changes.
  1. Type the name of the point into the **Point Name** box, or select the point using the data tree on the right, then click the **+** button.
  2. (Optional) Enter a value deadband if you want to filter out extraneous data. The number you enter will specify a high and low (plus or minus) range. Any value change falling within that range will not cause the trigger to fire. A positive or negative change greater than this value will activate the trigger and cause the row to be written.

  To create a trigger that gets reset automatically, please refer to An Auto-Resetting Trigger in the section called “Setting Trigger Conditions”.

- **Repeat Timer** fires cyclically, each time the number of seconds elapses.
- **Time of Day** fires at the time you specify. You can enter:
  - A number, indicating a specific value. For example, a `0` in the seconds field would cause the event only on the 0th second of the minute. A `30` would indicate only on the 30th second of the minute.
  - A list of numbers, separated by commas. For example, entering `0,15,30,45` in the minutes field would indicate that the event should fire on the hour and at 15, 30 and 45 minutes past the hour.
  - A range of numbers, separated by a dash. For example, entering `8-18` in the hours field would indicate that the event should fire every hour from 8 a.m. to 6 p.m.. Ranges can be mingled with lists, as in `0,4,8-16,20`.
  - An asterisk (`*`) indicates that the event should fire for every possible value of the field. For example, a `*` in the seconds field would cause the event to fire every second. A `*` in the hours field would cause the event to fire every hour.

To regularly log a record on specific days of the week, please refer to the section called “Setting Trigger Conditions”.

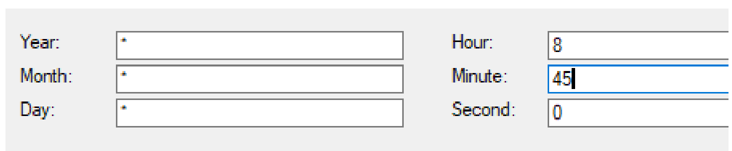
The ranges of the fields are:

Year:	`1970-*`	**Hour:**	`0-23`
Month:	`1-12`	**Minute:**	`0-59`
Day:	`1-31`	**Second:**	`0-59`

The year and month are entered differently here than for the Gamma `localtime` function, as explained in Time Conditions.

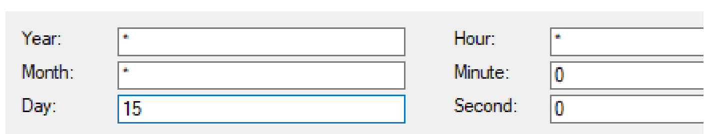
Examples:

- These entries:



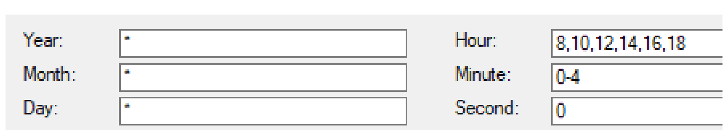
  would cause a row to be logged at 8:45 every day, every month, and every year.

- These entries:



  would cause a row to be logged every hour on the 15th day of each month, every year.

- These entries:

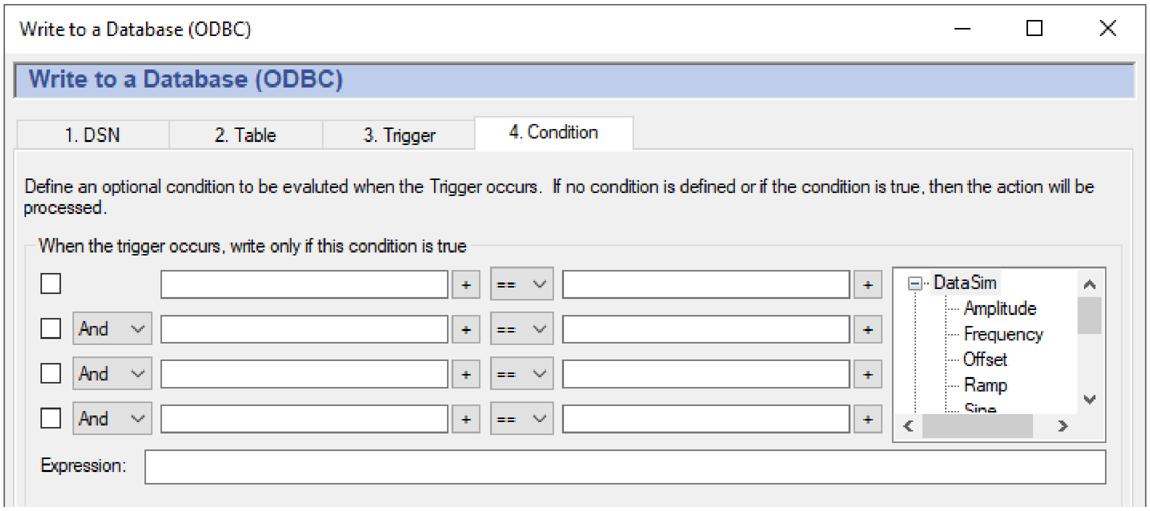


  would cause the event to fire every second for 5 minutes, every two hours between 8 a.m. and 6 p.m.

- **After** fires once, when the specified number of seconds elapses.
- **None** configures no trigger.

Setting Trigger Conditions

Each logging action can have up to four conditions that determine whether a row gets written to the database when the trigger fires.



Fill in the conditions according to the guidelines below. Check the box next to the condition to apply it. As you make entries, the corresponding *Gamma* code will appear in the display. The Gamma language is the DataHub program's built-in scripting language. The code that appears in the **Expression** box is the actual code that gets run by the Gamma engine. The order of precedence for "And" and "`Or`" operators (&& and `||`) is first And, then `Or`.

Point Value Conditions

Point names can be entered on either or both sides of the comparison. They can be picked from the data tree list, or typed in. Each point name needs to have a dollar sign ($) in front of it to indicate to the Gamma engine that this is a DataHub point. You can put numerical values into either side of the comparison.

When you enter a point name in a condition field, the current value of the point will be used in the evaluation. For example, you could define a condition that states that whenever the trigger event occurs, the action will only be executed if another point value is within a certain range.

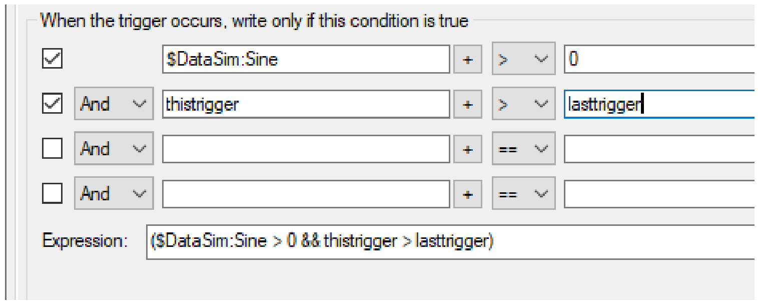
There are some automatic variables available for working with point values:

- `lasttrigger` - the value of the trigger point the last time this trigger was fired (even if the condition failed).
- `thistrigger` - the value of the trigger point now (even if the condition failed).
- `lastevent` - the value of the trigger the last time the event was actually executed (the

condition succeeded).

- `this` - the trigger point itself, not the value of the point.

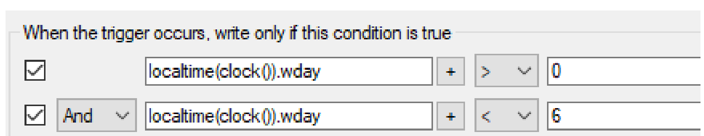
You can use these variables in any condition that is triggered by a data value change. For example, you could create some conditions like this:



Time Conditions

This provides an additional way to restrict the time, day, month, etc. when a message gets sent. In addition to the options on the triggers, here you have day-of-week condition statements which can give you more flexibility for events based on specific days of the week. These will work with any type of trigger event.

You can use the Gamma functions `clock` and `localtime` to specify particular days of the week. For example, these entries:



would create this Gamma code::

```
(localtime(clock()).wday > 0 && localtime(clock()).wday < 6)
```

which would cause data to be logged only Monday through Friday. The function `localtime` returns a class whose members contain information about the date, as follows:

`.sec`	The number of seconds after the minute (`0` - `59`).
`.min`	The number of minutes after the hour (`0` - `59`).
`.hour`	The number of hours past midnight (`0` - `23`).
`.mday`	The day of the month (`1` - `31`).
`.mon`	The number of months since January (`0` - `11`)
`.year`	The number of years since 1900.
`.wday`	The number of days since Sunday (`0` - `6`).

`.yday`	The number of days since January 1 (`0` - `365`)
`.isdst`	`1` if daylight saving time is in effect, `0` if not, and a negative number if the information is not available.

The year and month are entered differently here than for **Time of Day** trigger conditions, as explained in the section called “Assigning a Trigger”.

There are two automatic variables available for working with time values:

- `lasteventtime` - the system clock time (UTC floating point) that the last event was executed.
- `curtime` - the system clock time (UTC floating point) when the current trigger occurred.

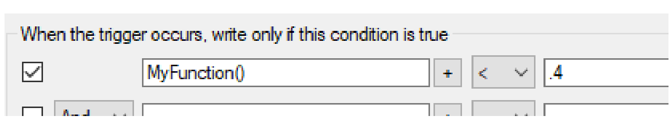
Custom Conditions

If the conditions you need to meet are beyond the scope of this interface, you can use a Gamma function to express virtually any condition you need. Then you can insert the function into one of the condition boxes, and set a condition based on the return value of the function.

To do this is you can create a DataHub script (`.g` file) that contains only the functions you will be using for conditions, without any classes or methods. For example, here is the complete contents of such a file, named `MyConditions.g`:

```
function MyFunction ()
{
    myvalue = $DataSim:Sine;
    princ("Value when the trigger fired: ", myvalue, "\n");
    myvalue;
}
```

This function prints the value of the `DataSim:Sine` point, and returns its value. We can use this function as a condition by calling it from one of the condition boxes in the interface, like this:



When the trigger fires, `MyFunction` is called, and the return value gets checked to see if it is less than `.4`. If so, the data gets logged.

Below are two practical examples demonstrating custom functions. The first creates an automatically resetting trigger, and the second lets you test for changed values before logging a point, which is useful if you are logging based on a timer.

An Auto-Resetting Trigger

This script can turn any DataHub point into a trigger that automatically resets. To use it, you first need to load and run the `TriggerFunctions.g` script (shown below). Then, if you put this formula:

```
HighWithReset($TriggerPoint)!= nil
```

into the condition boxes, whenever the *`TriggerPoint`* changes to a non-zero number in the DataHub instance, your trigger will fire. The script waits for a millisecond, then resets the *`TriggerPoint`* back to zero. The second function works similarly, but triggers on a change to zero, instead of a change to a non-zero number.

TriggerFunctions.g

```
/*
 * This file contains handy functions to perform more complex
 * condition handling in the Condition tab of the data logging
 * and email interfaces.
 */

/*
 * Test a trigger point for a non-zero value.  If the point is
 * non-zero, create a delayed event to reset the point to zero,
 * and return true, indicating that the condition has succeeded
 * and the action should proceed. If the value is 0, then simply
 * return nil indicating that the action should not proceed.  We
 * need to test for zero because when we reset the trigger point
 * to zero a second data change event will occur.
 *
 * The argument is unevaluated, so the condition should look
 * like this:
 *    HighWithReset($default:TriggerPoint) != nil
 */

function HighWithReset(!triggerpoint)
{
    local   value;
    if (!undefined_p(value = eval(triggerpoint)) && value != 0)
    {
        after(0.001, `setq(@triggerpoint, 0));
        t;
    }
    else
    {
        nil;
    }
```

```
}

/*
 * This is the inverse of HighWithReset (see above).  If the trigger
 * point is zero, perform the action and set the trigger point to 1.
 * If the trigger point is non-zero do nothing and return nil.
 */
function LowWithSet(!triggerpoint)
{
    local   value;
    if (!undefined_p(value = eval(triggerpoint)) && value == 0)
    {
        after(0.001, `setq(@triggerpoint, 1));
        t;
    }
    else
    {
        nil;
    }
}
```

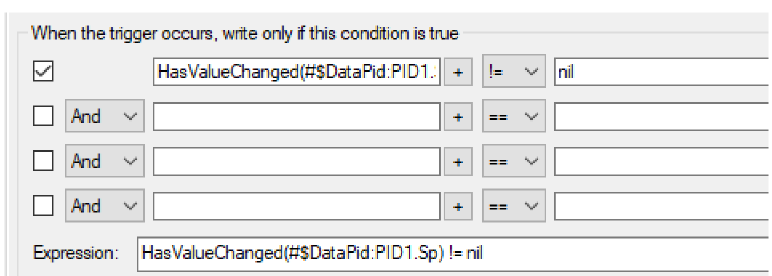
Test for Changed Values Before Logging

If you are logging data based on a timer, you can use this script to check the previously logged value, and only log a new row in the database if the value has changed. To use the script, you first need to load and run the `LogFunctions.g` script (shown below and included in the installation archive). Then, if you put this formula:

```
HasValueChanged(#$TestPoint)!= nil
```

into the condition boxes, when the *`TestPoint`* has not changed, the data for that row will not be logged.

The call to `HasValueChanged` uses the syntax `#$`*`pointname`* to specify the point. If you select the point from the tree to the right and press the **+** button, it will not include the # symbol. You need to manually add it. You can see the complete condition expression in the **Expression:** line beneath the condition selectors, like this:



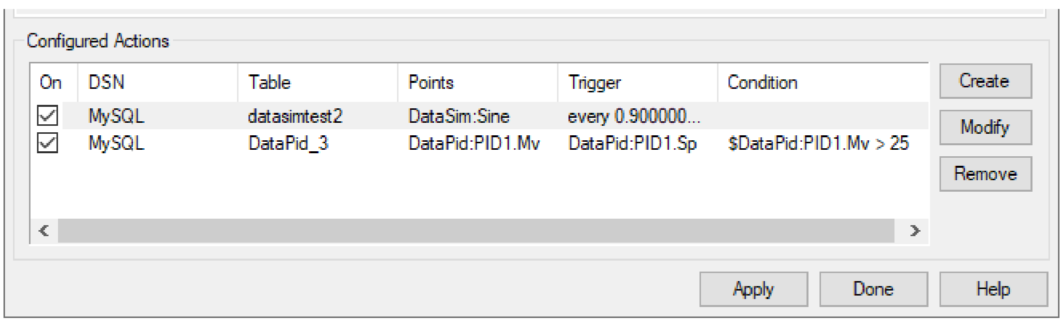
LogFunctions.g

```
/*
 * Functions that can be used by the Condition section of a Data
 * Logging configuration to filter whether data is actually written
 * to the database when a trigger occurs.
 */

// Change this to nil to silence the debugging statements that will
// be written to the script log.
LogFunctionDebug = t;

 /*
  * Track the previous value of a DataHub point and only allow the
  * logging action if the DataHub point value has changed since the
  * last time we logged it.
  *
  * Takes a single argument that is either a point symbol or a point
  * name as a string.
  *    e.g., "DataPid:PID1.Mv"
  *          #$DataPid:PID1.Mv
  *
  * Notice that a point symbol must be specified with the # operator
  * before the symbol to ensure that the symbol is passed, not the
  * value of the point.
  */

function HasValueChanged(point_symbol)
{
    local ptsym = symbol(point_symbol);
    local oldvalue = getprop(ptsym, #last_log_value);
    local curvalue;
    local result = nil;

    if (!undefined_p(curvalue = eval(ptsym)))
    {
        if (LogFunctionDebug)
            princ("Checking value of ",
    ptsym, ": previous = ", oldvalue,
                  ", current = ", curvalue, "\n");
        if (oldvalue != curvalue)
            result = t;
        setprop(ptsym, #last_log_value, curvalue);
    }
    else
```

```
    {
        if (LogFunctionDebug)
            princ("Log condition: value of ",
    ptsym, " is undefined\n");
    }
    result;
}
```

Configured Actions

A *configured action* will cause a row of data to be written into the table specified in your DSN, based on a trigger and optional conditions. It is the end result of your configuration activities in this interface. The **Configured Actions** list shows the actions you have configured, and allows you to create, modify, or remove actions, as well as turn them on or off.



The list of configured actions shows the actions you have already configured. Selecting an existing action from the list automatically fills in the **DSN**, **Table**, **Trigger**, and **Condition** tabs with its information. Checking or unchecking the **On** box at the left lets you switch the action on or off.

The Create button creates an action for the information currently entered in the **DSN**, **Table**, **Trigger**, and **Condition** tabs. If you press the **Create** button while a configured action is selected, it creates a duplicate of that configured action and adds it to the list. This is a quick way to configure similar actions.

The Modify button overwrites the selected configured action with the information currently entered in the **DSN**, **Table**, **Trigger**, and **Condition** tabs.

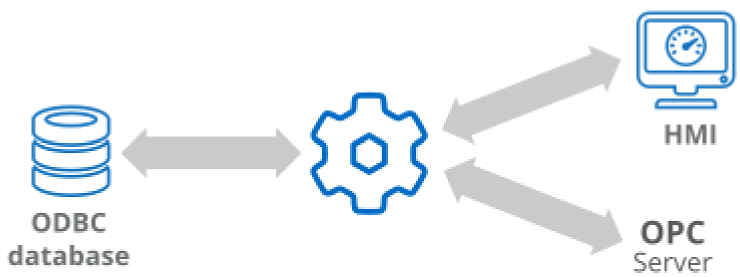
The Remove button removes a configured action.

Once a configured action has been created or modified, the changes won't take effect until you click the **Apply** or **Done** button. Each write action to the database gets logged in the DataHub Script Log. This allows you to check for error messages and ensure that your data is being written successfully. You can also verify the writes by querying the database itself.

Query a Database

Introduction

The DataHub program can query any ODBC compliant database, and bring the data back as DataHub points, or into a single point in XML format for use in $wvp;.



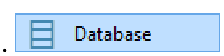
The DataHub ODBC Data Logging interface provides an easy way to connect to a database and submit a query. There are two options for writing the query to a DataHub instance: one DataHub point per row, or the whole query results in a single DataHub point. The fastest way to learn how to use the interface is by using the Quick Start.

Quick Start

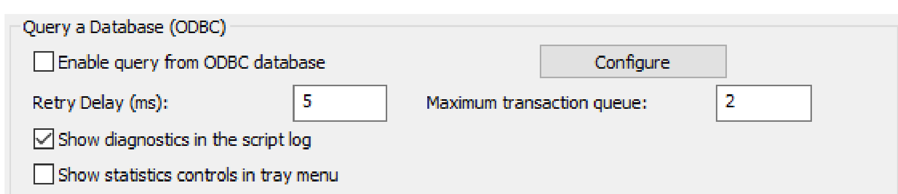
Here's how to configure a DataHub instance to query a database of your choice.

Click here to watch a video.

Open the Query ODBC Database window

1. In the DataHub Properties window, select **Database**. 

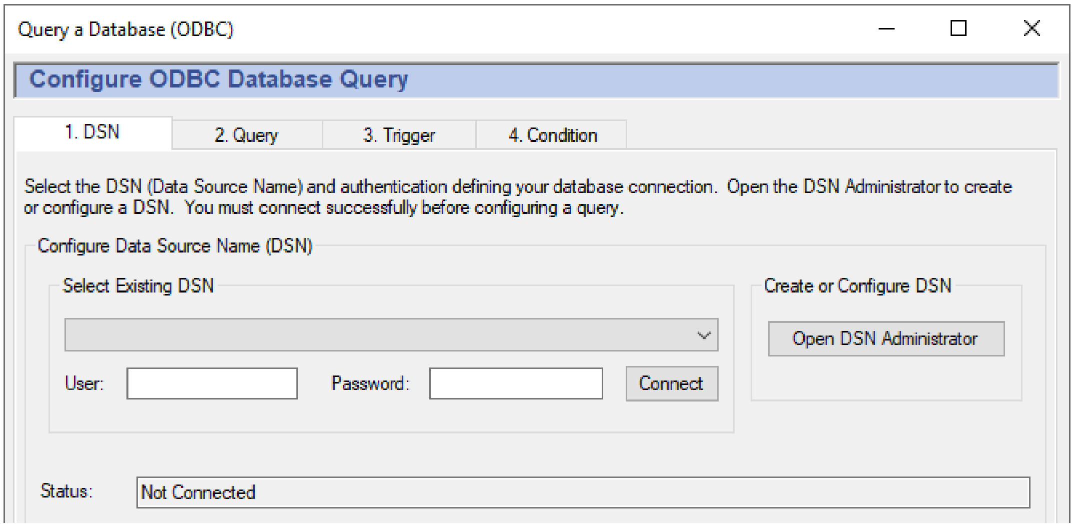
2. In the **Query a Database (ODBC)** section, click the **Configure** button.



This opens the Query a Database (ODBC) window, shown below.

Connect to the Database

1. Select the **1. DSN** tab. A *DSN* is a Data Source Name. Windows uses this name to identify the database you want to connect to.



2. From the drop-down box, select a DSN. If you do not have any DSNs, or you wish to create a new DSN, you can do this by opening the DSN Administrator. Please refer to Setting up a DSN for more details.
3. Enter the user name and password (if required), and click the **Connect** button. A "`Connected to ...`" message should appear in the message box. If you get an error message in the box, consult your system administrator.

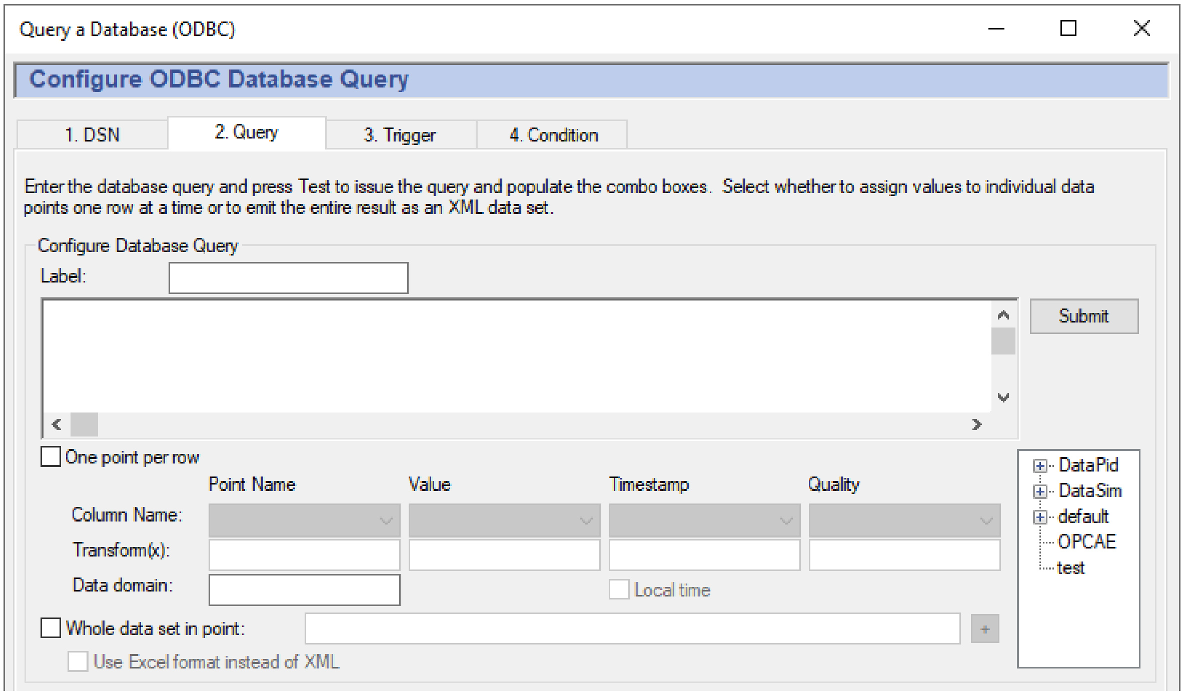
Configure a Query

For this and other queries in this chapter, we will use a simple example database named `test` with a table named `querytest` that has 4 columns and 3 rows.

ID	VariableName	VariableValue	Notes
1	Testpoint1	95	First test point
2	Testpoint2	87	Second test point
3	Testpoint3	19	Third test point

In our example, we will be writing the contents of the **VariableName** and **VariableValue** columns to the DataHub instance.

1. Select the **2. Query** tab.

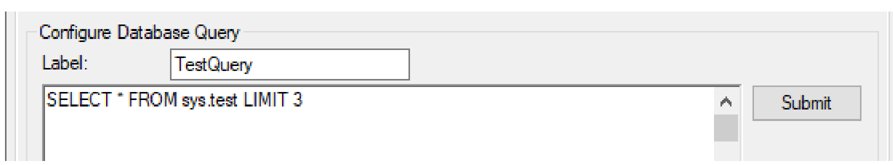


2. In the **Label:** field, enter a name for this query, such as **`TestQuery`**. This can be any string.

3. Enter a valid SQL query. As an example, for our small database, we can use a simple SQL query:

   ```
   SELECT * FROM database.table LIMIT 3;
   ```

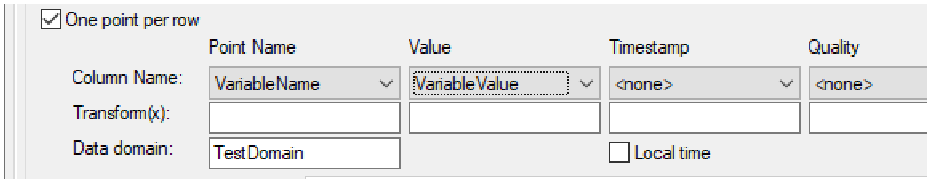
   If you use a `SELECT * FROM` query like this on a large database with a frequent timer, we recommend limiting the number of rows returned, to prevent hanging the database.



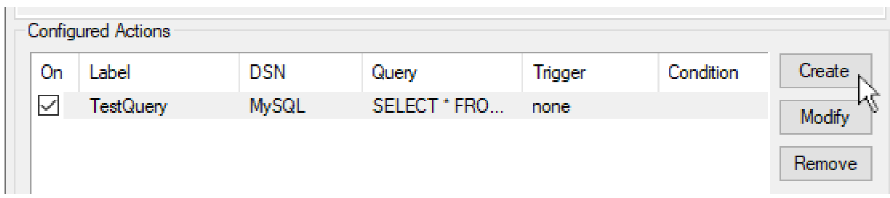
4. Press the **Submit** button to submit your query to the database for a check. If the query is not valid, a message will pop up informing you about any errors. You can also open the Script Log to see more information about your connection to the database, and the results of your query.

5. There are two options for how a query is written to the DataHub instance. Here we will introduce the **One point per row** option. For information about the **Whole data set in a point** option, please refer to the section called “Configuring a Database Query”.

   Select **One point per row**.



6. In the **Column Name / Point Name** dropdown list, choose the column name in your database that contains the point names that you will be using. For instance, in our demo database that column is named **VariableName**.
7. In the **Column Name / Value** dropdown list, choose the column name in your database that contains the values for the point names that you will be using. For instance, in our demo database that column is named **VariableValue**.
8. In the **Replace domain** field, enter the name of a new or existing domain. We've put in a name for a new domain, **TestDomain**.
9. Click the **Create** button.



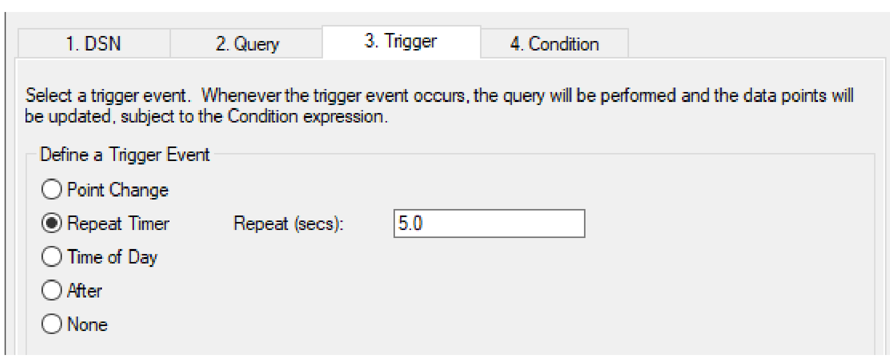
A new configured action should appear in the list. For more information about configured actions, please refer to the section called "Configured Actions"

Next, to get the DataHub instance to make the query, you need to assign a trigger.

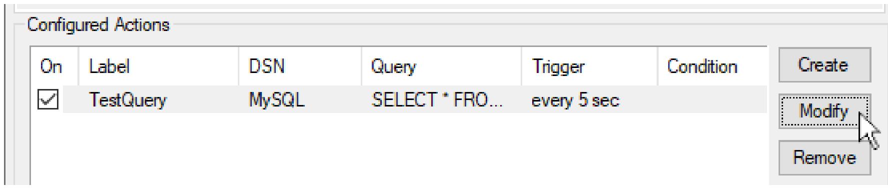
Assign a Trigger

For this example, we will set a repeat timer to re-query the database every 5 seconds.

1. Select the **3. Trigger** tab.
2. Select **Repeat Timer** and enter **5**.

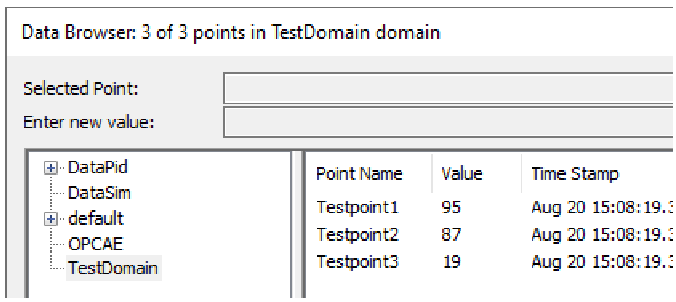


3. In the **Configured Actions** box, make sure that the configured action you just created is highlighted. If not, click on it to highlight it. Then click the **Modify** button.



Your configured action should now display **every 5 sec** in the **Trigger** column.

4. Click the **Apply** button to activate the configured action.
5. Open the Data Browser window. After 5 seconds, the points should appear in the Data Browser:



To test the updates, you can change a value associated with a point name in the database, and the change should appear in the Data Browser within 5 seconds.

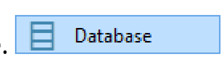
Should you not see the data points, or changes made to the values, you can open the Script Log to check for error messages and ensure that your query is being sent every 5 seconds.

If all is working as described, you have configured an action that queries a database for and writes the results into the DataHub instance. The remaining sections in this chapter explain the interface in more detail, and introduce the option of setting specific conditions for queries, if desired.

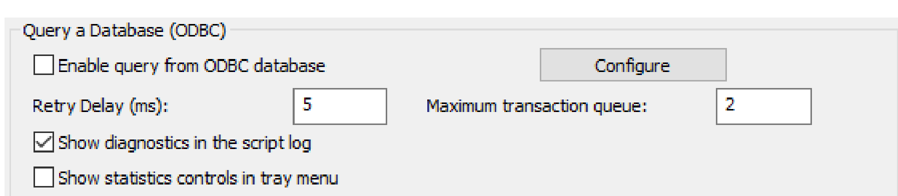
Setting up the DSN (Data Source Name)

A *DSN* is a Data Source Name. Windows uses this name to identify the database you want to connect to. This tab lets you select an existing DSN, or create a new one if necessary.

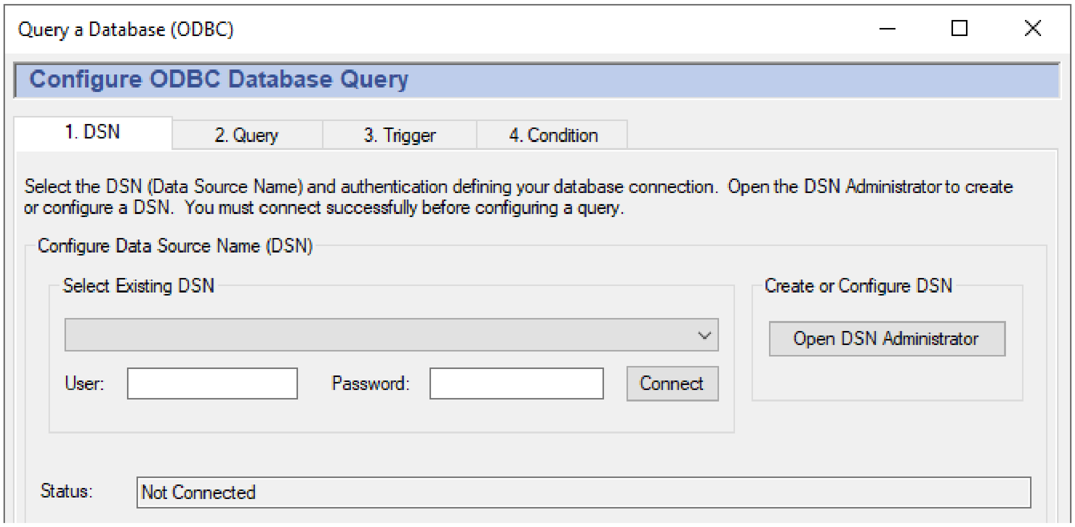
Open the Query a Database (ODBC) window

1. In the DataHub Properties window, select **Database**. 

2. In the **Query a Database (ODBC)** section click the **Configure** button.



3. Configure your DSN as explained below.



Selecting a DSN

1. To select a DSN, choose one from the drop-down box, and then enter the user name and password (if required).

   If your DSN is using Windows Authentication, leave the **User** and **Password** fields blank.

2. Click the **Connect** button. A "`Connected to ...`" message should appear in the message box. If you get an error message in the box, consult your system administrator.

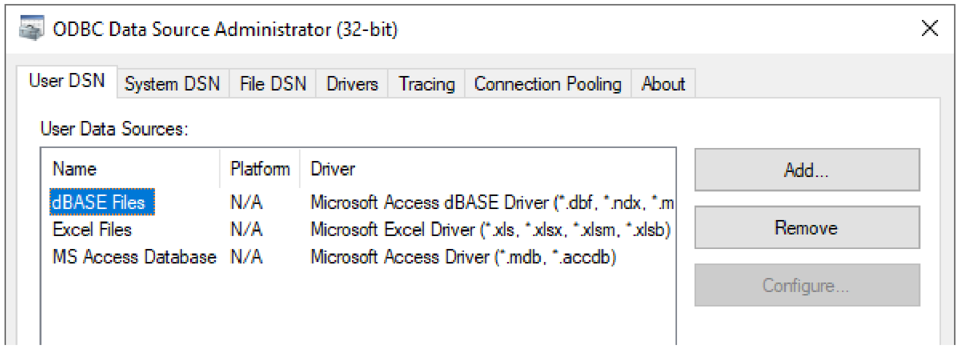
Creating or Configuring a DSN

Windows has different configuration programs for 32-bit and 64-bit DSNs. You need to use the 64-bit DSN administrator with 64-bit DataHub program, or you need to use the 32-bit DSN administrator with 32-bit DataHub program. The application name, `odbcad32.exe`, is the same for both the 32-bit version and the 64-bit version of the DSN Configuration tool. The difference is which folder it is in:

- The 32-bit version is in C:\Windows\SysWow64
- The 64-bit version is in C:\Windows\System32

Despite the apparent mismatch of folder names, those are correct. The DataHub instance will automatically choose the correct version when you select the **Open DSN Administrator** button.

1. To create or configure a DSN, click the **Open DSN Administrator** button. This opens the ODBC Data Source Administrator window.



2. Select the **User DSN** or **System DSN** tab, depending on how you plan to access your database.

   A user DSN is only available to the current user account, while a system DSN is available to any user account on the computer.

3. Now you can add a new database or configure an existing one.

   Add a new database

   1. Click the **Add** button. The Create New Data Source window will open, displaying a list of data source drivers.
   2. Select the data source driver that corresponds to your ODBC database. A data source setup window will open. Each data source setup window is different, but you should be able to find the appropriate entry fields easily enough.
   3. Enter the data source name and select the database.
   4. Enter any other required or optional information such as login name, password, etc. What entries need to be made and where they are entered depends on the particular data source setup window you are using.
   5. Click **OK** to return to the ODBC Data Source Administrator window. You should be able to see the new database and driver listed. If you need to make any changes, you can configure an exiting database, as explained below.

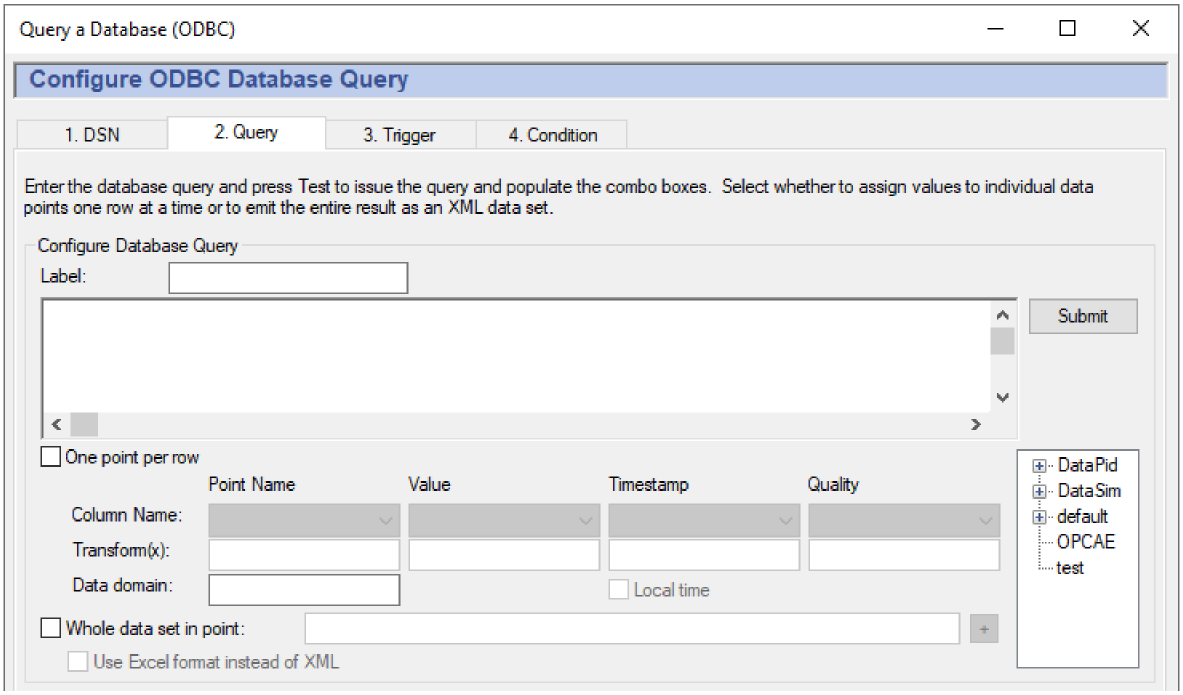
   Configure an existing database

   1. Select a data source name and click the **Configure...** button. This takes you to the data source setup window (explained above) where you can make changes to the configuration.
   2. Make your changes and click **OK** to return to the ODBC Data Source Administrator window. Any time you need to make a change, you can go to this window.

Once you have created a DSN, you can select it as explained above.

Configuring a Database Query

After you have set up a DSN you can create a database query.

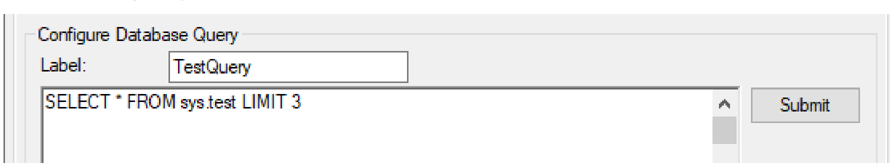


Preparing the Query

For this and other queries in this chapter, we will use a simple example database named `test` with a table named `querytest` that has 4 columns and 3 rows.

ID	VariableName	VariableValue	Notes
1	Testpoint1	95	First test point
2	Testpoint2	87	Second test point
3	Testpoint3	19	Third test point

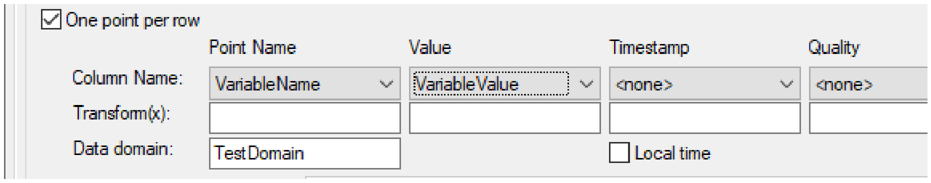
- In the **Label:** field, enter a name for this query, such as **`TestQuery`**. This can be any string.
- Enter a valid SQL query.



- The **Submit** submits your query to the database for a check. If the query is not valid, a message will pop up informing you about any errors. You can also open the Script Log to see more information about your connection to the database, and the results of your query.

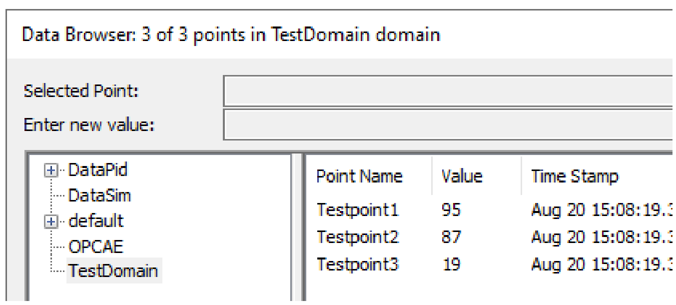
Write One Point Per Row to a DataHub Instance

- The **One point per row** option lets you assign one point in the DataHub instance for each uniquely named item in one column of a database.



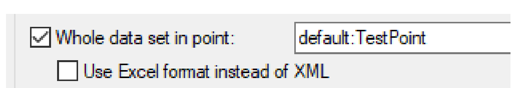
- The drop-down **Column Name** lists allow you to chose the columns that contain the point name and its value that will appear in the DataHub instance, as well as an associated time stamp and quality.
- The **Transform(x)** fields let you to perform transformations on the data in each row of the corresponding column. These transformations are written in the Gamma language, the DataHub Scripting language.

  For example, an entry of `string("MyTag", x)` under the **Point Name** would change points labelled `Pump1` and `Pump2` to `MyTagPump1` and `MyTagPump2`. Or, an entry of `10 * x` under the **Value** would multiply each value by `10`.
- The output of **One point per row** for our example database would appear in the DataHub Data Browser like this:



Put a Whole Data Set into One DataHub Point

The **Whole data set in point** option lets you put the entire results of the query into one DataHub point.



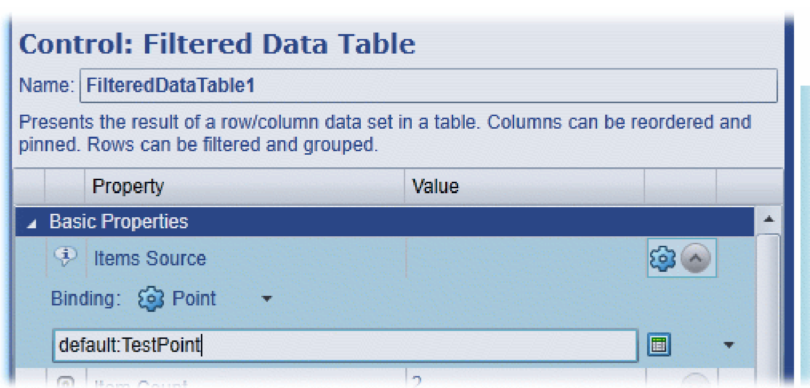
The results can be written in XML format (the default), or for Excel by selecting the **Use Excel format instead of XML** option.

For example, using the XML option, running our query of `SELECT * FROM test.querytest LIMIT 3;` on our example database would write the following XML-formatted data as the value of a single point:

```
<TableData>
  <column name="ID" type="int" datatype="-6" />
```

```
  <column name="VariableName" type="string" datatype="-9" />
  <column name="VariableValue" type="double" datatype="8" />
  <column name="Notes" type="string" datatype="-9" />
  <row>
    <ID>1</ID>
    <VariableName>Testpoint1</VariableName>
    <VariableValue>95</VariableValue>
    <Notes>First test point</Notes>
  </row>
  <row>
    <ID>2</ID>
    <VariableName>Testpoint2</VariableName>
    <VariableValue>87</VariableValue>
    <Notes>Second test point</Notes>
  </row>
  <row>
    <ID>3</ID>
    <VariableName>Testpoint3</VariableName>
    <VariableValue>19</VariableValue>
    <Notes>Third test point</Notes>
  </row>
</TableData>
```

This data can be parsed by an XML parser, and is particularly useful for displaying in the WebView application, using the WebView Filtered Data Table control. In the WebView application, you would add a Filtered Data Table to a page, and configure this point as the **Items Source**:



The data would then appear in the control:

ID	VariableName	VariableValue	Notes
1	Testpoint1	95	First test point
2	Testpoint2	87	Second test point
3	Testpoint3	19	Third test point

Page 1 of 1

The Excel output generated with the **Use Excel format instead of XML** option would look like this when dragged and dropped into an Excel worksheet:

A	B	C	D	E
	ID	VariableName	VariableValue	Notes
	1	Testpoint1	95	First test point
	2	Testpoint2	87	Second test point
	3	Testpoint3	19	Third test point

Dynamic Database Queries

It is possible to create dynamic database queries by inserting Gamma expressions into the query. The value, time, and quality attributes of the DataHub points are accessed by using the following syntax:

Button	Syntax	Example
Name	*domainname*:*pointname*	`DataSim:Sine`
Value	`<%= $`*domainname*`:`*pointname* `%>`	`<%= $DataSim:Sine %>`
Time	`<%= PointTimeString (# $`*domainname*`:`*pointname*`) %>`	`<%= PointTimeString (# $DataSim:Sine) %>`
Quality	`<%= PointQualityString (# $`*domainname*`:`*pointname*`) %>`	`<%= PointQualityString (# $DataSim:Sine) %>`

In this syntax, the special characters are used as follows:

Character	Use
`<% ... %>`	The enclosed expression will be evaluated by the Gamma engine, DataHub scripting processor.
`$`	Indicates to the Gamma engine that this is a DataHub point name.
`PointTimeString()`	A Gamma function that returns the timestamp of a DataHub point in an easily readable format.
`PointQualityString()`	A Gamma function that returns the quality of a DataHub point, as a text string.

Character	Use
#	Protects the DataHub point from being evaluated by the Gamma engine until the function is called.

The query string is processed using the "asp" Gamma processor, so you can insert any Gamma string into the query.

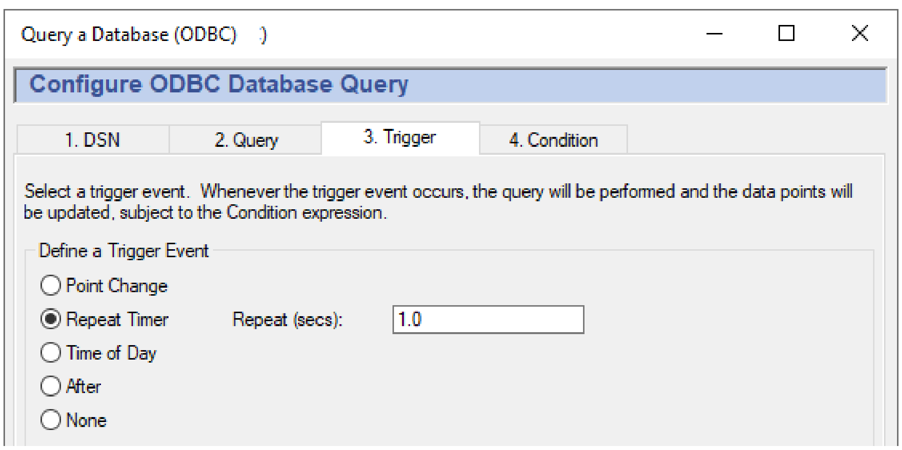
Example

A query using a selection criteria based on the point `PLC1.ResourceX` in data domain `records` would look something like this:

```
select top 1 OrderNo, from.Orders
where Resource=<%= $records:PLC1.ResourceX %>
and Priority=10 order by DueDate asc
```

Assigning a Trigger

A trigger is an event that causes your query to be sent to the database. A trigger event can be either a point value change, a repeat timer, a time of day timer, or an "after" timer. You can assign a different trigger for each query, or an identical trigger to any number of queries. A query action can be configured to execute on every trigger event, or you can assign trigger conditions that are evaluated whenever a trigger occurs, to determine if the action should be executed.



The four kinds of triggers are:

- **Point Change** fires whenever a specified trigger point changes.
  1. Type the name of the point into the **Point Name** box, or select the point using the data tree on the right, then click the **+** button.
  2. (Optional) Enter a value deadband if you want to filter out extraneous data. The number you enter will specify a high and low (plus or minus) range. Any value

change falling within that range will not cause the trigger to fire. A positive or negative change greater than this value will activate the trigger and cause the row to be written.

To create a trigger that gets reset automatically, please refer to An Auto-Resetting Trigger in the section called “Setting Trigger Conditions”.

- **Repeat Timer** fires cyclically, each time the specified number of seconds elapses.
- **Time of Day** fires at the time you specify. You can enter:
  - A number, indicating a specific value. For example, a `0` in the seconds field would cause the event only on the 0th second of the minute. A `30` would indicate only on the 30th second of the minute.
  - A list of numbers, separated by commas. For example, entering `0,15,30,45` in the minutes field would indicate that the event should fire on the hour and at 15, 30 and 45 minutes past the hour.
  - A range of numbers, separated by a dash. For example, entering `8-18` in the hours field would indicate that the event should fire every hour from 8 a.m. to 6 p.m.. Ranges can be mingled with lists, as in `0,4,8-16,20`.
  - An asterisk (`*`) indicates that the event should fire for every possible value of the field. For example, a `*` in the seconds field would cause the event to fire every second. A `*` in the hours field would cause the event to fire every hour.

To regularly log a record on specific days of the week, please refer to the section called “Setting Trigger Conditions”.

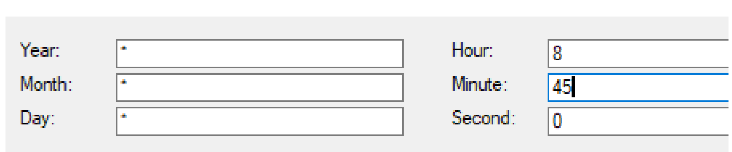
The ranges of the fields are:

Year:	`1970-*`	**Hour:**	`0-23`
Month:	`1-12`	**Minute:**	`0-59`
Day:	`1-31`	**Second:**	`0-59`

The year and month are entered differently here than for the Gamma `localtime` function, as explained in Time Conditions.

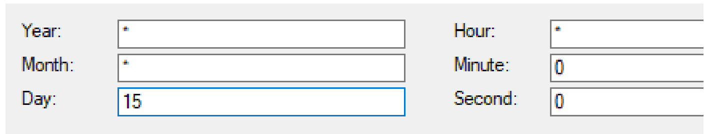
Examples:

- These entries:



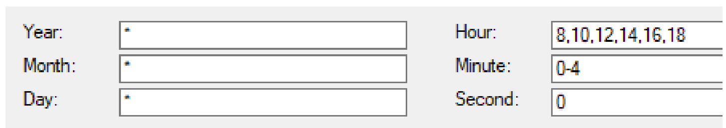
would trigger a query at 8:45 every day, every month, and every year.

- These entries:



would trigger a query every hour on the 15th day of each month, every year.

- These entries:

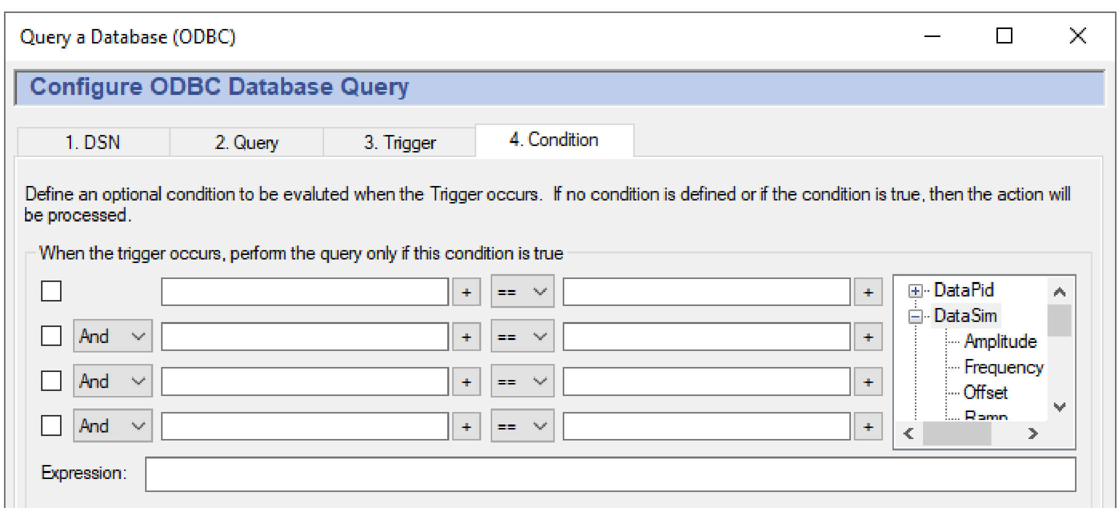


would trigger a query every second for 5 minutes, every two hours between 8 a.m. and 6 p.m.

- **After** fires once, when the specified number of seconds elapses.
- **None** configures no trigger.

Setting Trigger Conditions

Each query can have up to four conditions that determine whether it gets sent to the database when the trigger fires.



Fill in the conditions according to the guidelines below. Check the box next to the condition to apply it. As you make entries, the corresponding *Gamma* code will appear in the display. The Gamma language is the DataHub program's built-in scripting language.

The code that appears in the **Expression** box is the actual code that gets run by the Gamma engine. The order of precedence for "And" and "`Or`" operators (&& and `||`) is first And, then `Or`.

Point Value Conditions

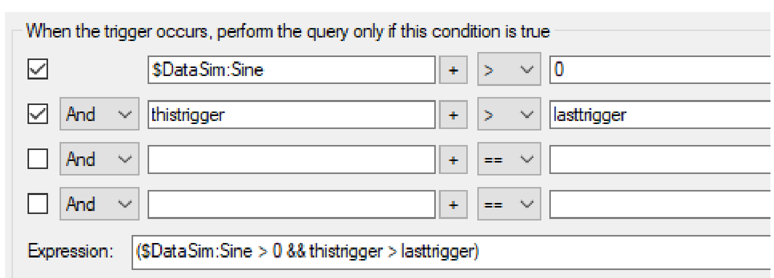
Point names can be entered on either or both sides of the comparison. They can be picked from the data tree list, or typed in. Each point name needs to have a dollar sign ($) in front of it to indicate to the Gamma engine that this is a DataHub point. You can put numerical values into either side of the comparison.

When you enter a point name in a condition field, the current value of the point will be used in the evaluation. For example, you could define a condition that states that whenever the trigger event occurs, the action will only be executed if another point value is within a certain range.

There are some automatic variables available for working with point values:

- `lasttrigger` - the value of the trigger point the last time this trigger was fired (even if the condition failed).
- `thistrigger` - the value of the trigger point now (even if the condition failed).
- `lastevent` - the value of the trigger the last time the event was actually executed (the condition succeeded).
- `this` - the trigger point itself, not the value of the point.

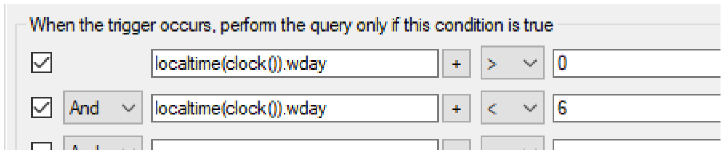
You can use these variables in any condition that is triggered by a data value change. For example, you could create some conditions like this:



Time Conditions

This provides an additional way to restrict the time, day, month, etc. when a query gets sent. In addition to the options on the triggers, here you have day-of-week condition statements which can give you more flexibility for events based on specific days of the week. These will work with any type of trigger event.

You can use the Gamma functions `clock` and `localtime` to specify particular days of the week. For example, these entries:



would create this Gamma code::

```
(localtime(clock()).wday > 0 && localtime(clock()).wday < 6)
```

which would cause a query to be sent only Monday through Friday. The function `localtime` returns a class whose members contain information about the date, as follows:

`.sec`	The number of seconds after the minute (`0` - `59`).
`.min`	The number of minutes after the hour (`0` - `59`).
`.hour`	The number of hours past midnight (`0` - `23`).
`.mday`	The day of the month (`1` - `31`).
`.mon`	The number of months since January (`0` - `11`)
`.year`	The number of years since 1900.
`.wday`	The number of days since Sunday (`0` - `6`).
`.yday`	The number of days since January 1 (`0` - `365`)
`.isdst`	`1` if daylight saving time is in effect, `0` if not, and a negative number if the information is not available.

The year and month are entered differently here than for **Time of Day** trigger conditions, as explained in the section called “Assigning a Trigger”.

There are two automatic variables available for working with time values:

- `lasteventtime` - the system clock time (UTC floating point) that the last event was executed.
- `curtime` - the system clock time (UTC floating point) when the current trigger occurred.

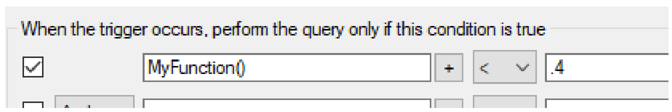
Custom Conditions

If the conditions you need to meet are beyond the scope of this interface, you can use a Gamma function to express virtually any condition you need. Then you can insert the function into one of the condition boxes, and set a condition based on the return value of the function.

To do this is you can create a DataHub script (`.g` file) that contains only the functions you will be using for conditions, without any classes or methods. For example, here is the complete contents of such a file, named `MyConditions.g`:

```
function MyFunction ()
{
    myvalue = $DataSim:Sine;
    princ("Value when the trigger fired: ", myvalue, "\n");
    myvalue;
}
```

This function prints the value of the `DataSim:Sine` point, and returns its value. We can use this function as a condition by calling it from one of the condition boxes in the interface, like this:



When the trigger fires, `MyFunction` is called, and the return value gets checked to see if it is less than `.4`. If so, the data gets logged.

Example: An Auto-Resetting Trigger

This script can turn any DataHub point into a trigger that automatically resets. To use it, you first need to load and run the `TriggerFunctions.g` script (shown below and included in the installation archive). Then, if you put this formula:

```
HighWithReset($TriggerPoint)!= nil
```

into the condition boxes, whenever the *`TriggerPoint`* changes to a non-zero number in the DataHub instance, your trigger will fire. The script waits for a millisecond, then resets the *`TriggerPoint`* back to zero. The second function works similarly, but triggers on a change to zero, instead of a change to a non-zero number.

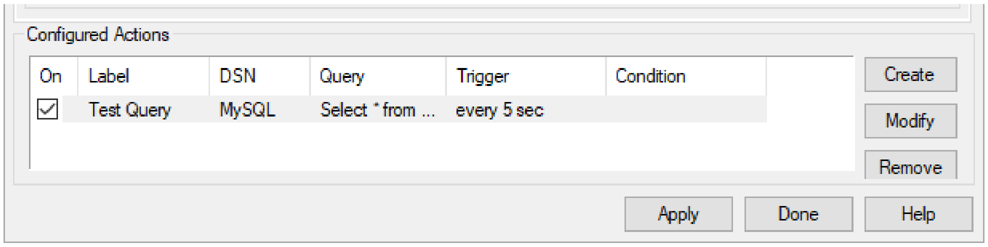
TriggerFunctions.g

```

/*
 * This file contains handy functions to perform more complex
 * condition handling in the Condition tab of the data logging
 * and email interfaces.
 */

/*
 * Test a trigger point for a non-zero value.  If the point is
 * non-zero, create a delayed event to reset the point to zero,
 * and return true, indicating that the condition has succeeded
 * and the action should proceed. If the value is 0, then simply
 * return nil indicating that the action should not proceed.  We
 * need to test for zero because when we reset the trigger point
 * to zero a second data change event will occur.
```

```
 *
 * The argument is unevaluated, so the condition should look
 * like this:
 *    HighWithReset($default:TriggerPoint) != nil
 */

function HighWithReset(!triggerpoint)
{
    local   value;
    if (!undefined_p(value = eval(triggerpoint)) && value != 0)
    {
        after(0.001, `setq(@triggerpoint, 0));
        t;
    }
    else
    {
        nil;
    }
}

/*
 * This is the inverse of HighWithReset (see above).  If the trigger
 * point is zero, perform the action and set the trigger point to 1.
 * If the trigger point is non-zero do nothing and return nil.
 */
function LowWithSet(!triggerpoint)
{
    local   value;
    if (!undefined_p(value = eval(triggerpoint)) && value == 0)
    {
        after(0.001, `setq(@triggerpoint, 1));
        t;
    }
    else
    {
        nil;
    }
}
```

Configured Actions

A *configured action* will cause your query to be sent to the database, according to the trigger and any conditions you have specified. It is the end result of your configuration activities in this interface. The **Configured Actions** list shows the actions you have configured, and allows you to create, modify, or remove actions, as well as turn them on or off.



The list of configured actions shows the actions you have already configured. Selecting an existing action from the list automatically fills in the **DSN**, **Query**, **Trigger**, and **Condition** tabs with its information. Checking or unchecking the **On** box at the left lets you switch the action on or off.

The Create button creates an action for the information currently entered in the **DSN**, **Query**, **Trigger**, and **Condition** tabs. If you press the **Create** button while a configured action is selected, it creates a duplicate of that configured action and adds it to the list. This is a quick way to configure similar actions.

The Modify button overwrites the selected configured action with the information currently entered in the **DSN**, **Query**, **Trigger**, and **Condition** tabs.

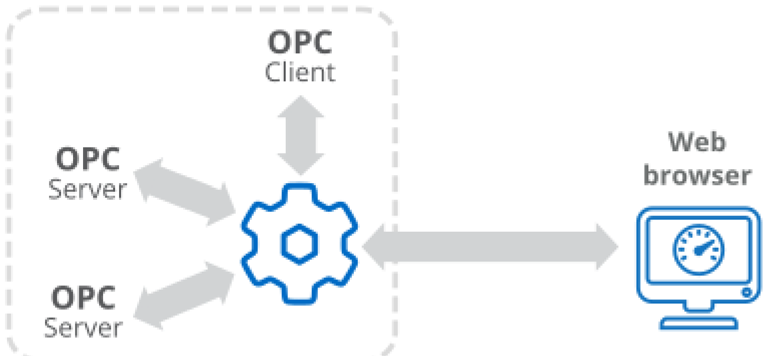
The Remove button removes a configured action.

Once a configured action has been created or modified, the changes won't take effect until you click the **Apply** or **Done** button. Each query to the database gets logged in the DataHub Script Log. This allows you to check for error messages and ensure that your query was sent successfully. You can verify the results of the query in the Data Browser.

Using the Web Server

Introduction

The DataHub program has a built-in web server that lets you display live data in a web page in several different ways, depending on your needs. The data can come from any data source that is connected to the DataHub instance. A two-way data flow allows the user to view data and also write data back to the DataHub instance.



There are several different display technologies available:

- **ASP (Active Server Pages)** DataHub scripts embedded in an HTML page are run by the DataHub instance each time the page is requested by the client. The DataHub scripts generate the page content dynamically before sending the page to the browser. This is also called "server-side scripting".
- **WebSocket** Not yet documented

Here is a comparison chart for these technologies:

	ASP	WebSocket
Web browser support	Desktop and mobile	Desktop and mobile
Plug-in/Active X required	No	No
Update speeds	No updates - Manual refresh required	Fast updates
System requirements (CPU and memory)	Low	Low
Bandwidth requirements (Will depend on point count and update rate)	Very low	Moderate to low
Security (Password / SSL protection)	Yes	Yes

	ASP	WebSocket
Firewall friendly	Yes	Yes
Licensing (Licenses required in addition to the standard DataHub Node license)	DataHub Web Server license	DataHub Web Server license, + TCP Link license for each connection
Programming Requirements	Uses DataHub scripting language	Uses HTML or JavaScript
Types of Application Common uses	Good for displaying static or slow moving data. Used for shift reports and statistics.	Not yet documented.

These different display technologies can be used together in the same page. For example, you can use ASP to access data from an ODBC database and display it as part of the web page, along with the live data from the DataHub instance.

More about ASP

- Most process data does not update very quickly, so ASP is suitable for a wide range of applications.
- ASP will typically use very few system resources and bandwidth, so it is good for low speed connections.
- ASP is the most efficient method for handling a large number of user connections.
- ASP pages are generated by a script running in the DataHub instance. This means you can use the script to bring in data from other sources, such as from SQL databases. The web page can then display data from both live sources and database or text file archives.
- Web pages that are generated by ASP scripts can usually be displayed on all desktop and mobile web browsers. This is because while the scripts themselves are written in the Gamma language (the DataHub script language), the web pages they generate are delivered as plain HTML.
- In order to see new point values in an ASP page, you need to refresh the web page manually.

More about WebSocket

- Not yet documented.
- Not yet documented.
- Not yet documented.

Configuring the DataHub Web Server

To configure the DataHub Web Server, follow these steps:

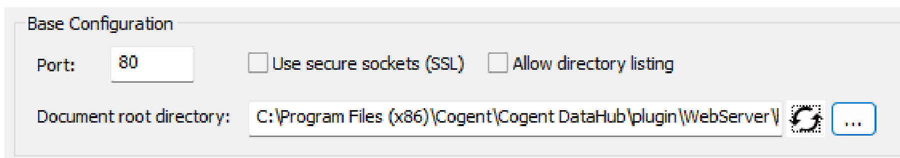
1. With a DataHub instance running, right click on the DataHub system-tray icon and

choose **Properties**.

2. In the Properties window, select **Web Server** .

3. Check the **Act as web server** box.

4. The DataHub Web Server is preconfigured to run on port number 80, but you might need to change that setting in the **Base Configuration** section:



When using the DataHub Web Server to support WebSocket connections, we recommend using SSL.

When using SSL, we recommend using port 443.

Windows allows multiple users on a single TCP port, and never refuses a connection. However, this can cause irregular behavior. It is essential that the DataHub Web Server be the exclusive user of a port.

To get a list of which ports are in use on your machine, follow these steps:

a. From the Windows **Start** menu, choose **Run**.

b. Enter the executable name **`cmd.exe`** and click **OK**.

c. At the command prompt, type:

```
netstat -p tcp -b -a -n
```

```
C:\Documents and Settings\Bill>netstat -p tcp -b -a -n

Active Connections

  Proto  Local Address          Foreign Address        State           PID
  TCP    0.0.0.0:135            0.0.0.0:0              LISTENING       1188
  [svchost.exe]

  TCP    0.0.0.0:445            0.0.0.0:0              LISTENING       4
  [System]

  TCP    0.0.0.0:1723           0.0.0.0:0              LISTENING       4
  [System]

  TCP    0.0.0.0:27203          0.0.0.0:0              LISTENING       1112
  [Skype.exe]

  TCP    192.168.1.102:139      0.0.0.0:0              ESTABLISHED     4
  [System]

  TCP    127.0.0.1:1148         127.0.0.1:1149         ESTABLISHED     2712
  [thunderbird.exe]
```

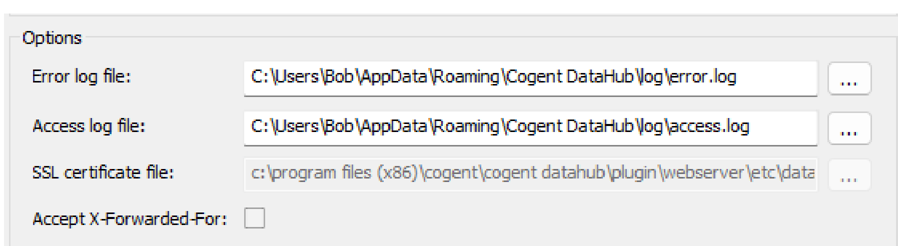
The result is a table showing the tcp protocol and executable name of all programs in use. There are two columns of interest: `Local Address` and `State`. In `Local Address`, the numbers at the end (after the colon) are the port number that the process is using. The `State` column shows the state of that process. The only state we are interested in is `LISTENING`. Whatever port you are using for the DataHub Web Server, it should be the only process on that port.

If you have one or more programs established or listening on the same port as the DataHub instance, you have two choices:

- Change the port number for the DataHub Web Server (as illustrated above), or
- Change the port number for every other program that is using that port.

Port numbers `1` through `1024` are reserved. Port `80`, for example, is reserved for HTTP, which is why we make it the default for the DataHub Web Server. If you change the DataHub Web Server from port `80`, we suggest setting it to a number between `1025` and `65535`.

5. Configure any desired options, according to these guidelines:



Error log file:

The path and name of the file where errors are logged.

Access log file:

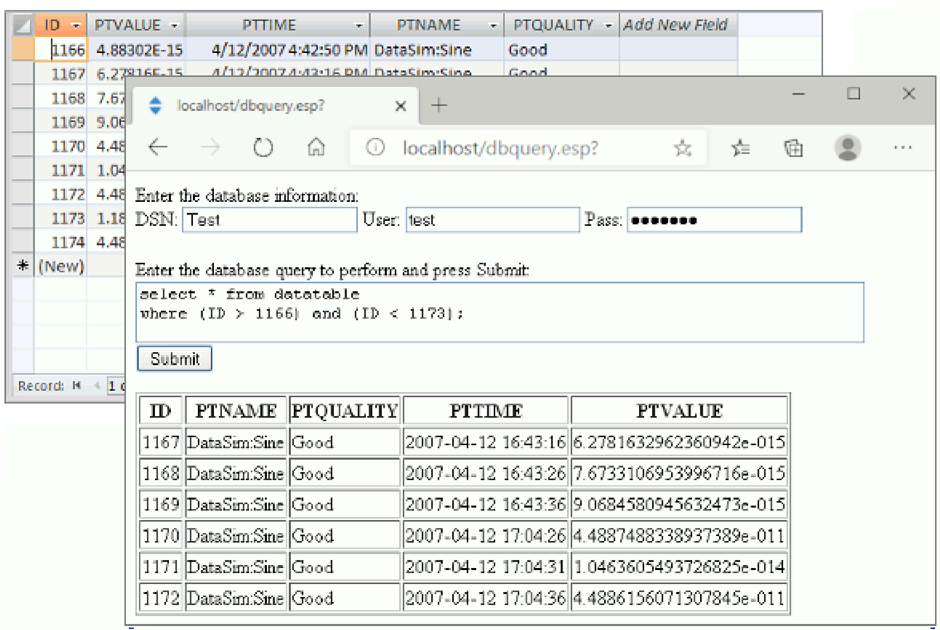
The path and name of the file where access attempts, successes, and failures are logged.

SSL certificate file:

The path and name of the certificate file used for secure sockets (SSL). Please see SSL Certificates for more information about SSL certificates in the DataHub program.

Using ASP to Query a Database and Display Results

Using DataHub program's ODBC scripting functionality, it is possible to send an SQL query from a web page to a database, and view the results in the page. The `dbquery.asp` demo page included in the DataHub distribution gives an example of how this is done. With a DataHub instance running on your local machine, you can view this page by typing `localhost/dbquery.asp` into your web browser:



You simply enter a DSN, user name, and password (if any) for the database, and an SQL query. When you press the **Submit** button, the page sends the query to the DataHub instance, which passes the query to the database, and returns the results, displaying them in the table on this page.

The source file for this page is included with all the other ASP files here in your DataHub distribution:

```
C:\Program Files (x86)\Cogent\Cogent DataHub\Plugin\Webserver\
html\dbquery.asp
C:\Program Files\Cogent\Cogent DataHub\Plugin\Webserver\
html\dbquery.asp
```

Here is a copy of the page source:

```
<html>
<head>
<%
/*
 * This file presents an entry form for the user to specify a
 * DSN, user name, password and SQL query to be executed by the
 * DataHub.  The result is displayed as a table in the user's
 * browser.
 *
 * Normally, the DSN, user name and password would be hard-coded
 * into the Gamma portion of this ASP file.  The ASP file is
 * stored on the server running the DataHub, and all Gamma code
 * is stripped from the file and executed before the result is
 * returned to the user.  Therefore the DSN, user name and
 * password are never transmitted across the network to the user.
 */

require ("AJAXSupport");
require ("ODBCSupport");

local cmpfn, getArg, sortfn;

/* Set up some function for quickly accessing the URL arguments */
function cmpfn(x,y) { strcmp(x[0],y); }
function sortfn(x,y) { strcmp(x[0],y[0]); }
function getArg(name, dflt)
{
    local    arg = bsearch(_vars, name, cmpfn);
    if (arg && !undefined_p(car(arg)))
        arg = car(arg)[1];
    else
        arg = dflt;
    arg;
}
_vars = sort(_vars,sortfn);

/* Read the input URL arguments */
local DSN = getArg("DSN","Enter DSN");
local Password = getArg("Password","Enter Password");
local Username = getArg("Username","Enter Username");
local Query = getArg("Query","");

/* Connect to the database */
local env, conn, Connect, DoQuery;

function Connect ()
```

```
{
    local   ret;

    /* Create the ODBC environment and connection */
    env = ODBC_AllocEnvironment();
    conn = env.AllocConnection();

    /* Attempt the connection. */
    ret = conn.Connect (DSN, Username, Password);
    if (ret != SQL_SUCCESS && ret != SQL_SUCCESS_WITH_INFO)
        error (conn.GetDiagRec());
}

function DoQuery()
{
    local    result = conn.QueryToTempClass(nil, Query);
}

%>
</head>

<body>

Enter the database information:
<form>
DSN: <input type="text"
      id="DSN" name="DSN" value="<%= DSN %>">
User: <input type="text"
       id="Username" name="Username" value="<%= Username %>">
Pass: <input type="password"
       id="Password" name="Password" value="<%= Password %>">
<br>
<br>
Enter the database query to perform and press Submit:
<br>
<textarea name="Query" wrap="logical" rows="10" cols="80">
<%= Query %></textarea>
<br>
<input type="submit" id="Submit" value="Submit">
</form>

<%
try {
if (Query != "")
{
    Connect();
```

```
    local result = DoQuery();
    if (!result || length(result) == 0)
    {
    }
    else
    {
        local first = result[0];
        %> <div style="overflow: auto; width: 660; height: 300"> <%
        %> <table border="1"> <%
        %> <tr> <%
        with var in instance_vars(first) do
        {
            %> <th><%= car(var) %></th> <%
        }
        %> </tr> <%
        with row in result do
        {
            %> <tr> <%
            with var in instance_vars(row) do
            {
                %> <td><%= cdr(var) %></td> <%
            }
            %> </tr> <%
        }
        %> </table> <%
        %> </div> <%
    }
}
} catch {
%>
    A problem occurred while running server-side scripts
 on this page:<br>
    <%= _last_error_ %>
<%
}

/* Do a little cleanup.  The garbage collector would eventually
   get to this, but we can be kind and unwind. */
if (conn)
{
    conn.Disconnect();
    destroy (conn);
}
if (env)
    destroy (env);
```

```
%>

</body>
</html>
```

Connecting Browser Applications

Web applications can acquire real-time information from the DataHub Web Server using two methods:

- **HTTP requests to ASP documents** are used to poll data relatively infrequently.
- **WebSocket connections** are used to acquire real-time data at high speed with low latency

ASP Document Requests

An ASP document is a primarily static document with script snippets embedded within it using a special syntax:

- **<%= expression %>** (With an = sign) Evaluates the expression and inserts the result as a string into the output document, replacing all characters from the opening <%= to the closing %>. The expression is not a complete statement and must not end with a semicolon character or other statement completion syntax. For example, `3 + 2` is an expression. `x = 3 + 2;` is a statement.
- **<% statement or fragment %>** (Without an = sign) Evaluates the statements within the delimiters, and deletes all characters in the output document from the opening <% to the closing %>. The code within the delimiters does not need to be a complete statement. A single statement could be split across multiple occurrences of the `<% %>` pair. This allows you to, for example, create a loop that mixes literal text with computed values by breaking the opening and closing braces of the loop body across multiple `<% %>` regions. The concatenation of all statements and statement fragments must form a syntactically correct script.
- **All other characters** All characters, including white space, not contained within `<%= %>` or `<% %>` pairs are treated as literal text and simply copied to the output document.

When an ASP document is evaluated, all code within the special delimiters is evaluated to construct the output document. This document is then returned to the originator of the HTTP request.

ASP scripts run in the same global context as all other Gamma scripts, meaning that they have full access to other functions and scripts you define. It also means that a long-running script within an ASP page will delay other scripts. It is a good idea to keep the run-time of ASP scripts low.

The resulting output from an ASP document does not need to be valid HTML. It could be JSON, XML, plain text, or any text format that the client application requires.

Place your ASP documents in the folder `{config}\WebContent` or one of its sub-folders, where `{config}` indicates the folder containing your DataHub instance configuration, and `WebContent` will be treated as the root of the HTML file system.

ASP documents must be named with a `.asp` extension.

WebSocket Connections

A WebSocket is a persistent TCP connection between the browser page and the DataHub data engine. It uses the DHTP command set, giving it similar performance characteristics to a DataHub tunnel. The result is that the web page can interact with the DataHub data at high speeds with very low latencies.

A WebSocket connection requires you to write some JavaScript in your web page to create and maintain the connection to a DataHub instance. The DataHub installation contains some JavaScript files to help with this:

- `/scripts/DHWebSocket.js`
- `/scripts/lispparse.js`

These files are located here (32-bit and 64-bit versions):

```
C:\Program Files (x86)\Cogent\Cogent DataHub\Plugin\WebServer\html\
                                                                  scripts
C:\Program Files\Cogent\Cogent DataHub\Plugin\WebServer\html\scripts
```

Load these two files using `<script/>` tags in your HTML file. They provide the WebSocket implementation and the message parser respectively.

The WebSocket connection is asynchronous, meaning that your JavaScript page will send messages due to events on the page, typically user interactions, timers, or changes to the connection state, and will not wait for a response to those messages. Similarly, messages from the DataHub server will arrive at any time. Your JavaScript code is therefore designed as a collection of event handlers that respond to different events from the connection or from the web page.

A typical implementation of a WebSocket connection to the DataHub server looks like this:

- Add the two JavaScript references as listed above.
- Create a `<script>` tag that contains the initialization for the WebSocket.
  - Create a new `DataHubWebSocket()`.
  - Optionally set a user name and password.
  - Optionally set a connection heartbeat and timeout.
  - Define callbacks for connection events:
    - `onConnectionSuccess`
    - `onConnectionFailure`
  - Define handlers for data point change events:

    - `addPointHandler`
- Start the background connection loop:
    - `connect(host, port, isSSL)`

Once the connection callbacks and data point change event handlers are defined, the `DataHubWebSocket` implementation will trigger them based on events on the connection or the arrival of data from the DataHub server.

The `DataHubWebSocket` class

`send (string)`

Transmits a LISP-formatted command to the DataHub server. Any command listed in the DataHub command set can be transmitted, so long as the user connecting on this WebSocket has sufficient permission to execute it. For example:

```
ws.send("(cset \"DataPid:PID1.Sp\"50)");
```

`setAuth(username, password)`

Sets the user name and password to be used to authenticate on this connection. This will automatically be sent to the server when the connection is first established. Note that the password is transmitted in plain text, so it is advisable to use an HTTPS connection. For example:

```
ws.setAuth("admin", "admin");
```

`setHeartbeat(heartbeat, timeout)`

Sets the heartbeat and timeout of the connection in milliseconds. Setting both of these to zero will disable the heartbeat. If the heartbeat is disabled it could take a long time to detect some kinds of connectivity failure. The heartbeat should be less than half the timeout. For example:

```
ws.setHeartbeat(5000,15000);
```

`connect(hostname, port, is_ssl)`

Starts the connection process. The connection process continues in the background after this call, and is not complete until either `onConnectionSuccess` or `onConnectionFailure` is called. If the connection fails it will automatically re-try every 5 seconds. For example:

```
ws.connect(location.hostname, location.port,
           location.protocol == "https:");
```

`disconnect()`

Terminates the WebSocket connection and stops the 5-second re-try timer. The `DataHubWebSocket` will not attempt to connect again until connect() is called again. For example:

```
ws.disconnect();
```

`addPointHandler(pointName, handlerFunction)`

Adds a function to the point change handler table for the specified point name. The universal point name, `*`, indicates all points. If multiple handlers are defined for a point then all handlers will be called each time the value of the point changes. If a universal handler is defined, it will be called in addition to any specific handlers. The universal handler is called after all specific handlers complete.

The handler function is a JavaScript function accepting a single argument. The argument is an array of the tokens from a `(point)` message, which contains the same tokens as the `(write)` message. All tokens are delivered as strings, and should be converted to numbers where appropriate. For example:

```
ws.addPointHandler("DataPid:PID1.Sp", function(tokens)
{
    console.log (tokens[1] + " = " + tokens[3]);
});
```

`removePointHandler(pointName, handlerFunction)`

Removes a point value change handler from the handler table. The `handlerFunction` must compare as equal (using == comparison) to the `handlerFunction` originally provided to `addPointHandler`.

`registerPoint(pointName)`

Sends a message to the DataHub server to register to be notified of value changes for this point. The point name must be fully qualified, including the domain: prefix. If the WebSocket is not currently connected, the point name will be stored, and it will automatically be registered when the connection is subsequently established. If the point is already registered, this call is ignored. For example:

```
ws.registerPoint("DataPid:PID1.Mv");
```

`registerDomain(domainName, onceOnly)`

Sends a message to the DataHub server to register to be notified for all points in a data domain. If *`onceOnly`* is true, the domain is registered such that exactly one value message will be transmitted for each point. If a new point is added to the domain after this call is made, that point will be automatically registered. If *`onceOnly`* is false, the DataHub server will transmit the current values of all points immediately, and then transmit any subsequent value changes for each point until the connection is lost or the point is unregistered. If the domain is already registered, this call is ignored. For example:

```
e.g., ws.registerDomain("DataPid", false);
```

`unregisterPoint(pointName)`

Sends a message to the DataHub server indicating that it should not transmit value change notifications for this point. If the point is not currently registered then this call does nothing. For example:

```
ws.unregisterPoint("DataPid:PID1.Mv");
```

`unregisterDomain(domainName)`

Sends a message to the DataHub server indicating that it should not transmit value change notifications for any point in this data domain. For example:

```
ws.unregisterDomain("DataPid");
```

`escaped(string, isQuoted)`

Adds escape sequences to the provided string such that it can be correctly parsed by the DataHub server. If *`isQuoted`* is true, the returned string will start and end with double-quote characters. If *isQuoted* is false, the caller is responsible for adding the double-quote characters to the message being sent to the DataHub server. For example:

```
ws.escaped('The dog said "woof"!', false) > The dog said \"woof\"!
ws.escaped('The dog said "woof"!', true) > "The dog said \"woof\"!"
```

`ISOlocaltimeStr(date)`, `ISOlocaldateStr(date)`, `ISOlocalDTstr(date)`

Accepts an argument of type Date, and returns a string representing the ISO-formatted time string, date string, and date+time string respectively representing the local time representation of the provided date. For example:

```
ws.ISOlocaltimeStr(new Date()) > '09:41:02'
ws.ISOlocaldateStr(new Date()) > '2021-10-26'
ws.ISOlocalDTstr(new Date()) > '2021-10-26 09:41:02'
```

`StampTime(seconds)`

Accepts a floating point number of seconds in the Unix epoch (seconds since January 1, 1970) and returns a the local ISO time representation with millisecond accuracy. For example:

```
ws.StampTime(Date.now()/1000.0) # '09:41:02.452'
```

The `DataHubWebSocket` class exposes an array called `handlers` that allows you to define custom code that will run when any command message arrives from the DataHub server. By default, two handlers are defined, for `point` and echo messages respectively. You can replace these with your own handlers if you do not want to use the default point handling mechanism.

A command handler is a function taking a single argument. The argument is an array of the tokens in the command produced by parsing the incoming string. The first token in the array is the name of the command.

To add a custom event handler for any message, assign a function to `handlers[command]`. For example, to add a custom handler for a `(domains name1 name2)` message arriving from the DataHub server, do:

```
ws.handlers["domains"] = function (data) { /* do something */ };
```

A handler can be disabled by setting its function to null.

Complete web page example: WebSocketApp.html

```
<html>
  <head>
    <title>Simple WebSocket connection to DataHub</title>
    <!-- These two scripts are necessary to make a WebSocket
    connection to the DataHub server -->
    <script src="/scripts/DHWebSocket.js"></script>
    <script src="/scripts/lispparse.js"></script>
  </head>
```

```
<body>
  <h1>Simple WebSocket connection to DataHub</h1>
  <h3>Connection messages:</h3>
  <div id="connlog"></div>
  <h3>Data Values:</h3>
  <div id="datalog"></div>
  <script>
  // Collect a user name and password somehow from
  // the user, if necessary.
  var username = "";
  var password = "";

  ws = new DataHubWebSocket();
  ws.setAuth(username, password);
  ws.setHeartbeat(5000, 30000);

  // This function will be called if the connection succeeds.
  // It will be called every time the connection is established or
  // re-established after a connection loss. You should treat all
  // connections as being fresh - the DataHub server will not
  // maintain state after a connection loss.  This means that any
  // data point  registrations and other setup commands must be
  // re-transmitted each time.
  ws.onConnectionSuccess = function (host, port)
  {
      logConnection("Connection succeeded");

      // This code will register for the current values of all
      // points in the DataPid domain, but not for future changes.
      ws.registerDomain("DataPid", true);

      // Request a list of all data domains.  The return will be
      // handled in the handler for the response message,
      // (domains domain1 domain2 ...)
      ws.send("(domains)");
  }

  // This function will be called each time a connection attempt
  // fails, and each time that a previously  successful connection
  // is disconnected.
  ws.onConnectionFailure = function (host, port)
  {
      logConnection("Connection failed to "
                    + host + ":" + port);
  }
```

```
// During onConnectionSuccess above we sent a (domains)
// command.  This handles the response when it arrives.
ws.handlers[ "domains"] = function (data)
{
    logConnection("Domains: " + data);

    // This code will register for point changes from all
    // domains, including all newly created points and
    // all new values of every point as they change.
    for (var i = 1; i < data.length; i++)
    {
        ws.registerDomain(data[i], false);
    }
}

// When a message arrives and does not have a specific handler,
// it will execute the special AsyncMessage handler instead.
ws.handlers[ "AsyncMessage"] = function (data)
{
    logConnection("AsyncMessage: " + data);
}

// Ignore (alive) messages.  They are produced when the
// connection is idle and a heartbeat time has been set.
ws.handlers[ "alive"] = function (data)
{
    logConnection("Received alive message");
};

// Create a point change handler that logs the point value.
function pointHandler (data)
{
    logData("Point: " + data);
}

// Add the point change handler to all points.  We could use a
// fully-qualified point name (like "DataPid:PID.Mv") instead
// of "*" here to call the above handler only for that point.
// If there is a "*" handler it will be also be called after
// any point-specific handlers.
ws.addPointHandler("*", pointHandler);

// Logging functions that distinguish connection messages
// from data value messages.  They limit the size of the
// message history to 4096 bytes.
```

```
    var maxMessageSize = 4096;

    function log(elementId, message)
    {
        var logTag = document.getElementById(elementId);
        var str = logTag.innerHTML;

        str += "[" + ws.StampTime(Date.now() / 1000) +
               "] " + message + "<br/>\n";
        if (str.length > maxMessageSize)
        {
            var pos = str.indexOf("\n", str.length - maxMessageSize);
            str = str.substring(pos);
        }
        logTag.innerHTML = str;
    }

    function logConnection(message)
    {
        log("connlog", message);
    }

    function logData(message)
    {
        log("datalog", message);
    }

    // Finally, start the connection process.  The connection is not
    // actually made during this call.  Instead an asynchronous con-
    // nection attempt is made, and we will be notified of its success
    // or failure in onConnectionSuccess or onConnectionFailure.
    ws.connect(location.hostname, location.port,
               location.protocol == "https:");
    </script>
  </body>
</html>
```

ASP File Locations

As a security precaution, ASP files can only be loaded from specific base URL locations. You can add more URL paths as necessary. By default, ASP pages can only be loaded from the following URL locations:

```
/
/PointList
```

These are URL paths, not file system paths. URL paths are determined relative to the document root path. In the DataHub program, there are in fact two document roots, the Web Server root and the user content root. The Web Server root contains files that are typically common to all DataHub instances, and the user content root contains user-generated content for a particular DataHub instance. If an identically named document exists in both roots, the document in the user content root will take precedence.

Web Server Document Root

The Web Server document root is defined in the DataHub Web Server properties dialog. This is normally the `html` folder within the DataHub installation folder. The files in this folder are not intended to be modified by the user. If you re-install the DataHub program, it will overwrite files in this folder.

The default Web Server root for 32-bit DataHub installations is:

```
C:\Program Files (x86)\Cogent\Cogent DataHub\plugin\WebServer\html\
```

The default Web Server root for 64-bit DataHub program installations is:

```
C:\Program Files\Cogent\Cogent DataHub\plugin\WebServer\html\
```

This default path can be reconfigured in the Properties window Web Server option, if desired.

The ASP file locations are folders named after one of the URL paths, appended to the document root. For example, in the 64-bit DataHub program, the installed ASP files are located relative to the Web Server document root:

```
C:\Program Files\Cogent\Cogent DataHub\plugin\WebServer\html\
C:\Program Files\Cogent\Cogent DataHub\plugin\WebServer\html\PointList
```

User Content Document Root

There is a second document root for user-created content. This root is the `WebContent` folder, located in the DataHub configuration folder, here by default:

```
C:\Users\UserName\AppData\Roaming\Cogent DataHub\WebContent\
```

User-created ASP files must go into one of the folders named after a URL path, appended to this root:

```
C:\Users\UserName\AppData\Roaming\Cogent DataHub\WebContent\
C:\Users\UserName\AppData\Roaming\Cogent DataHub\WebContent\PointList
```

You can change the default DataHub configuration folder using the `-H` command-line option, or by setting it through the DataHub Service Manager application. If you make that change, you must also move all user-created ASP files to correctly-named folders in the new configuration folder.

Adding ASP folders

You can add ASP folders by adding URL paths to the three in the list above. This is done by hand-editing the `plugin_AspHandler.cfg` file in your DataHub configuration folder. Just copy any `UrlRule` line and modify the `BasePath` to the path that you want to serve ASP pages from.

If you do not find the `plugin_AspHandler.cfg` file, you can create one, using this content as the starting point:

```
<?xml version="1.0" encoding="utf-8"?>
<AspHandlerSettings xmlns:xsd="http://www.w3.org/2001/XMLSchema"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <UrlRule BasePath="/" IncludeSubdirs="false"
     ByOrganization="false" RuleResult="Allow" />
    <UrlRule BasePath="/PointList" IncludeSubdirs="false"
     ByOrganization="false" RuleResult="Allow" />
</AspHandlerSettings>
```

When you add a new `UrlRule` to this file, it will allow ASP pages to be loaded from an identically named folder in either of the two roots: the Web Server document root, or the user content document root.

Using MQTT

MQTT is a publish/subscribe messaging protocol. It allows data sources and users called *clients* to connect to a server called a *broker*, and exchange their data through it. Clients can act as both publishers and subscribers simultaneously. The DataHub program provides both MQTT client and MQTT broker functionality.

Because it is a messaging protocol, MQTT is different from a data communications protocol. MQTT acts as a data transport layer, similar to TCP, but it does not specify a particular format for the data payload. The message format is specified by a client when it connects. Any clients that want to connect to each other must use the same message format. The broker, of course, must also use that same message format.

Connecting Incoming MQTT Clients

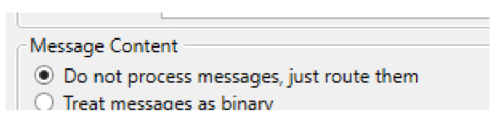
The DataHub MQTT Broker offers two modes of operation: standard and gateway.

You must allow Remote Connections in Security for any incoming connections over the network.

Standard MQTT Broker Mode

In standard MQTT broker mode the DataHub MQTT Broker simply passes messages from one client to another, and the messages remain completely independent of the DataHub program's data set.

To configure the DataHub MQTT Broker as a stand-alone broker, simply select the **Do not process messages, just route them** option in the **Message Content** section of the MQTT Broker configuration.



Gateway Broker Mode

In gateway mode you can integrate MQTT messages with the DataHub data set, as normal DataHub data points. Here is how you configure a DataHub instance for each of these modes. There are three options for gateway mode:

- **Binary** messages are Base-64 encoded and stored in DataHub points as strings.
- **Text** messages are interpreted as UTF-8 text stored in DataHub points as strings.
- **JSON** messages get interpreted by the DataHub instance as data point values that can have associated quality, timestamps, and so on.

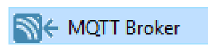
For more information about these options, please refer to Message Content for the MQTT Broker.

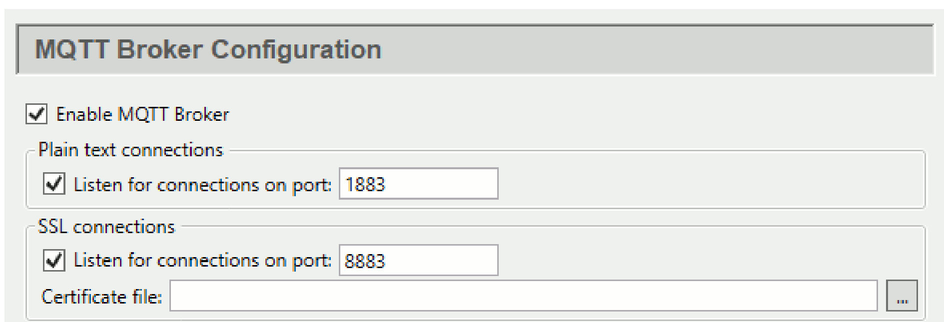
Changing the JSON client message format

The DataHub MQTT Broker's default JSON message format looks like this:

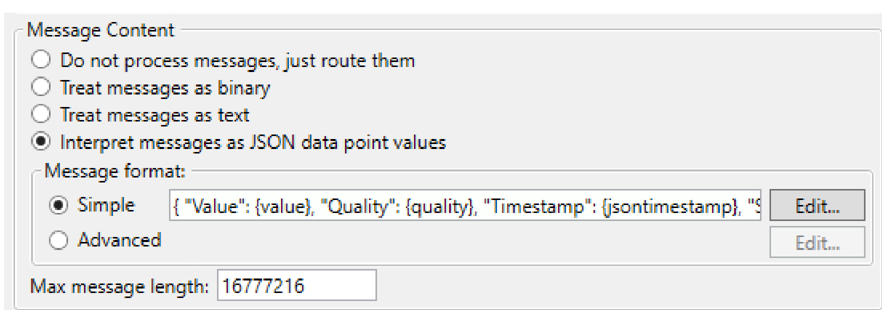
```
{ "Value": {value}, "Quality": {quality},
"Timestamp": {jsontimestamp}, "SenderId": {sender} }
```

This JSON format allows the DataHub instance to assign an MQTT topic to a data point, and send or receive a value, quality, timestamp, and sender ID for that point. To connect a client that uses a different JSON message format, you need to change this default format for that client's format, as follows:

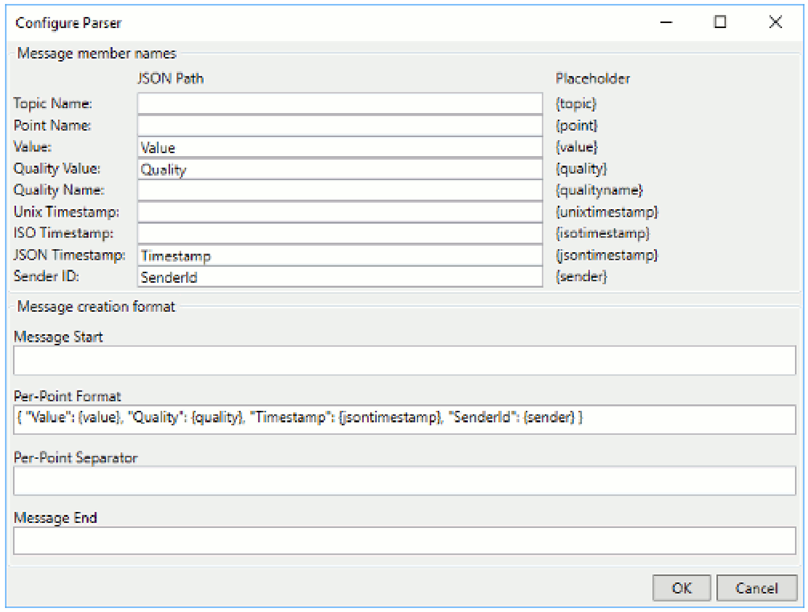
1. With a DataHub instance running, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **MQTT Broker**. 



3. In the Message Content section ...



press the **Edit** button to open the Configure Parser window:



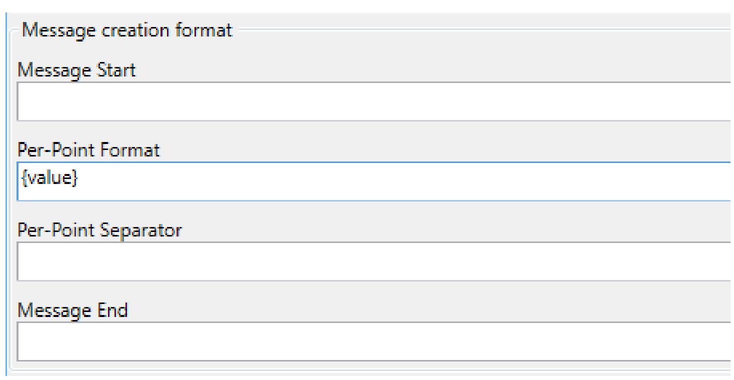
If you know the client message format

1. In the **Per-Point Format** field, enter your MQTT client message format.
2. Click **OK** and then **Apply** to save your settings.
3. Make any other desired changes to the MQTT Broker configuration as described in the section called “MQTT Broker”.

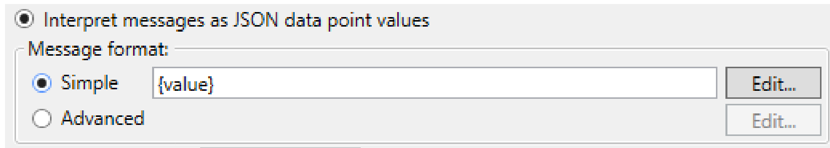
The DataHub MQTT Broker is now configured for your MQTT client.

If you want to accept any client message

1. In the **Per-Point Format** field enter just the string: `{value}`.



2. Delete any entries in the **Message Start**, **Per-Point Separator**, and **Message End** fields.
3. Click **OK** and then **Apply** to save your settings. Your **Message format** should now look like this:



Now the DataHub instance will accept any client message, parsing it as follows:

- Numbers without decimal points become integer values.
- Numbers with decimal points become real values.
- Everything else becomes a text string.

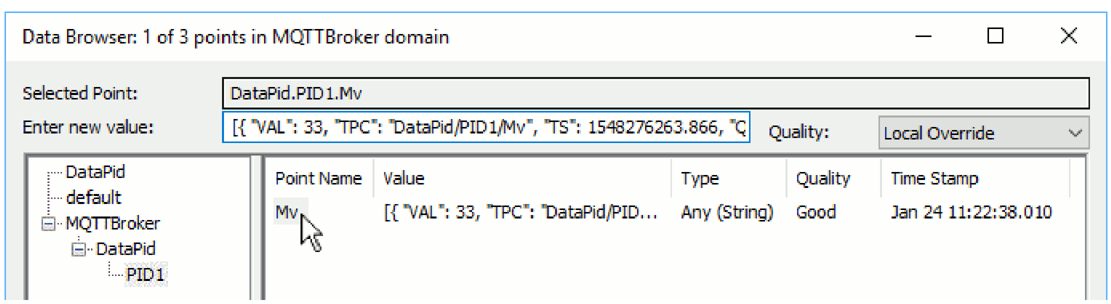
If you want to discover and use the client message format

If you don't know the client message format, but want to use it as the DataHub MQTT message format, you can use the `{value}` message format to discover it, as follows:

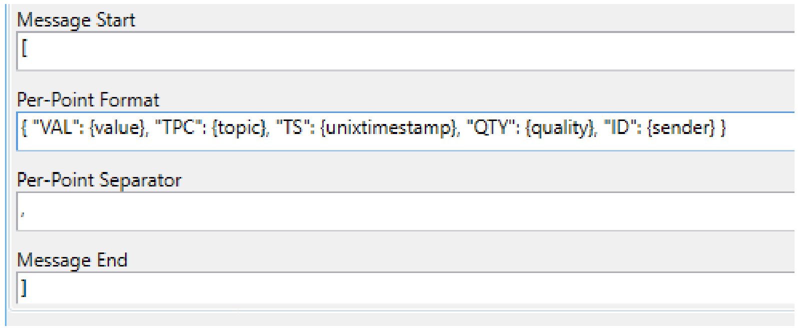
1. Ensure that the DataHub MQTT Broker is configured with the `{value}` message format, as described above.
2. Start your MQTT client, connect to the MQTT Broker, and send a message. For example, here is a message that is not in the DataHub program's default message format, but can write to the point `MQTTBroker:DataPid.PID1.Mv` in the DataHub instance.

```
[{ "VAL": 33, "TPC": "DataPid/PID1/Mv", "TS": 1548276263.866,
"QTY": 192, "ID": "" }]
```

3. When the DataHub MQTT Broker receives this message, you will be able to see the entire, unparsed string as the value for a point in the Data Browser. The point is in the domain that you have configured for the MQTT Broker.

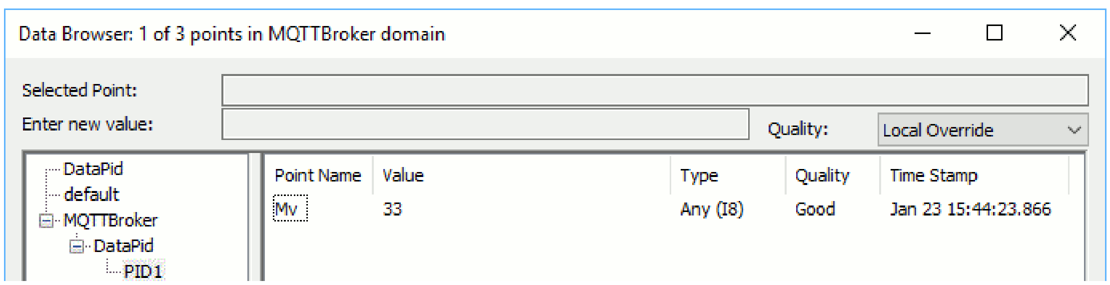


4. Click on the point name to display the value in the **Enter new value** field.
5. Copy the complete string and paste it into the **Per-Point Format** field of the Configure Parser window of the DataHub MQTT Broker configuration.
6. Remove the outer pair of square brackets (`[` and `]`) from the string, and replace the values of the parameters with the placeholder values, like `{topic}`, `{value}`, `{quality}`, etc.



7. Restore the entries for **Message Start** ([ ), **Per-Point Separator** (,), and **Message End** ( ]) fields.
8. Click **OK** and then **Apply** to save your settings.
9. Make any other desired changes to the MQTT Broker configuration as described in the section called "MQTT Broker".

The DataHub MQTT Broker is now configured for your MQTT client. If you push a message from the client with a new value, that value should appear in the Data Browser.



To make the MQTT connection, use the IP address of the computer running the DataHub instance, and the port that you have configured. The defaults are 1883 for plain text and 8883 for SSL.

The DataHub MQTT Broker does not support WebSocket connections for MQTT.

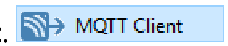
Connecting Outbound to an MQTT Broker

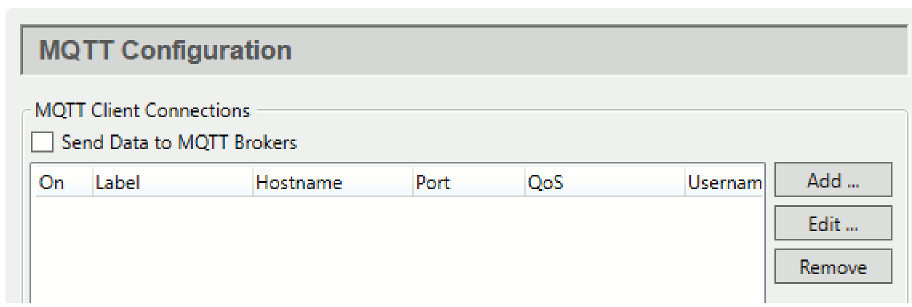
The DataHub MQTT Client option lets you connect out to virtually any MQTT broker, to publish or subscribe to any or all topics. If you are using Azure IoT Hub, Google IoT, or AWS IoT Core, please see those sections for configuring client connections. To connect to any other MQTT broker, here is what you need to do.

To keep things simple, if you plan to run an MQTT broker on your local machine, ensure that the DataHub MQTT Broker is not also running. You can disable it by unchecking the **Enable MQTT Broker** box in the MQTT Broker configuration.

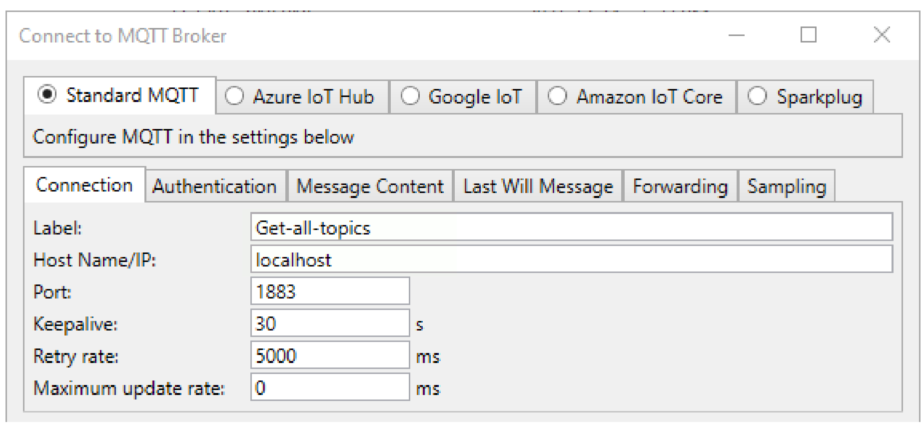
Subscribe (get topics)

Before pushing any data to the MQTT broker, it can be useful to know some or all of its topics. This procedure shows how to register a DataHub instance with an MQTT broker and bring its topics into the DataHub MQTT client and the DataHub data set.

1. In the DataHub Properties window, select **MQTT Client**. 

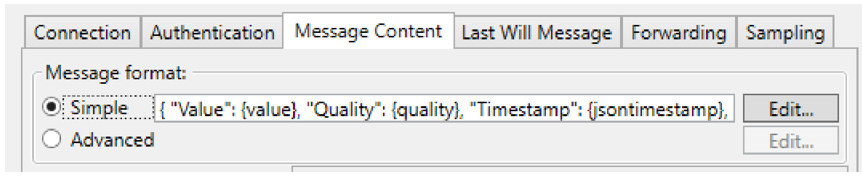


2. Click the **Add** button to open the Connect to MQTT Broker window.
3. In the **Standard MQTT** tab, for the **Connection** enter the following:

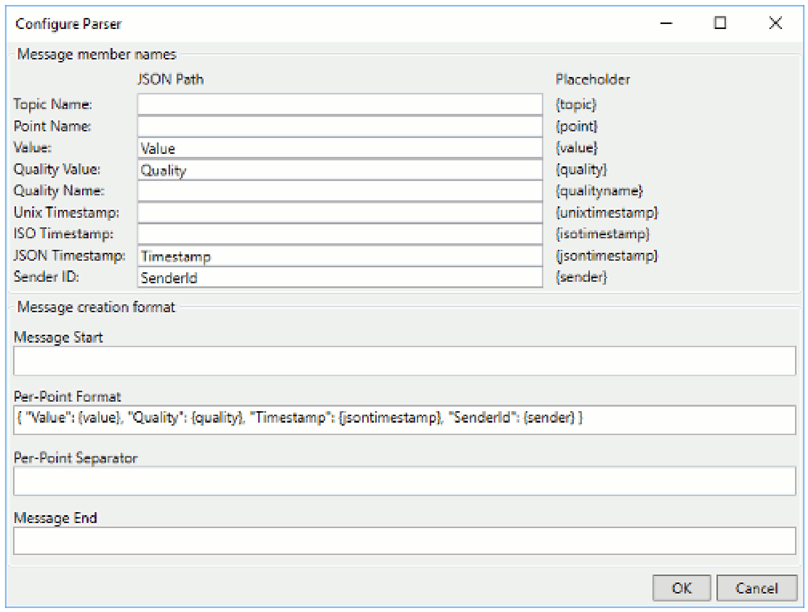


- **Label:** Enter any text string.
- **Host:** Enter the name or IP address of the host of the broker.
- **Port:** `1883` (the default)
- **Keepalive:** `30` (the default)
- **Retry rate:** `5000` (the default)
- **Maximum update rate:** `0` (the default).

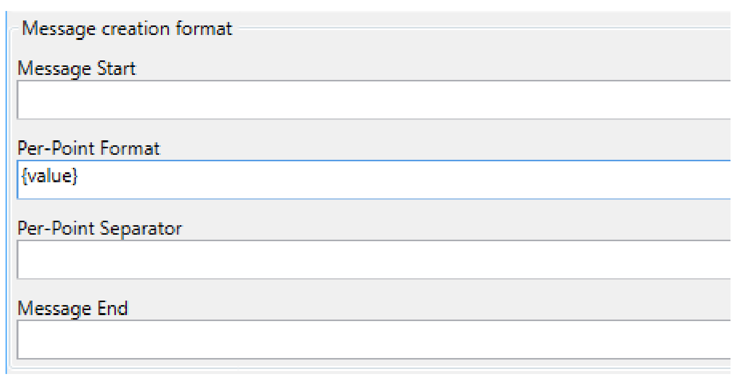
4. In the **Message Content** tab ...



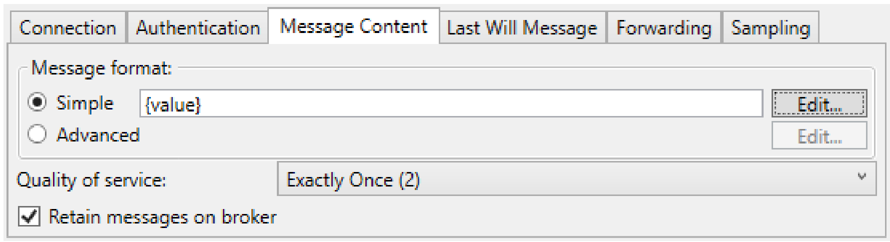
press the **Edit Format** button to open the Configure Parser window:



5. In the **Per-Point Format** field enter just the string: `{value}`.

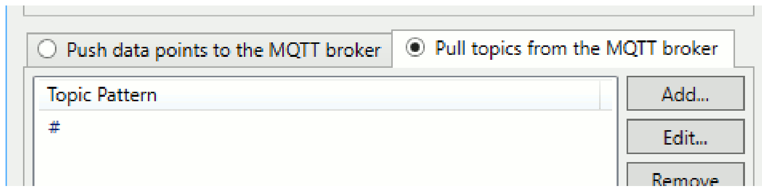


6. Delete any entries in the **Message Start**, **Per-Point Separator**, and **Message End** fields.
7. Click **OK**. Your **Message format** should now look like this:

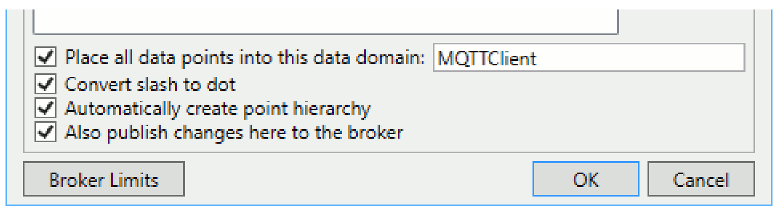


For information on the other tabs here, please see Authentication, Last Will Message, Forwarding, and Sampling in the MQTT Client section of the Properties Window chapter.

8. Choose **Pull topics from the MQTT Broker**.

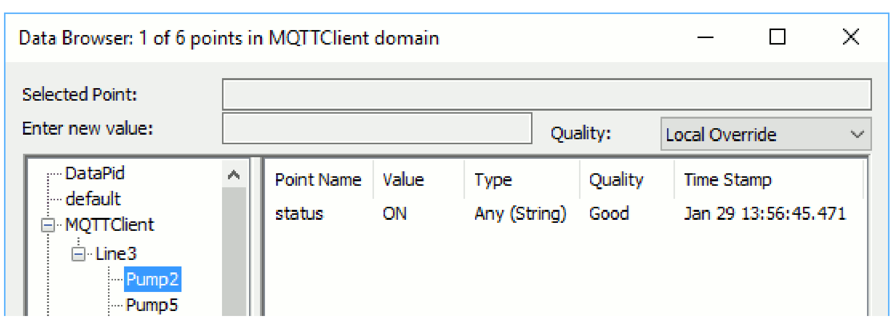


9. Click the **Add** button and enter the hash symbol (#), which tells the broker that you want to subscribe to all topics.
10. Check the **Place all data points into this data domain** box, and enter **`MQTTClient`** in the entry field.



This keeps all of your MQTTClient points separate from other DataHub data.

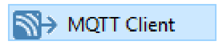
11. Click **OK** and then **Apply** to save your settings.
12. Open the DataHub Data Browser. You should now see all of the topics from the MQTT Broker in the **MQTTClient** domain.

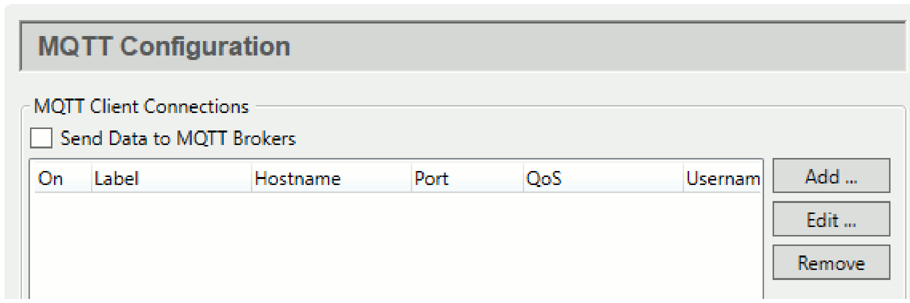


If the broker's payload format does not map directly to DataHub points, you may wish to change it. Please see Message Payload Formats for more details.

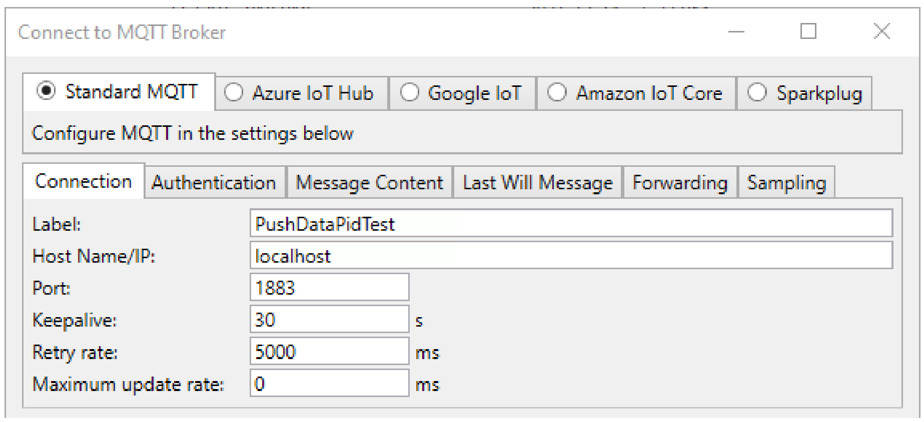
Subscribe (push data)

This procedure shows how to push data from DataPid to your MQTT broker.

1. In the Properties window, select **MQTT Client**. 



2. Click the **Add** button to open the Connect to MQTT Broker window:

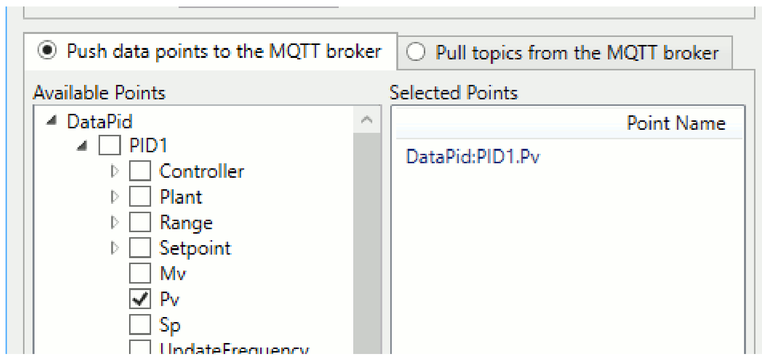


3. In the **Standard MQTT** section, **Connection** tab, enter the following:
   - **Label:** Enter any text string.
   - **Host:** Enter the name or IP address of the host of the broker.
   - **Port:** `1883` (the default)
   - **Keepalive:** `30` (the default)
   - **Retry rate:** `5000` (the default)
   - **Maximum update rate:** `0` (the default).
4. In **Authentication**, enter the **Username** and **Password** for the MQTT broker, if applicable.

This example uses the DataHub program's default JSON message content format. If you want to use a different format to send data to a broker, please refer to the client Message Content documentation for how to change it. If you want to simply send the unparsed values, please refer to the Unparsed Values documentation.

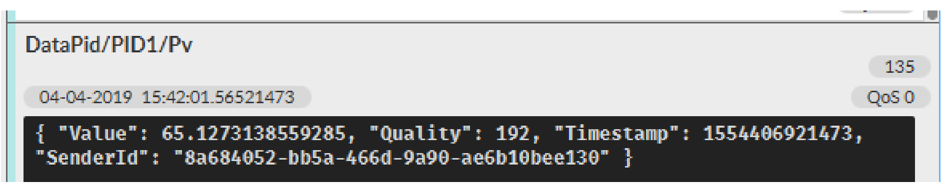
For information on the other tabs here, please see Message Content, Last Will Message, Forwarding, and Sampling in the MQTT Client section of the Properties Window chapter.

5. In the **Push data points to the MQTT broker** section, **Available Points** list, open the **DataPid** tree and select the point `Pv`. (If you don't see the `DataPid` domain, start DataPid.)



6. Click **OK**, and then **Apply**.

7. In the MQTT broker or a connected MQTT client, you should see the values for **DataPid:PID1.Pv** updating. These messages are using the DataHub program's default message content format.

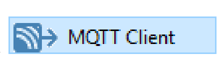


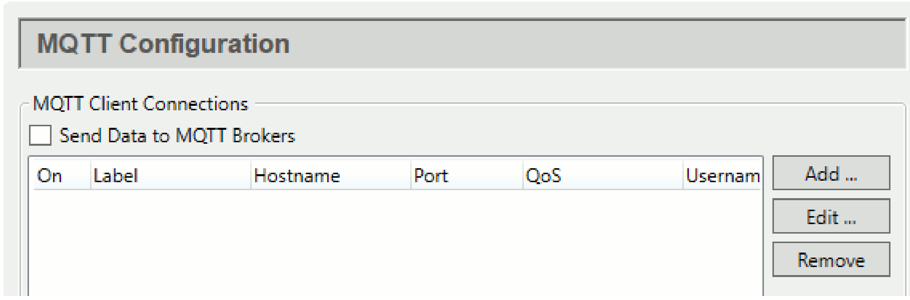
You have now configured the DataHub MQTT Client to push a value to an MQTT Broker. For more information about the MQTT Client feature, please refer to the section called "MQTT Client".

Subscribe (pull data)

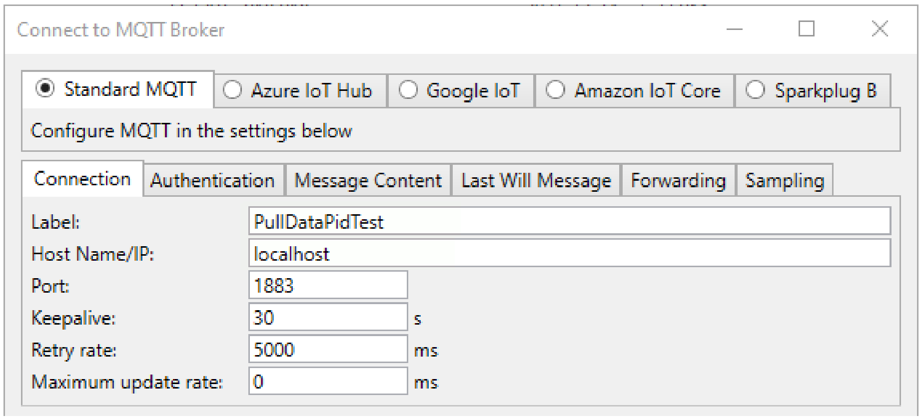
With data from DataPid being pushed to your MQTT broker, you can now create an MQTT client connection to pull that topic and its data from the broker.

If you have not yet completed the previous procedure, please do it now for best results here.

1. In the Properties window, select **MQTT Client**. 



2. Click the **Add** button to open the Connect to MQTT Broker window:

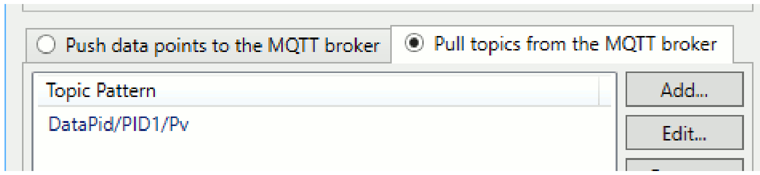


3. In the **Standard MQTT** section, **Connection** tab, enter the following:
   - **Label:** Enter any text string, different from any previous label.
   - **Host:** Enter the name or IP address of the host of the broker.
   - **Port:** `1883` (the default)
   - **Keepalive:** `30` (the default)
   - **Retry rate:** `5000` (the default)
   - **Maximum update rate:** `0` (the default)

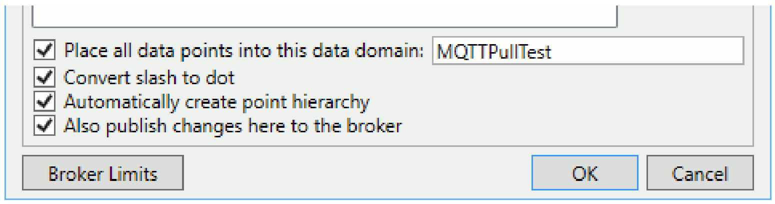
   These settings assume that the broker is using the DataHub program's default JSON message content format. If your broker is using a different format, please refer to the Message Content documentation for how to change it. If you want to simply receive unparsed values from the broker, please refer to the Unparsed Values documentation.

   For information on the other tabs here, please see Authentication, Message Content, Last Will Message, Forwarding, and Sampling in the MQTT Client section of the Properties Window chapter.

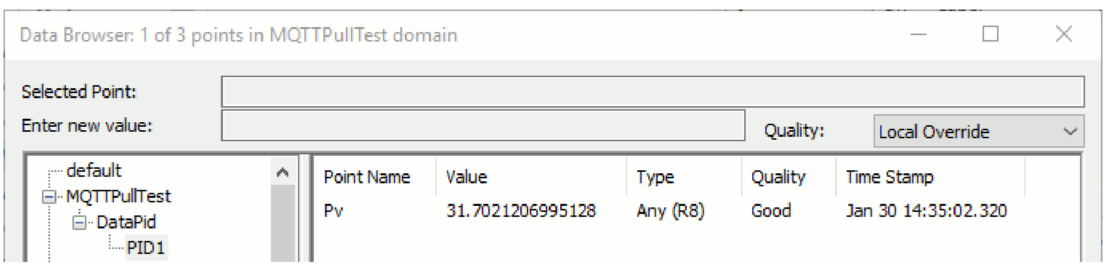
4. In the **Pull topics from the MQTT broker** section, click the **Add** button and enter **`DataPid/PID1/Pv`**.



5. Click the **Place all data points into this data domain** button and enter a domain name, such as `MQTTPullTest`.



6. Click **OK**, and then **Apply**.
7. In the Data Browser, you should see the values for **DataPid:PID1.Pv** updating, as normal DataHub point values.



You have now configured the DataHub MQTT Client for a topic to pull values from an MQTT broker. For more information about the MQTT Client feature, please refer to the section called “MQTT Client”.

Message Payload Formats

Messages for or from an MQTT broker might not have a payload format that maps directly to DataHub points. Data points in the DataHub program are 4-element tuples of the form (`name`, `value`, `quality`, `timestamp`). Those are the only elements that can be extracted from the information being sent to or arriving in an MQTT payload for the DataHub instance. In the JSON format, these rules will be applied:

- Only one of `topic` or `point` will be used.
- Only one `timestamp` will be used.
- Only one of `quality` or `qualityname` will be used.

If the payload format is the same for each item, and if elements of the payload represent quantities that should be placed in a DataHub point, then it is possible to create a simple parsing template. For example, if you have a payload like this:

```
{ "PT": "MyPoint", "VAL": 33, "TS": 1548276263.866, "QTY": 192,  ... }
```

As long as the elements correspond to name, value, timestamp and quality then a possible template could be constructed like this:

```
{"PT": {point}, "VAL": {value}, "TS": {jsontimestamp},
 "QTY": {quality}}
```

Where the value of `"PT"` is the point name, the value of `"VAL"` is the point value, the value of `"TS"` is a Unix, ISO, or JSON timestamp, and the value of `"QTY"` is the point quality. Other placeholders are available to use in the template, as provided in the editor.

If the payload represents multiple points with a common JSON format such as this array of points:

```
[ { "PT": "MyPoint", "VAL": 33, "TS": 1548276.866, "QTY": 192, ... },
  { "PT": "MyPoint2", "VAL": 66, "TS": 1574462.566, "QTY": 192, ... },
  { ... }, ...]
```

Then, in the editor, the **Message Start** field would hold an open array bracket (`[`), the **Per-Point Separator** field would be a comma (`,`), and the **Message End** field would hold a closed array bracket (`]`). The **Per-Point Format** field would hold the common parser template string such as above with appropriate placeholders. This would associate the values coming from the MQTT broker with properties of DataHub points, populating each point with meaningful content that could then be used by connected DataHub clients.

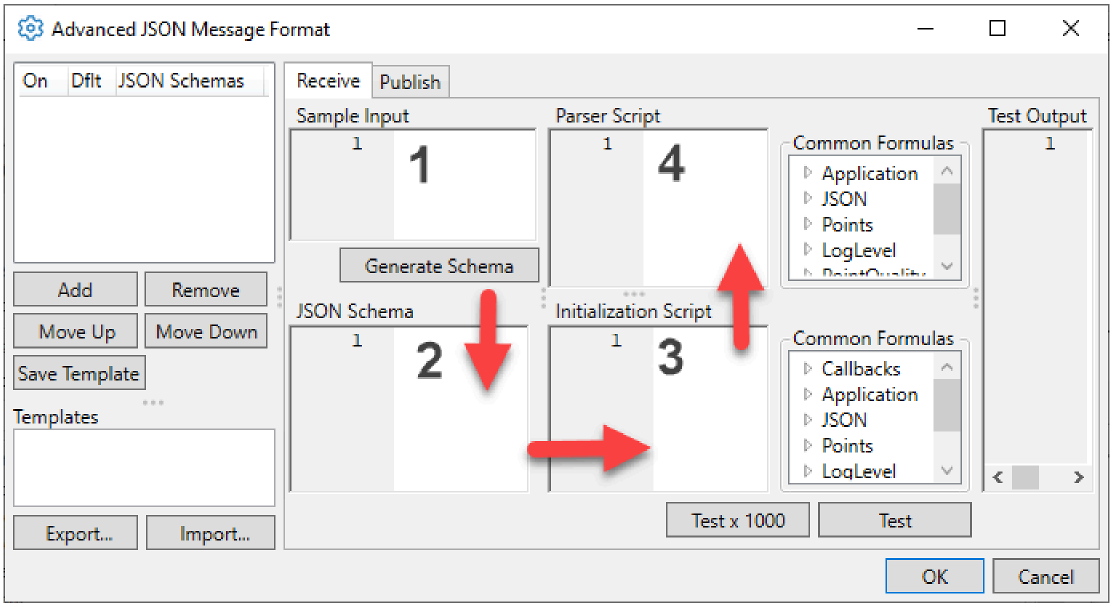
If you have a more complex JSON payload, or if the format of the payload differs from item to item, then it may be necessary to use the Advanced Parser. This allows you to input a raw JSON payload string obtained from using the per-point format set to `{value}`, and use it to generate a matching schema that can be adjusted as needed.

MQTT Advanced Parser Tutorial

Both the MQTT Client and MQTT Broker features include an Advanced option that allows you to accept and use any number of different JSON formats for incoming and outgoing MQTT messages. This lets you integrate MQTT data between MQTT clients, as well as all other DataHub protocols.

This section of the documentation is an introduction to the MQTT Advanced Parser interface, a brief walk-through to illustrate how to use it. For more information, please see MQTT Advanced Parser Reference.

The Advanced JSON Message Format window consists of four main panels, which are typically used in sequence:



1. **Sample Input** is where you start, by putting in an MQTT message sample. This should be a complete sample, with the maximum message content that the device can produce. If your device manufacturer does not provide a sample message format, you can determine one by setting the DataHub MQTT Broker to treat all messages as plain text, then connecting the device. (See how.) The message will be placed in a data point in the DataHub Data Browser, and you can copy it from there.

2. **JSON Schema** is the JSON schema that describes the messages that the device produces. If the device manufacturer provides a schema, you can enter it here. If not, enter a sample message (above) and press the **Generate Schema** button to create a schema from that message. If necessary, you can then edit the schema to add missing fields or remove any that are not required. Your schema should include a "required" member listing all fields that are guaranteed to be part of all messages. If no "required" member is set then all valid JSON will match the schema, which makes it impossible to differentiate different device schemas.

3. **Initialization Script** is run just one time, when the first message using the schema is received for each topic. This is used to create functions that will run once per topic, or once per received message to guide the parsing process. If the device is generating data at high speed, place as much of your code here as possible to minimize the CPU load when parsing messages from the device. This script can be empty.

4. **Parser Script** is run for every message received from any MQTT topic that matches the schema. It extracts data from the message and writes it to DataHub data point values. The minimum parser script consists of a single line:

```
app.ProcessJson();
```

Example - Part One

An example device may be generating MQTT messages with content like this:

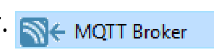
```
{"devicename": "Pump3","manufacturer": "Acme Co.","speed": 47.33,
"gpm": 37.4,"status": true,"tstamp": 1633677890,"qcomms": 64,
"activate": false,"setpoint": 47}
```

Or, to make it more readable:

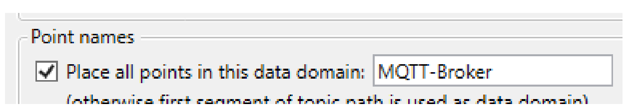
```
{
    "devicename": "Pump3",
    "manufacturer": "Acme Co.",
    "speed": 47.33,
    "gpm": 37.4,
    "status": true,
    "tstamp": 1633677890,
    "qcomms": 64,
    "activate": false,
    "setpoint": 47
}
```

Each line represents an MQTT topic and its value, which you might want to put into a DataHub instance, as DataHub points. For this example, let's say you don't need the `manufacturer` topic to show up as a DataHub point. And you want to have the `tstamp` topic act as a timestamp for several other points, and `qcomms` as their quality.

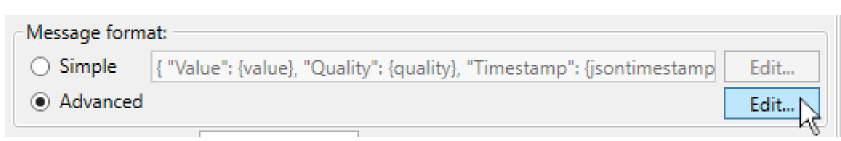
In this first part of the example, we will enter the message and generate a schema. Then we'll modify the output with a simple script, test the results, and view them in the Data Browser.

1. In the DataHub Properties window, go to MQTT Broker. 

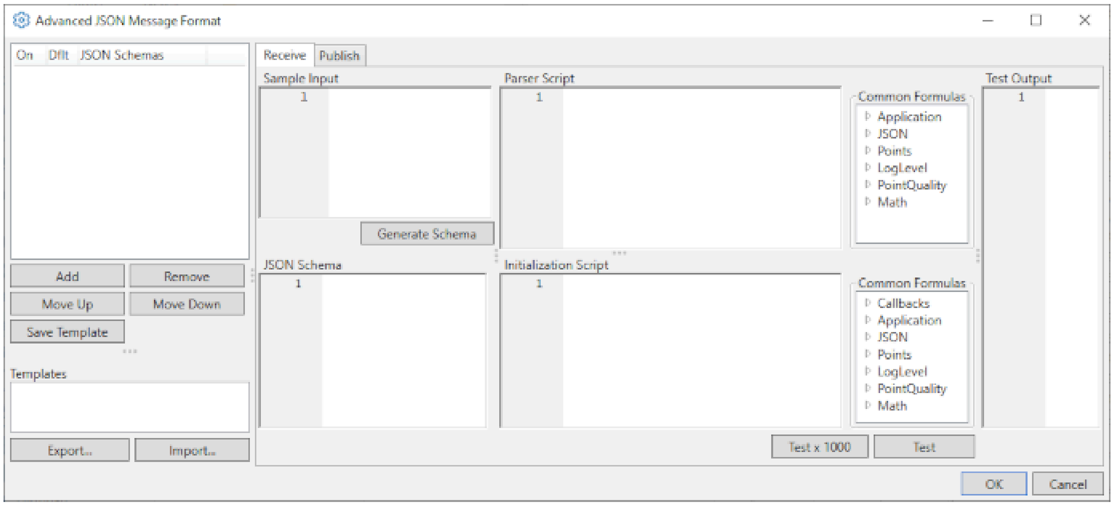
2. For this demo, in **Point names**, check the **Place all points in this data domain** button, enter `MQTT-Broker`, and click the **Apply** button.



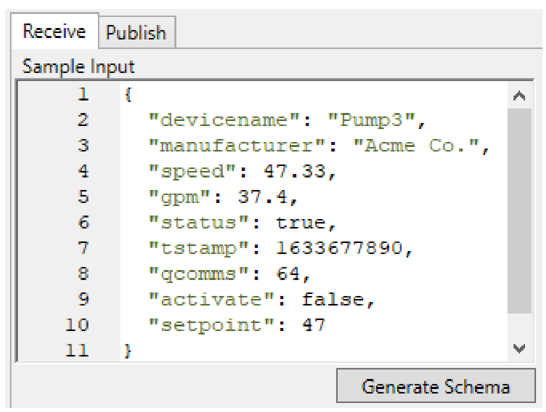
3. In **Message format**, select **Advanced** and click the **Edit** button.



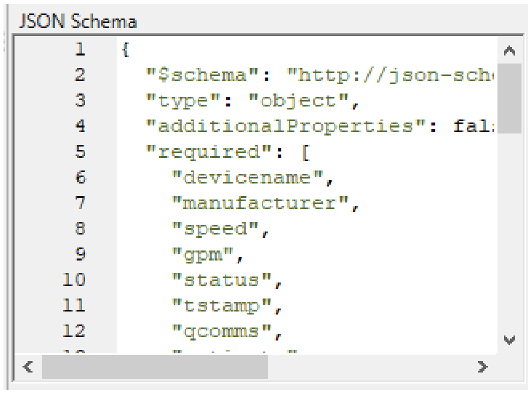
The Advanced JSON Message Format window will open.



4. Create a new JSON schema by selecting the **Add** button in the top left-hand panel. Give your schema a name that identifies the type of device that generates these messages.
5. Select your newly-created schema in the list.
6. Copy the example device output given above into the **Sample Input** panel.

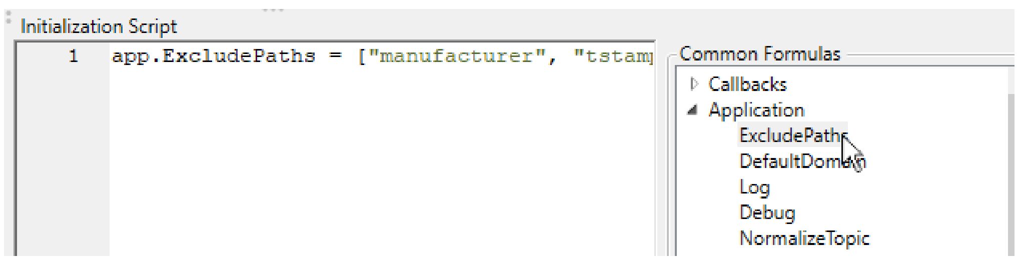


7. Click the **Generate Schema** button. The system will generate a JSON schema and display it.



8. To the right of the **Initialization Script** panel, in the **Common Formulas**, open the **Application** group and double click **ExcludePaths**. It will put the `app.ExcludePaths` function into the **Initialization Script** panel:

```
app.ExcludePaths = [];
```

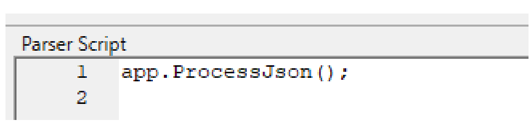


9. Add these names of the topics to exclude, as strings:

```
app.Excludepaths = ["manufacturer", "tstamp", "qcomms"];
```

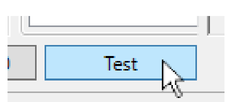
We put `tstamp` and `qcomms` here because although we will be using their data later in the next part of the example, we don't want them to be treated as points by the DataHub engine.

10. Notice that there is one line, the `app.ProcessJson()` function, in the **Parser Script** panel:

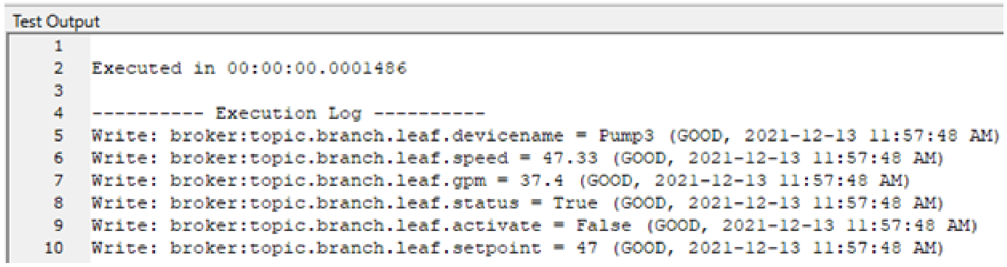


This is the default entry, the minimum needed to process the JSON output. We will leave it as-is for now.

11. Click the **Test** button at the bottom of the **Initialization Script** panel.

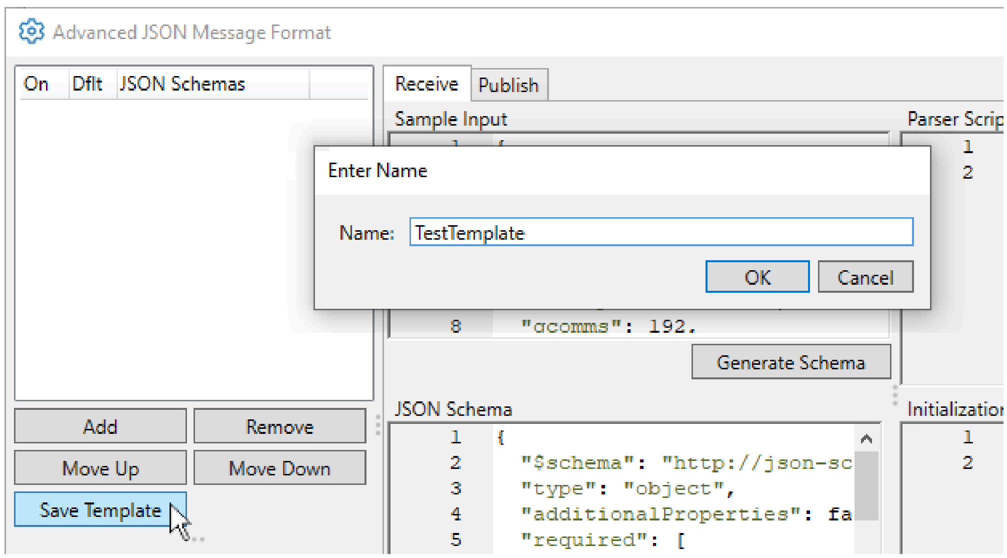


In the **Test Output** panel, you should see something like this:



This test feature lets you see what will get sent to your DataHub instance. You can use it to check for errors in your scripts, and to ensure you have the right format and content for your data points. If you don't see something similar to this, check your work, make any necessary changes, and test again.

12. Once you have confirmed your test output is correct, you can click the **Save Template** button in the left-hand panel to save your settings as a template.

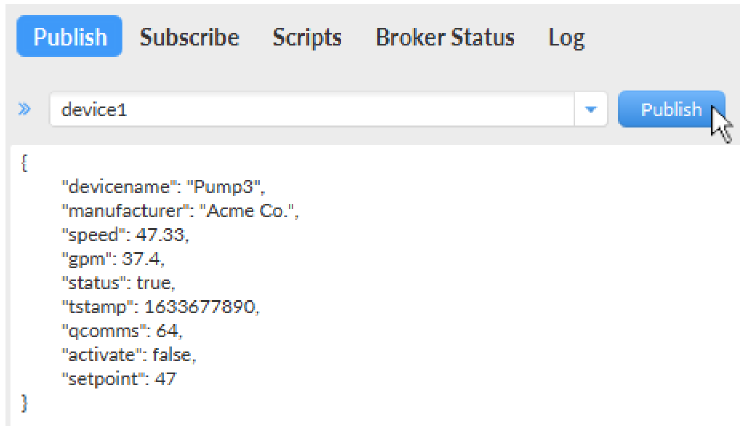


Enter a name for your template, and click **OK**.

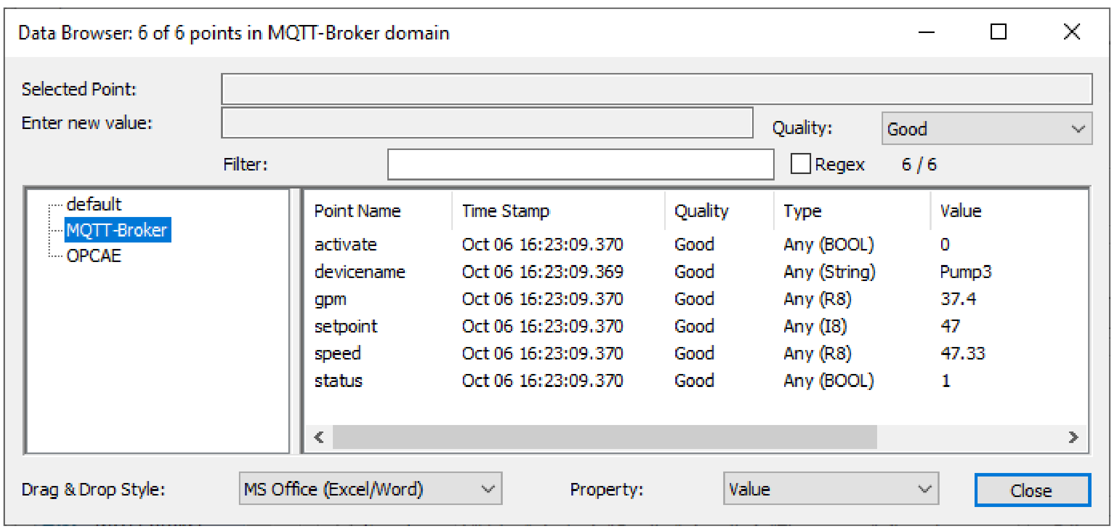
13. Then click the **OK** button at the bottom right of the Advanced JSON Message Format window to close it.

14. Click the **Apply** button in the Properties window to apply and save your changes.

15. To test your configuration, you will need to send an MQTT message in the same format to your DataHub instance. You can use any MQTT test client. Connect it to the DataHub instance, and send the message.



16. In the DataHub instance, click the **View Data** button to open the Data Browser to see the data points and data.



You have now seen how to enter a sample message, generate a schema, modify the output with a simple script, test the results, save and apply the template, and then view it in the Data Browser.

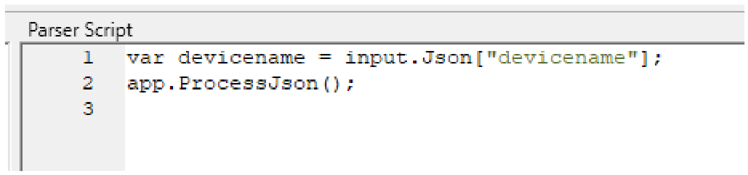
Example - Part Two

By default, data points get written with a path derived from the topic on which the message was delivered. In our example device, the name of the device is part of the JSON payload. We would prefer to publish the data points with the device name as part of the point name. To do this, we can extract the device name as part of the parser script, and then use that in the app.PointNameModifier callback to alter the point name the parser produces.

1. In the DataHub MQTT Broker, reopen the Advanced JSON Message Format window to continue editing.

2. In the Parser Script, we need to extract the device name and store it in a local variable. This needs to be in the Parser Script, not the Initialization Script because the device name is different for each message, and not known until the message arrives. To do this, add the following line to the Parser Script:

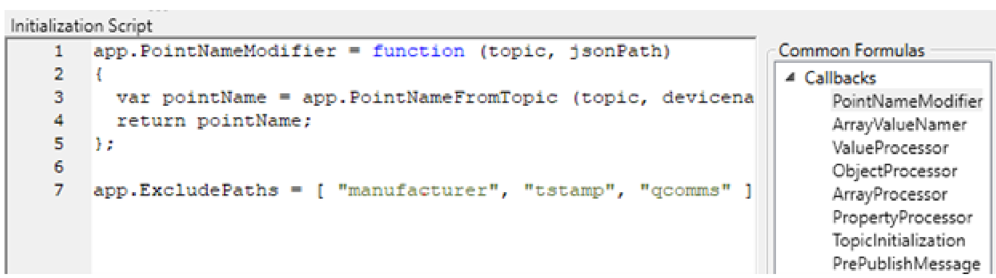
```
var devicename = input.Json["devicename"];
```



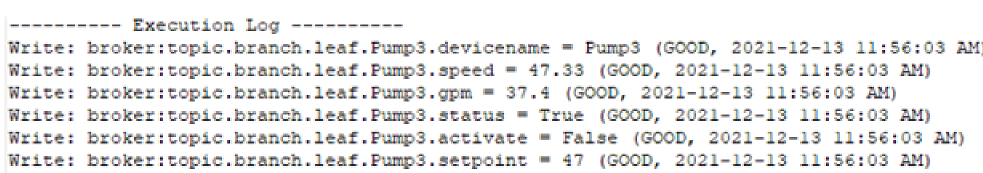
3. Add this code to the Initialization Script:

```
app.PointNameModifier = function (topic, jsonPath)
{
  var pointName = app.PointNameFromTopic (topic, devicename +
                                          "/" + jsonPath);
  return pointName;
};
```

Remember, you can find code templates for callbacks, applications, JSON, and more in **Common Formulas**. Double-click to enter them into the work space.



4. Click the **Test** button. Your test output should now look like this:

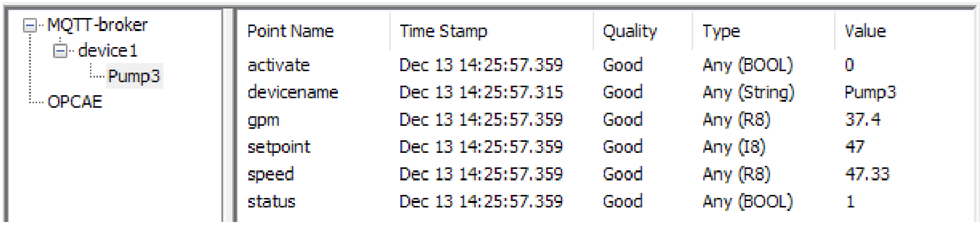


The `topic.branch.leaf.` text is a placeholder in the test output. It will be replaced by the actual path specified by the MQTT client.

5. Click **OK** to close the Advanced JSON Message Format window, and then click **Apply**.

6. Restart your DataHub instance to clear any unused data points.

7. Reconnect your MQTT demo client to your DataHub instance and resend the sample message. The Data Browser display should show the data points in the **device1** branch of the **MQTT-Broker** domain.

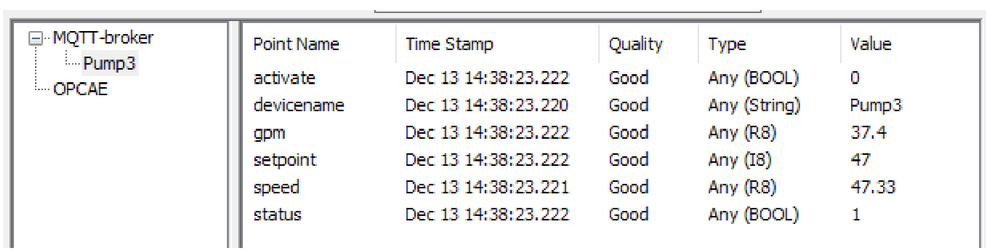


Point Name	Time Stamp	Quality	Type	Value
activate	Dec 13 14:25:57.359	Good	Any (BOOL)	0
devicename	Dec 13 14:25:57.315	Good	Any (String)	Pump3
gpm	Dec 13 14:25:57.359	Good	Any (R8)	37.4
setpoint	Dec 13 14:25:57.359	Good	Any (I8)	47
speed	Dec 13 14:25:57.359	Good	Any (R8)	47.33
status	Dec 13 14:25:57.359	Good	Any (BOOL)	1

8. This may not be exactly what we want either. The `devicename` field is sufficient to identify this device, so we do not want the additional path created by the topic name. We can remove a single level of the topic before computing the point names by modifying the app.PointNameModifier to remove the last path element from the topic:

```
app.PointNameModifier = function (topic, jsonPath)
{
  topic = topic.Delete(-1,1) + "/" + devicename;
  var pointName = app.PointNameFromTopic (topic, jsonPath);
  return pointName;
};
```

9. Restart your DataHub instance to clear any unused data points, and then reconnect your MQTT demo client and send the sample message again. You should now see data points like this:



Point Name	Time Stamp	Quality	Type	Value
activate	Dec 13 14:38:23.222	Good	Any (BOOL)	0
devicename	Dec 13 14:38:23.220	Good	Any (String)	Pump3
gpm	Dec 13 14:38:23.222	Good	Any (R8)	37.4
setpoint	Dec 13 14:38:23.222	Good	Any (I8)	47
speed	Dec 13 14:38:23.221	Good	Any (R8)	47.33
status	Dec 13 14:38:23.222	Good	Any (BOOL)	1

Now, the default behavior of the system is to insert a quality value of `192` (GOOD) and a timestamp of the current system time. But you can change those to the quality and timestamp coming from the device itself. In our example, the values of `qcomms` and `tstamp` contain that information. Here's how you can extract it and apply it to the data points.

1. Reopen the Advanced JSON Message Format window to continue editing.
2. In the **Initialization Script**, add a ValueProcessor callback that overrides the standard behaviour of `app.ProcessJson` when it is provided. We will use this to write the data point values ourselves, with our own timestamp and quality:

```
app.ValueProcessor = function (topic, jsonPath, obj)
{
  app.WritePoint (topic, jsonPath, obj, quality,
                  JsonExtensions.GetDate(timestamp));
};
```

3. In the **Parser Script**, add these lines to assign the values from the device.

```
var quality = input.Json["qcomms"];
var timestamp = input.Json["tstamp"];
```

Parser Script

```
var devicename = input.Json["devicename"];
var quality = input.Json["qcomms"];
var timestamp = input.Json["tstamp"];
app.ProcessJson();
```

These assign the values for the time stamp and quality coming from the sample input (`input.JSON`) to the `timestamp` and `quality` variables specified in the `app.WritePoint` function. Since these values may change for each message, they need to be assigned in the **Parser Script**. All of these lines of code must be written above the final `app.ProcessJson();` line.

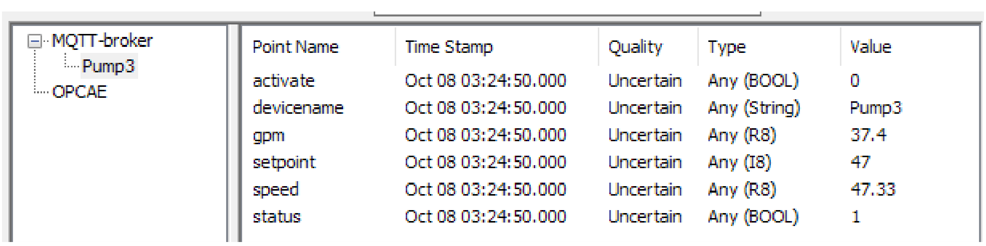
We use the `JsonExtensions.GetDate` function to convert the numerical time stamp coming from the device into a date/time format.

4. Click the **Test** button. The test output shows that the quality (64 = UNCERTAIN) and timestamp (1633677890 = 2021-10-08 7:24:50 AM) are now coming from the sample input, and are not being generated by the DataHub instance.

```
---------- Execution Log ----------
Write: MQTT-Broker:topic.branch.leaf.devicename = Pump3 (UNCERTAIN, 2021-10-08 7:24:50 AM)
Write: MQTT-Broker:topic.branch.leaf.speed = 47.33 (UNCERTAIN, 2021-10-08 7:24:50 AM)
Write: MQTT-Broker:topic.branch.leaf.gpm = 37.4 (UNCERTAIN, 2021-10-08 7:24:50 AM)
Write: MQTT-Broker:topic.branch.leaf.status = True (UNCERTAIN, 2021-10-08 7:24:50 AM)
Write: MQTT-Broker:topic.branch.leaf.activate = False (UNCERTAIN, 2021-10-08 7:24:50 AM)
Write: MQTT-Broker:topic.branch.leaf.setpoint = 47 (UNCERTAIN, 2021-10-08 7:24:50 AM)
```

5. Click **OK** to close the Advanced JSON Message Format window, and then click **Apply**.

6. Reconnect your MQTT demo client to your DataHub instance and resend the sample message. You should now see that the MQTT test client values for time stamp and quality were sent to the DataHub instance.

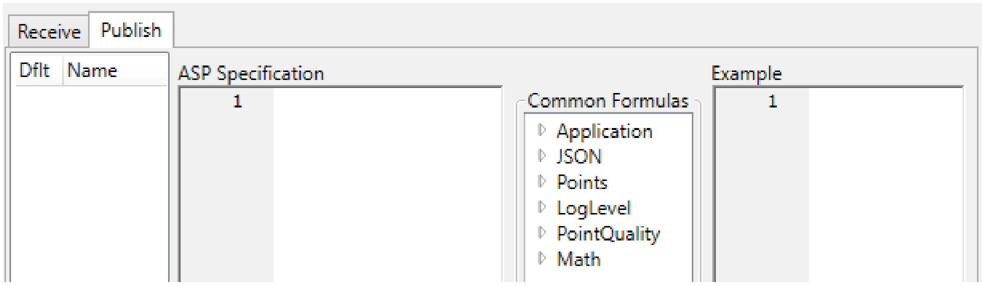


The multiple-hour difference in time stamps is because the **Test Output** parser displays dates in GMT0 time, while the DataHub Data Browser displays dates in local time.

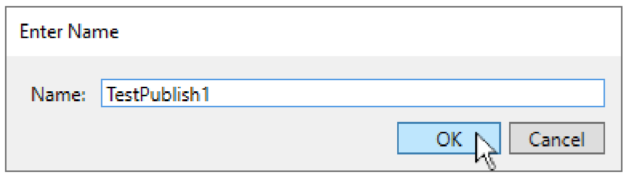
Example - Part Three

So far we've shown how to receive data from a device or other MQTT client. Now we will look at publishing data back to the client. For this we will use the data points `setpoint` and `activate`.

1. In the DataHub MQTT Broker, reopen the Advanced JSON Message Format window to continue editing.
2. Click the **Publish** tab at the top to open the **Publish** interface.

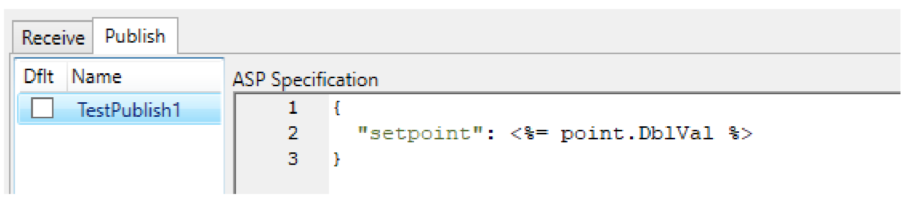


3. Click the **Add** button, enter the name `TestPublish1`, and click **OK**.



4. In the **ASP Specification**, enter the following:

```
{
    "setpoint": <%= point.DblVal %>
}
```

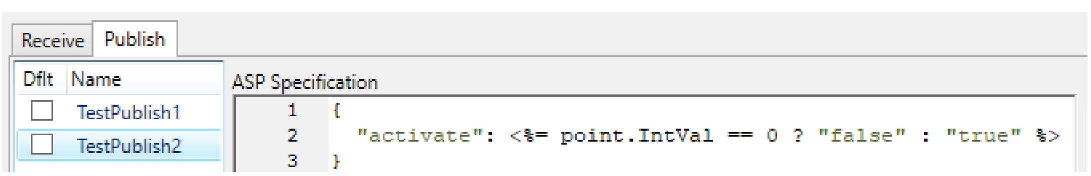


This is a simple publish format for the 'setpoint' value, which will allow the DataHub data engine to write it to the device as a double.

5. Click the **Add** button again, enter the name `TestPublish2`, and click **OK**.

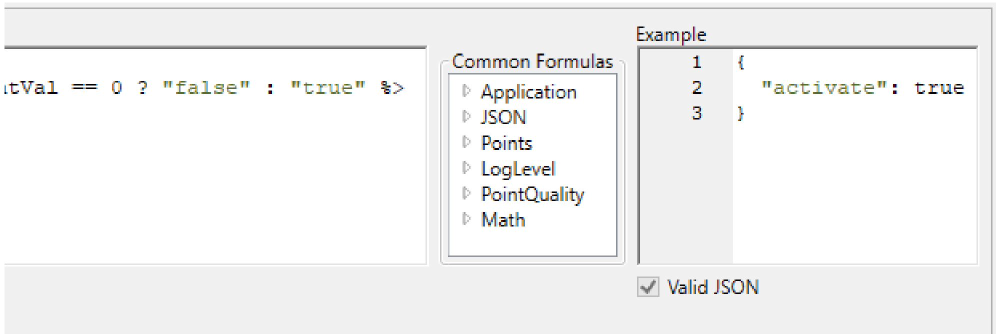
In the ASP Specification, enter the following:

```
{
    "activate": <%= point.IntVal == 0 ? "false" : "true" %>
}
```



This tells the DataHub data engine to convert boolean entries of `0` or `1` to the string `false` or `true`, to match the data format of the device.

As you enter each specification, the system generates an example of the MQTT formatted message that will get sent to the client. A checkbox at the bottom indicates whether this is valid JSON.

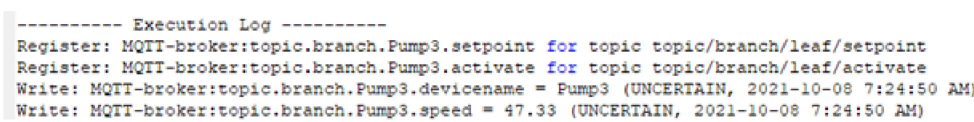


6. Now we need to call these specifications. Switch back to the **Receive** tab, and in the **Initialization Script** panel, add the following lines:

```
app.TopicInitialization = function (topic, originalTopic, message, json)
{
 app.RegisterPoint(topic, "setpoint", "TestPublish1");
 app.RegisterPoint(topic, "activate", "TestPublish2");
};
```

   The `app.TopicInitialization` allows you to associate data points and publish formats. The `app.RegisterPoint` function registers these two points with the DataHub data engine, and specifies the JSON output format for each.

7. Click the **Test** button to verify the output.



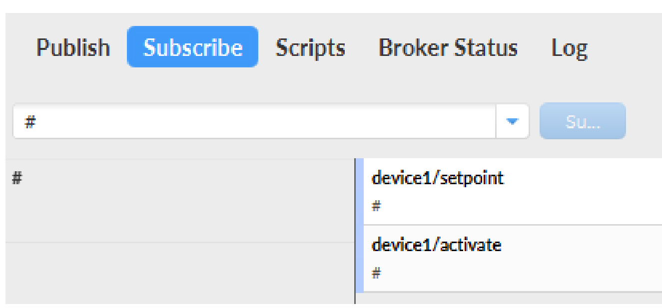
```
---------- Execution Log ----------
Register: MQTT-broker:topic.branch.Pump3.setpoint for topic topic/branch/leaf/setpoint
Register: MQTT-broker:topic.branch.Pump3.activate for topic topic/branch/leaf/activate
Write: MQTT-broker:topic.branch.Pump3.devicename = Pump3 (UNCERTAIN, 2021-10-08 7:24:50 AM)
Write: MQTT-broker:topic.branch.Pump3.speed = 47.33 (UNCERTAIN, 2021-10-08 7:24:50 AM)
```

8. Click **OK** to close the Advanced JSON Message Format window, and then click **Apply**.

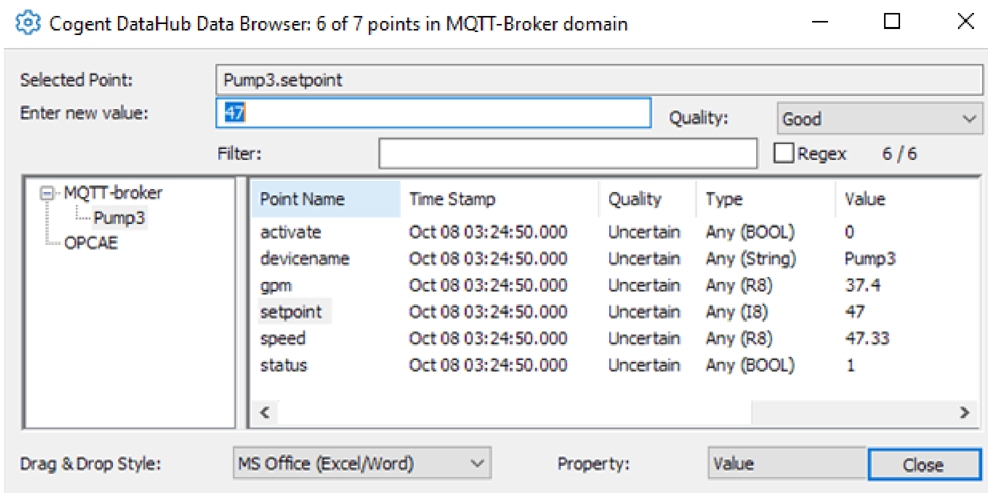
9. Restart your DataHub instance to clear any unused data points.

10. Reconnect your MQTT demo client to your DataHub instance and resend the sample message.

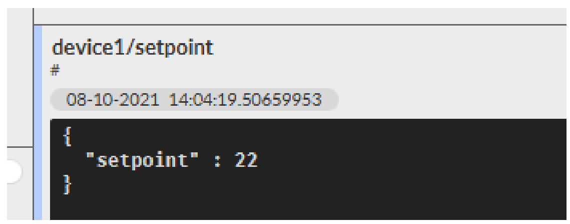
11. Subscribe to all points by using just the hash (#) character. You should receive messages from the 'setpoint' and 'activate' points.



12. To test, open the Data Browser to the **device1** branch of the **MQTT-Broker** domain.



13. Click on **setpoint** and enter a new value. When you press **Enter**, the value will get transmitted to your MQTT client.



These examples give a brief introduction to the power and flexibility of the MQTT Advanced Parser. Please see the MQTT Advanced Parser Reference section for more detailed information.

MQTT Advanced Parser Reference

Overview

MQTT specifies how to construct a message header so it can be routed by an MQTT broker, but it does not specify the message content. Essentially, MQTT is an envelope specification, not a content specification. This poses challenges when MQTT clients from different developers need to work together. Clients need to agree upon the content of an MQTT message in order to interoperate.

If there are multiple MQTT clients from different developers operating in the same system, every client must know how to format messages for, and interpret messages from, every other client. It is impractical to expect every client developer to support every other.

Most MQTT clients format their message content as UTF-8 encoded JSON text. The semantics of the JSON message are determined by the client developer, based on the use case. For example, a weather sensor might generate JSON messages containing fields named “temperature”, “pressure” and “humidity”. Any MQTT client wishing to process this information must understand the meaning of each of these field names. This understanding requires two parts:

1. The *schema* of the message, expressing the field names, types and organization of the message.
2. The *semantics* of the message, expressing the meanings of each field.

The schema can be expressed as a JSON Schema, which is a JSON document that describes the content and organization of a message. The semantics of a message must be described in terms of how to process that message. In effect, the semantics are encapsulated in a script.

Both the DataHub MQTT Client and MQTT Broker features offer the **Advanced** MQTT configuration option that allows you to specify JSON schemas and scripts for any number of different JSON formats. This allows MQTT applications in a heterogeneous environment to interoperate with one another, with SCADA and industrial applications, and with any other protocol supported by the DataHub program.

Receiving and Publishing

MQTT systems generally consist of “publishers” of information and “subscribers” to that information. When publishing, a client constructs a message payload from data that it manages, wraps the message in an MQTT envelope, and transmits that to a “topic” on an MQTT broker. An MQTT topic is similar to a point name, tag, item or node in control system terminology. A topic and its message payload constitute a (name, value) pair. The publisher typically creates the payload using string construction or serialization of a data structure. When the DataHub application is acting as a publisher, it constructs a string using an ASP document. That provides a convenient way to express both the literal text of the payload as well as the variable content from data points, clock, etc. It is the responsibility of the system integrator to provide this ASP document. In some cases, an MQTT client may expect different payload formats on different topics, even from the same publisher. This means that there may be more than one ASP document describing the different payloads, with each document associated with one or more topics. A receiving client typically must run code that encapsulates semantic knowledge about the message it is receiving. When the DataHub application is operating as a receiver, it uses an S-Sharp script to construct data points based on the fields in the message payload. S-Sharp is documented here. It is the responsibility of the system integrator to supply this script.

The publisher typically creates the payload using string construction or serialization of a data structure. When the DataHub application is acting as a publisher, it constructs a string using an ASP document. That provides a convenient way to express both the literal text of the payload as well as the variable content from data points, clock, etc. It is the responsibility of the system integrator to provide this ASP document.

In some cases, an MQTT client may expect different payload formats on different topics, even from the same publisher. This means that there may be more than one ASP document describing the different payloads, with each document associated with one or more topics.

A receiving client typically must run code that encapsulates semantic knowledge about the message it is receiving. When the DataHub application is operating as a receiver, it uses an S-Sharp script to construct data points based on the fields in the message payload. It is the responsibility of the system integrator to supply this script.

Determining which Parser to Use

In a typical system, devices can be added or removed from the network at any time. When those devices begin publishing their information, the receiver must be able to both detect that the device is active and to determine the type of information it is publishing. The DataHub MQTT Client and Broker examine each incoming message and compare it to the set of defined JSON schemas. If a schema match is found, they run the associated script to extract the data point information. The incoming message is compared to each JSON schema in order until the first match is found. If the system contains devices that produce similar messages, the schemas must be specified in order from most precise to least precise to ensure that the correct match is made.

This schema determination is done without user intervention, so there is no extra work required to add another device to the network.

Creating a New Message Format

You can create any number of message formats, each representing a different type of MQTT publishing on the network. Each format consists of a single JSON schema and its associated script, and zero or more publication formats as ASP documents.

Receive Format

A receive format consists of 4 parts:

1. **A sample input message:** a complete JSON message payload typical of the messages that the device will produce. If a device can produce different amounts of content in its messages, this sample should contain the maximum message content that the device will produce. This is used to test the parser script, and to generate the message schema if necessary.
2. **A JSON message schema:** the JSON schema that described the messages that the device will produce. If the device manufacturer provides a schema, enter it here. If not, you can enter a sample message and press the “Generate Schema” button to create a reasonable schema that describes that message. You may need to edit the schema after generation to add missing fields or to determine which fields are required vs. optional.
3. **An initialization script:** a script that is run once when the first message using this schema is received for any topic. That is, it is run once, not once per topic. This provides an opportunity to create functions that will be used in the parser script, or to create a function that will run once per topic. If the device is generating data at high speed, place as much of your code here as possible to minimize the CPU load when parsing subsequent messages from the device. The initialization script can be empty.
4. **A parser script:** a script that is run for every message that matches the schema that is

received from any MQTT topic. Use this script to extract data from the message and to write data point values to the DataHub data engine. Once this information is in a data point it can be used by any other connected client, regardless of protocol (e.g., OPC, DDE, etc.). The minimum parser script consists of a single line:

```
app.ProcessJson();
```

Testing a Receive Format

Once you have supplied the sample input, schema and scripts, press the “Test” button to submit the sample message as if it had been received via MQTT. The sample message will be compared to the schema to ensure that they match, and then the initialization script will run, followed by the parser script. Any debug, log, and error messages will be displayed in the test output panel.

If the script would have written data points to the DataHub data engine, a line will be added to the test output to indicate that a point would have been updated. No actual changes will be made to the data points when running a test.

If a script attempts to read a data point, the test execution will supply a synthetic numeric value instead of reading a point from the data engine. If a point does not exist in the data engine, the test execution will synthesize a value for it as if it had existed.

Script Execution

JSON is a recursive notation. Any object field or array element in a JSON document can have any type as its value, including other objects and arrays, to arbitrary depth. To process the incoming JSON message, the parser recursively visits every field and array element in the document, and executes callback functions that you provide at every level.

There are four callback functions that are called during this descent. It is the responsibility of the system integrator to provide these callbacks.

- **`app.ObjectProcessor`** is called when a JSON object type is encountered during processing. Normally this function can be omitted. The default behaviour is to continue the recursion. If you supply this function and it returns a boolean `false`, all further processing on this object will be stopped.
- **`app.ArrayProcessor`** is called when a JSON array type is encountered during processing. Normally this function can be omitted. The default behaviour is to continue the recursion. If you supply this function and it returns a boolean `false`, all further processing on this array will be stopped.
- **`app.PropertyProcessor`** is called when a JSON property type is encountered during processing. A JSON property is a field of a JSON object. Normally this function can be omitted. The default behaviour is to continue the recursion. If you supply this function and it returns a boolean `false`, all further processing on this array will be stopped.
- **`app.ValueProcessor`** is called when a JSON field with a scalar value (not an array or object) is encountered during processing. This function can be omitted. The default behaviour is to write the value to a data point whose name is computed from the JSON path to this property, in the default data domain.

When a point name is computed from a JSON path, the default behaviour is to construct the point by concatenating the default domain, a colon and the path field names separated by dot characters. For array elements, the default is to append an open bracket ([ ), an index starting at zero, and a closed bracket ( ]) to the preceding path. The parser provides two callbacks to modify this behaviour:

- **`app.TopicNameModifier`** accepts a topic string and a JSON document. It returns a string, representing a modified topic name that should be used instead of the original topic for this message. Use this to change point names and topics based on the contents of the JSON document. This can be useful when a device transmits data for different subsystems via the same topic, differentiating the subsystems through a name in the JSON payload.
- **`app.PointNameModifier`** accepts a path of elements separated by slash characters. It must return a fully qualified point name (including the domain: prefix). If the point name contains dot characters then a hierarchy will be created in the data engine by splitting on the dots if a value is written to this point. This function can be omitted. The default behaviour is to call `app.PointNameFromTopic` for this JSON path.
- **`app.ArrayValueNamer`** accepts a parent path and a numeric index, starting at zero. It must return a path formed from the input path and index. For example, if path is Plant1/Temperatures and the index is 1, then some possible return values could be:

  ```
  Plant1/Temperatures[1]
  Plant1/Temperatures-1
  Plant1/Temperatures01
  ```

  This function can be omitted. The default behaviour is to append `[ + ` *`index`* ` + ]` to the JSON path.

When a topic is identified as producing a specific schema for the first time, that topic is associated with that schema to speed up processing for subsequent messages. When that association is made, a callback will be executed if it is defined:

- **`app.TopicInitialization`** runs when a topic is first identified as producing a specific schema. This gives the integrator the opportunity to log a message or run some special processing. Particularly, this is where an association can be made between data points and publish formats using the `app.RegisterPoint` function, providing for bi-directional communication with the device via MQTT. `app.TopicInitialization` supplies both the original topic the produced this message and the topic as modified by `app.TopicNameModifier`.

When the callback functions run, the following variables are defined to provide context for the callback:

- **`input`** is an object of type `JsonParserData` with the following members:
  - **`input.Json`** is the JToken object representing the root of the JSON document. This is typically a JObject or a JArray. For more information on these types, consult the Newtonsoft.Json documentation.

- **`input.Level`** is the current processing level in the recursive processing, where the root is level 0.

- **`topic`** is the full name of the MQTT topic on which this message was delivered.
- **`app`** is an object that supplies methods and data members:
  - **`app.ProcessJson()`** Start the recursive processing of the JSON message.
  - **`app.PointNameModifier()`** The point name modifier method described above.
  - **`app.ObjectProcessor()`** The object processor method described above.
  - **`app.ArrayProcessor()`** The array processor method described above.
  - **`app.PropertyProcessor()`** The property processor method described above.
  - **`app.ValueProcessor()`** The value processor method described above.
  - **`app.ArrayValueNamer()`** The array value naming method described above.
  - **`app.TopicInitialization()`** The topic initialization method described above.
  - **`app.ExcludePaths`** An array of strings representing the full JSON paths to fields that should not be processed. You would use this, for example, to ignore a field that contains a date that you do not want to be written to a data point. Instead, you would extract that date and use it as the timestamp when writing other data points.
  - **`app.DefaultDomain`** A read-only string representing the data domain configured for the MQTT broker or client. If there is no default domain configured for this broker or client, then the first element of a path (topic or JSON path) will be used as the domain name when creating DataHub data points.
  - **`app.RegisterPoint`** There are multiple forms of this function with different signatures. This function associates a data point with a publish format. If the point name is null, or the form of `app.RegisterPoint` does not accept a point name, then the data point name is formed by concatenating the topic and path arguments separated by a slash and then calling the `PointNameModifier` function on the result. The full topic is formed by concatenating the `topic` and `jsonPath` arguments. If the `jsonPath` is null then it is ignored. Whenever the data point changes in the DataHub data engine, the point value will be written to the full topic.
  - **`app.WritePoint`** There are multiple forms of this function with different signatures. This function writes a value to a DataHub data point with the given *`quality`* and *`timestamp`*. At least one of *`jsonPath`*, *`pointName`*, and *`basepointName`* must be a non-empty string. The target point name will be determined as follows:
    - If *`topic`* is not null and `app.PointNameModifier` is set, a point name will be created from *`topic`* and *`jsonPath`* using `app.PointNameModifier`, otherwise
    - If *`pointName`* is null, a point name will be created from *`topic`* *`jsonPath`* using `PointNameFromTopic`, otherwise
    - *`pointName`* will be used without modification. In this case *`pointName`* must be a fully qualified name, including the `domain:` prefix.
  - **`app.WritePoint(`*`pointName, value`*`)`** Writes a value to a DataHub point with

`quality = PointQuality.Good` and a timestamp of the current system time.

- **`app.WritePoint(`*`pointName`*`, `*`value`*`, `*`quality`*`, `*`timestamp`*`)`** Writes a value to a DataHub point with the provided *`quality`* and *`timestamp`*.
- **`app.WritePoint(`*`topic`*`, `*`jsonPath`*`, `*`value`*`)`** Writes a value to a DataHub point with *`quality`* `= PointQuality.Good` and a *`timestamp`* of the current system time.
- **`app.WritePoint(`*`topic`*`, `*`jsonPath`*`, `*`value`*`, `*`quality`*`, `*`timestamp`*`)`** Writes a value to a DataHub point with the provided *`quality`* and *`timestamp`*.
- **`app.WritePoint(`*`topic`*`, `*`jsonPath`*`, `*`property`*`)`** Writes a value to a DataHub point with *`quality`* `= PointQuality.Good` and a *`timestamp`* of the current system time. The value written to the data point is the value of the `JProperty` property.
- **`app.WritePoint(`*`basePointName`*`, `*`property`*`, `*`quality`*`, `*`timestamp`*`)`** Writes a value to a DataHub data point with the given *`quality`* and *`timestamp`*. The value is provided as a `JProperty` rather than a simple value. The value written to the data point is the value of the `JProperty`.
- **`DataPoint app.ReadPoint(`*`pointName`*`)`** Reads a single data point from the DataHub data engine. This returns a `DataPoint` instance from which the value can be extracted using `point.DblVal`, `point.StrVal`, etc. The available members of a `DataPoint` are listed in the **Common Formulas** table, under **Points**, in the Advanced JSON Message Format window.
- **`DataPoint[] app.ReadPoints(`*`pointNames`*`)`** Reads multiple data points from the DataHub data engine. This is much more efficient than reading multiple points one at a time using `ReadPoint`. The list of *`pointNames`* can be any `IEnumerable`*`string`* type.
- **`DataPoint[] app.GetChildren(`*`parentname`*`, `*`pattern`*`, `*`includeLeaves`*`, `*`includeBranches`*`, `*`recursive`*`)`** Retrieves the current names and values for all child points of the *`parentname`*, a fully qualified point name, including the *`domain:`* prefix. The *`pattern`* is a globbing pattern, not a regular expression. See the `shell_match` function for the matching rules. Use the asterisk character (*) to retrieve all child points. For *`includeLeaves`* and *`includeBranches`*, an entry of `true` or `false` indicates whether to retrieve leaf or branch points, respectively. For *`recursive`*, an entry of `true` or `false` indicates whether to recursively descend into all descendent children of the parent point. If *`recursive`* is `false`, `GetChildren` will return only the immediate children of the parent point.
- **`DataPoint[] app.GetRegisteredPoints()`** Returns a list of the points that have been configured for this connection.
- **`app.Log(`*`message`*`)`** Logs a message. During testing this will write the *`message`* to the test output pane. At runtime this will write the *`message`* to the DataHub Event Log. This function does not add a newline at the end of the message.
- **`app.Debug(`*`message`*`)`** Logs a *`message`* only during testing. At runtime this will do nothing.
- **`string app.PointNameFromTopic(`*`topic`*`)`** Constructs a point name given an MQTT topic or JSON path. MQTT topics and JSON paths are sequences of path

elements separated by forward slash characters. The first character should not be a slash. The path is converted to a DataHub point name by concatenating the default domain (see `app.DefaultDomain`), a colon character (`:`), and the path elements separated by dot characters. If a path element contains a dot, it will be converted to a slash in the point name. If no default domain is set then the first element of the *`topic`* will be used as the domain name, and the point name will be constructed from all subsequent path elements. If the first element in the *`topic`* name is `app.DefaultDomain`, it is removed from the resulting point name to avoid having it included twice.

- **`string app.TopicFromPointName(`*`pointName`*`)`** Constructs a topic name from a point name. The point name (*`pointName`*) should be fully qualified, including the *`domain`*`:` *`prefix`*. All dot characters in the point name will be converted to slash characters in the resulting topic name. If the point name contains a slash character, it will be converted to a dot in the topic name. If the domain name of the point is `app.DefaultDomain` then the domain name is omitted from the resulting topic. Otherwise, the domain name in the point will be treated like any other path element.
- **`string app.Command(`*`string`*`)`** Sends a command to the DataHub data engine. Any command in the DataHub command set may be transmitted. For example, you could send a **set_canonical** command during topic initialization to set the canonical type of a generated point.

For the **Message** options, the variable `msg` contains client information for use when configuring the Advanced Parser.

- **`msg`** A global variable that contains client information:
  - **`msg.ClientId`** The client ID of the connection. In the DataHub broker this is the ID of the client that originated a message. In a DataHub client, this is the client ID from the connection configuration.
  - **`msg.IpAddress`** In the DataHub broker, this is the IP address of the connected client. In the DataHub client, this is the hostname from the connection configuration.
  - **`msg.Username`** In the DataHub broker, this is the user name that the client used to log in, or `null` if there is no username. In the DataHub client, this is the username from the connection configuration, or `null` if no username is configured.

If your script references a data point structure, such as that returned by `app.ReadPoint` or in the `point` variable in a publish format, you can access some of the metadata associated with the point. This information can be read by your script, but must not be modified.

- **`point.MetaInfo`** The engineering unit information for the point. This could be null. The following fields are available:
  - **`Eu`** A string defining the engineering units, such as `m/s` or `kPa`.
  - **`Description`** A string describing the point.
  - **`EuHigh`** A double containing the upper bound of the engineering unit range.

  - **`EuLow`** A double containing the lower bound of the engineering unit range.
  - **`InstrumentHigh`** A double containing the upper bound of the raw measurement range.
  - **`InstrumentLow`** A double containing the lower bound of the raw measurement range.
  - **`ContactCloseLabel`** A string containing the label to use for a Boolean value of true.
  - **`ContactOpenLabel`** A string containing the label to use for a Boolean value of false.
- **`point.Origin`** The information indicating the source of the most recent value written to this point. This could be null. The following fields are available:
  - **`Label`** A string containing the label of the connection that originated the value. This could be `null`or an empty string. .
  - **`Description`** A string containing the description of the connection that originated the value. This could be `null`or an empty string.
  - **`User`** A string containing the name of the user credential associated with the connection. This could be `null`or an empty string.
  - **`Host`** A string containing the IP address or DNS name of the computer that originated an inbound connection, or the IP address or DNS name of the computer to which an outbound connection is targeted. This could be `null`or an empty string.
  - **`Type`** A string containing the type of connection that originated this value. This could be `null`or an empty string.
  - **`RefCount`** An integer that approximately indicates the number of points that share this origin. This is primarily used internally, and is not expected to be exact.
- Examples

```
var pt = app.ReadPoint(point.FullName);
var metadata = pt.MetaInfo;
if (metadata != null)
{
  app.Log(LogLevel.Info, "Description: " + metadata.Description);
}
```

Topic Name Manipulation

It is sometimes necessary to modify topic names by extracting or deleting parts of the topic path. The following methods are available on any string variable.

`Extract(`*`start`*`, `*`count`*`, `*`splitChar`*` = "/")` Returns *`count`* number of topic path elements starting at *`start`*. *`Start`* can be a number from `0` to the number of path segments in the topic - `1`. If *`start`* is negative then it will count from the last segment backward, where `-1` is the last segment. If the specified *`count`* of segments is larger than the actual count then all segments from *`start`* will be returned. If *`splitChar`* is provided, the path elements will be determined by splitting the string on that character. For example:

```
var myTopic = "plant1/device1/pump1";
myTopic.Extract(1,1)   -->  "device1"
myTopic.Extract(-1,1)   -->  "pump1"
myTopic.Extract(0,2)   -->  "plant1/device1"
```

`Delete(start, count, splitChar = "/")` Returns the topic with *count* segments deleted starting at *start*. *Start* can be a number from `0` to the number of path segments in the topic - `1`. If *start* is negative then it will count from the last segment backward, where -1 is the last segment. If the specified *count* of segments is larger than the actual count then all segments from *start* will be deleted. If *splitChar* is provided, the path elements will be determined by splitting the string on that character. For example:

```
var myTopic = "plant1/device1/pump1";
myTopic.Delete (1,1)   -->  "plant1/pump1"
myTopic.Delete (-1,1)   -->  "plant1/device1"
myTopic.Delete (0,2)   -->  "pump1"
```

`Append(string, splitChar = "/")` Appends two topic paths together, taking care that exactly one separator exists between the two paths. If *splitChar* is provided, it is used as the separator between the two paths. For example:

```
var myTopic = "plant1/device1/pump1";
myTopic.Append("pressure")   -->  "plant1/device1/pump1/pressure"
```

Initialization Script

The initialization script performs any processing that only needs to be run once for a given schema. This normally consists of

- Setting callbacks if necessary.
- Setting `app.ExcludePaths`.
- Creating any functions that will be called subsequently by the parser script.
- Creating any variables used by the callbacks or parser script.

If the data rate will be high then it is more efficient to move as much code as possible from the parser script to the initialization script.

Parser Script

This is the main processing script that runs each time a new message arrives. The message has already been validated against the schema, so the script can assume that any required fields are present in the resulting `input.Json` object.

There are two broad approaches to processing a message.

1. Call `app.ProcessJson()`. This recursively descends through the JSON object,

applying callbacks at each stage.

2. Manually extract information from the `input.Json` object and construct `app.WritePoint` calls from that information.

Before calling `app.ProcessJson`, you can extract specific information from `input.Json` to set variables that will be used by the processing callbacks. One common case is a message that contains a single timestamp and multiple data values. In that case, you could extract the timestamp and store it in a local variable, then create a custom `app.ValueProcessor` that writes a data point value using `app.WritePoint` with this timestamp. To avoid creating a new data point containing this timestamp, set `app.ExcludePaths` to omit the JSON field containing the timestamp.

When working with JSON tokens, all public members of `JToken`, `JArray`, `JObject` and `JProperty` are supported. See the Newtonsoft.Json.Linq documentation for more information. In addition to the built-in methods, the following methods are also available:

- **`JProperty.FullName(property,parentName)`** Returns the concatenation of `parentName` + “/” + the property name.
- **`JObject.ObjectProperties()`** Returns a `List`*`JProperty`* representing all direct child properties of the object whose values are `JObjects`.
- **`JObject.ArrayProperties()`** Returns a `List`*`JProperty`* representing all direct child properties of the object whose values are `JArrays`.
- **`JObject.AllProperties()`** Returns a `List`*`JProperty`* representing all direct child properties of the object.
- **`JObject.ScalarNames()`** Returns a `List`*`string`* containing the names of all direct child properties whose values are scalar values.
- **`JObject.ArrayNames()`** Returns a `List`*`string`* containing the names of all direct child properties whose values are arrays.
- **`JObject.ObjectNames()`** Returns a `List`*`string`* containing the names of all direct child properties whose values are objects.
- **`JToken.GetDate(propertyName)`** Returns a `DateTime` produced by converting the value of the child property identified by *`propertyName`*. The conversion from the property value to a `DateTime` follows these rules:
  - o If the value is a string, attempt to parse the value as an ISO-8601 timestamp.
  - If the value is a number:
    - If the value is > `10 * Int32.MaxValue`, treat the value as a JSON timestamp (number of milliseconds since Jan. 1, 1970)
    - Else, if the value is > `20,000`, treat the value as a UNIX timestamp (number of seconds since Jan. 1, 1970)
    - Else, if the value is > `0`, treat the value as an `OADate` (days since midnight, December 30, 1899)
    - Else, return Jan. 1, 1970.

- If the value is a `Date`, return the date unmodified.

The following functions are available to interpret timestamps. All UNIX and JSON timestamps are assumed to be in UTC. All `DateTime` results from timestamp conversion functions are explicitly in UTC.

- **`DoubleToDateTime(value)`** Convert a number to a `DateTime` according to the number rules in `JToken.GetDate()` above.
- **`GetDate(JValue)`** Convert a JSON token to a `DateTime` according to the rules in `JToken.GetDate()` above.
- **`DateFromIsoString(string)`** Convert a string in ISO-8601 format to a `DateTime`.
- **`DateFromUnixTime(seconds)`** Convert a UNIX timestamp (seconds since Jan. 1, 1970) to a `DateTime`.
- **`DateFromJsonTime(milliseconds)`** Convert a JSON timestamp (milliseconds since Jan. 1, 1970) to a `DateTime`.
- **`DateTime.ToUnixTime()`** This is a method on a `DateTime` variable that produces a long integer number of seconds since January 1, 1970.
- **`DateTime.ToJsonTime()`** This is a method on a `DateTime` variable that produces a long integer number of milliseconds since January 1, 1970.
- **`DateFromOADate(days)`** Convert an `OADate` (days since midnight, December 30, 1899) to a `DateTime`.

Common Formulas

For convenience, formulas and methods for S-Sharp scripts are listed in the **Common Formulas** pane. Those whose meaning or use is not self-evident are documented here or in other parts of this book. S-Sharp is documented here.

Application - see Script Execution.

JSON - see Parser Script.

Message - See Script Execution - Message.

Points - data point information and meta-information.

LogLevel - severity settings for error message logs.

PointQuality - all available point quality values.

Math - built-in math functions.

Publish Formats

Some MQTT devices can both transmit (publish) and receive (subscribe) data, providing a level of control over the device via MQTT messages. The format of the messages sent to the device is often very different from the format of messages that the device publishes. In some cases, the device may expect a different message format for different topics to which it subscribes.

Most MQTT topics published by a device are used only for transmission from the device, and not for receipt of commands or data from other sources. If the device subscribes to some topics, they are usually different from the topics to which it publishes. An MQTT broker communicating with that device must know the names of the topics to which the device publishes, and the names of the topics to which the device subscribes. Since the device does not publish data on the subscribed topics, an MQTT broker cannot identify those topics by their traffic. Instead, the MQTT broker must know how to form the topics to which the device subscribes based on some a-priori knowledge. The DataHub advanced MQTT parser provides a method for scripting this knowledge.

The DataHub advanced formatting mechanism supports multiple publish formats for a single receive format. The receive format implicitly identifies the type of device by matching a message to a JSON schema. Associating multiple publish formats with that device type accommodates the possibility that the device requires different publish formats for different topics.

Messages are published by the DataHub MQTT Broker or Client based on changes to data point values. The advanced message format must specify which data points will be mapped to which MQTT topics and publish formats to automatically publish the correct message to the correct topic when the relevant value changes. This is done by calling the `app.RegisterPoint()` function within the `app.TopicInitialization()` function defined by the system integrator. One of the arguments to `app.RegisterPoint()` is the label of a publish format. Another argument is the data point name, which must be constructed from the incoming topic, or from the payload of the incoming message. A third argument is the topic on which to publish a message. Once `app.RegisterPoint()` has been called, the DataHub engine will build a message and publish it on the specified topic whenever the point value changes.

Publish formats are specified using an ASP document specification. This is a simple format that combines literal text with scripting to create a primarily static document with some dynamic content. This can be used to create any text document, though in MQTT it is primarily used to create JSON messages.

If you select a publish format as the default by checking the associated check box, that format will be used whenever a value change occurs on a point that is associated with this topic, and for which no explicit publish format is specified.

Specifying ASP Documents

An ASP document is a primarily static document with script snippets embedded within it using a special syntax:

- **<%= expression %>** (With an = sign) Evaluates the expression and inserts the result as a string into the output document, replacing all characters from the opening <%= to the closing %>. The expression is not a complete statement and must not end with a semicolon character or other statement completion syntax. For example, `3 + 2` is an expression. `x = 3 + 2;` is a statement.

- **<% statement or fragment %>** (Without an = sign) Evaluates the statements within the delimiters, and deletes all characters in the output document from the opening <% to the closing %>. The code within the delimiters does not need to be a complete statement. A single statement could be split across multiple occurrences of the <% %> pair. This allows you to, for example, create a loop that mixes literal text with computed values by breaking the opening and closing braces of the loop body across multiple <% %> regions. The concatenation of all statements and statement fragments must form a syntactically correct script.
- **All other characters** All characters, including white space, not contained within <%= %> or <% %> pairs are treated as literal text and simply copied to the output document.

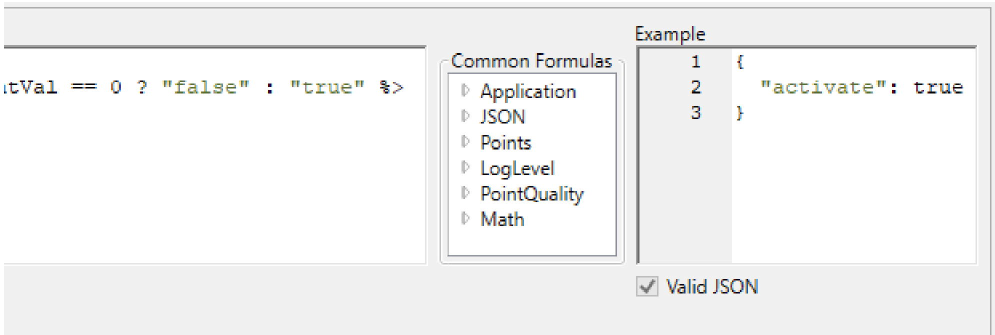
When an ASP document is evaluated, all code within the special delimiters is evaluated to construct the output document. This document is then published to the MQTT topic associated with the data point whose value has changed.

When an ASP document is being evaluated, the following variables and functions are available, in addition to many standard C# classes and methods:

- **app** This is an object that supplies methods and data members, described in the Receive Format section above.
- **`pathData`** This is an object that supplies information about the topic to which this message will be published. It provides the following members:
  - **`pathData.JsonPath`** A JSON element path associated with this topic and point. This is the path supplied as the second argument to `app.RegisterPoint` when this association was made.
  - **`pathData.PointName`** The name of the point that triggered this publication.
  - **`pathData.Topic`** The topic on which to publish this message.
  - **`pathData.AspPublishName`** The name of the publish format currently being evaluated.
  - **`pathData.FullTopic`** The concatenation of `Topic` + `"/"` + `JsonPath`.
- **`point`** The `DataPoint` that triggered this publication.

Testing a Publish Format

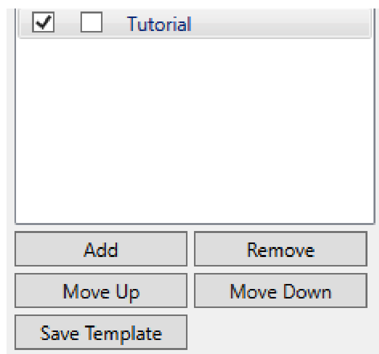
As you type into the ASP document editor, your documents will be periodically evaluated using synthetic data in place of actual names and values. The result of that evaluation will be displayed in the **Example** panel. If the result is a valid JSON document, the **Valid JSON** check-box will become checked.



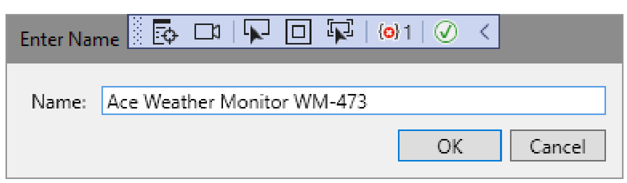
Exporting, Importing and Duplicating Parsers

Creating a parser for a device can be intricate and time-consuming. You may want to re-use your parser definitions in other projects, without the need to reconstruct the parsing and publishing scripts.

To save a parser configuration as a template, select the schema in the list, and then press the **Save Template** button below the parser list.



You will be prompted for a template name. Choose a name that represents the type of device for which this configuration applies.



The template will then be saved to disk in your DataHub configuration folder and added to the "Templates" list beneath the list of parsers.

You can create a parser configuration from this template by selecting the **+** button or double-clicking the template name. You can delete the template completely from disk by pressing the **X** button.

When you press the **+** button, a new parser definition is created based on the template and added to the parser list. This allows you to save a configuration and then duplicate it to make changes that would be typical of related devices from the same manufacturer. You can change the name of a parser in the parser list by double-clicking its name.

To export the template to a file, select the template in the Templates list and then press the **Export...** button. You will be prompted to store the template file on disk. You can copy this file to another system and use the **Import...** button to load that template into your Templates list on the destination system. As you work with more MQTT devices your library of templates will grow, reducing the time and effort of subsequent projects.

Broker $SYS Topics

Here is a list of the $SYS topics in the DataHub MQTT broker. You can also get a live view of the $SYS topics by creating a DataHub MQTT client connection in a DataHub instance that connects to the MQTT broker in the same DataHub instance. Subscribe to the topic pattern $SYS/# to see all $SYS topics.

`$SYS/broker/bytes/received`
: The total number of bytes received since the broker started.

`$SYS/broker/bytes/sent`
: The total number of bytes sent since the broker started.

`$SYS/broker/clients/active`
: Deprecated: see $SYS/broker/clients/connected

`$SYS/broker/clients/connected`
: The number of currently connected clients.

`$SYS/broker/clients/maximum`
: The maximum number of clients that have been connected to the broker at the same time.

`$SYS/broker/clients/total`
: The total number of active and inactive clients currently connected and registered on the broker.

`$SYS/broker/load/bytes/received/+`
: The moving average of the number of bytes received by the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/broker/load/bytes/received/15min`. The value returned represents the number of bytes received in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/load/bytes/sent/+`
: The moving average of the number of bytes sent by the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/`

`broker/load/bytes/sent/15min`. The value returned represents the number of bytes sent in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/load/connections/+`
: The moving average of the number of `CONNECT` packets received by the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/broker/load/connections/15min`. The value returned represents the number of connections received in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/load/messages/received/+`
: The moving average of the number of all types of MQTT messages received by the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/broker/load/messages/received/15min`. The value returned represents the number of MQTT messages received in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/load/messages/sent/+`
: The moving average of the number of all types of MQTT messages sent by the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/broker/load/messages/sent/15min`. The value returned represents the number of MQTT messages sent in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/load/publish/sent/+`
: The moving average of the number of all types of `PUBLISH` messages sent by the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/broker/load/publish/sent/15min`. The value returned represents the number of `PUBLISH` messages sent in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/load/sockets/+`
: The moving average of the number of socket connections opened to the broker over different time intervals. The final + of the hierarchy can be `1min`, `5min` or `15min`, like this: `$SYS/broker/load/publish/sent/15min`. The value returned represents the number of socket connections in 1 minute, averaged over 1, 5 or 15 minutes.

`$SYS/broker/messages/received`
: The total number of messages of any type received since the broker started.

`$SYS/broker/messages/sent`
: The total number of messages of any type sent since the broker started.

`$SYS/broker/messages/stored`
: The number of messages currently held in the message store. This includes retained messages and messages queued for durable clients.

`$SYS/broker/publish/bytes/sent`
: The total number of bytes in `PUBLISH` messages sent since the broker started.

`$SYS/broker/publish/messages/sent`
: The total number of `PUBLISH` messages sent since the broker started.

`$SYS/broker/retained messages/count`
: The total number of retained messages active on the broker.

`$SYS/broker/store/messages/bytes`
: The number of bytes currently held by message payloads in the message store. This includes retained messages and messages queued for durable clients.

`$SYS/broker/store/messages/count`
: The number of messages currently held in the message store. This includes retained messages and messages queued for durable clients.

`$SYS/broker/subscriptions/count`
: The total number of subscriptions active on the broker.

`$SYS/broker/uptime`
: The amount of time that the broker has been running, in a human-readable form.

`$SYS/broker/version`
: The version of the broker. Static.

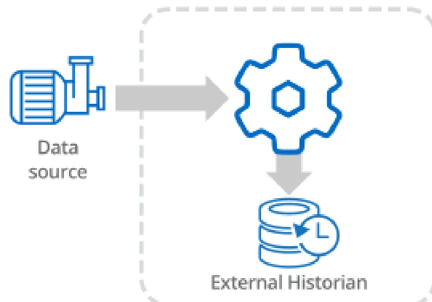
Using the External Historian

Typical Scenarios

Here are some typical scenarios for working with an External Historian.

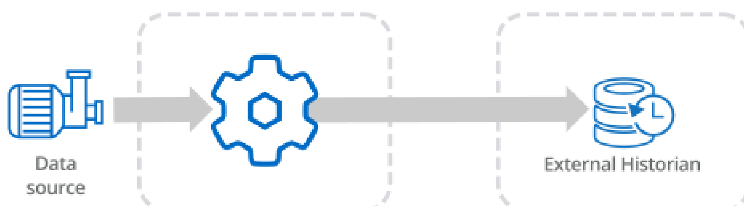
External Historian 1 - Local Connection

For storing data on an external historian running on the same computer as the DataHub instance. This can be used with any supported historian. See Connecting.



External Historian 2 - Networked Connection

For storing data on a networked external historian. This can be used with any supported historian. See Connecting.

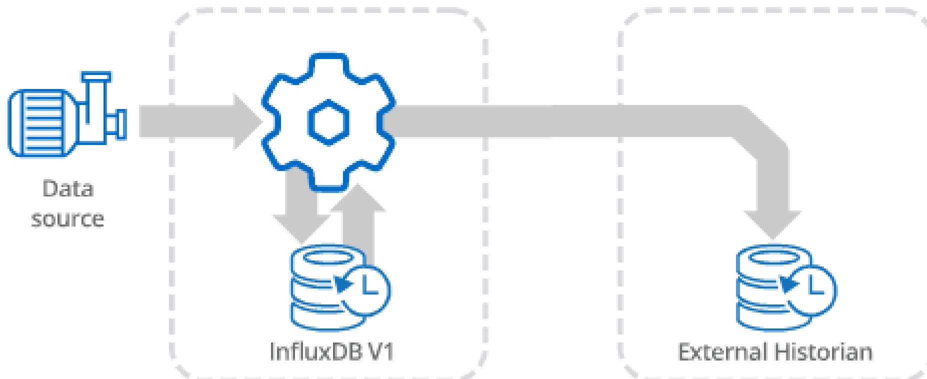


The DataHub program supports AVEVA's store-and-forwarding functionality for AVEVA Historian and AVEVA Insight over this kind of networked connection.

External Historian 3 - Local and Networked Connection for Store & Forward

For storing data on a local external historian, and forwarding it to a networked external historian. The local historian for this scenario can be either InfluxDB v1 or an ODBC database with the proper configuration. Since InfluxDB is supported only on 64-bit Windows operating systems, the OS must be 64-bit for that option.

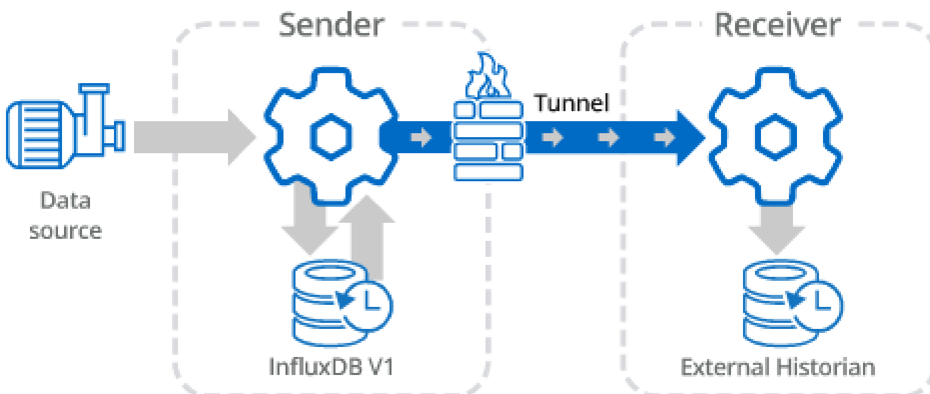
The networked historian can be any supported historian. This involves creating two historian connections. The first connection stores data from the data source into the local historian, and the second retrieves data from the local historian and writes it to the networked historian. See Store and Forward.



In many cases it is more secure to send the External Historian data across a tunnel. Here are some typical scenarios:

External Historian 4 - Tunnel (Push)

The DataHub instance on the sending side pushes data from its external historian across a tunnel to the receiving side, where it is stored in an external historian there. The historian on the sending side must be InfluxDB or an ODBC database with the proper configuration. The historian on the receiving side can be any supported historian. See Tunnel (Push).

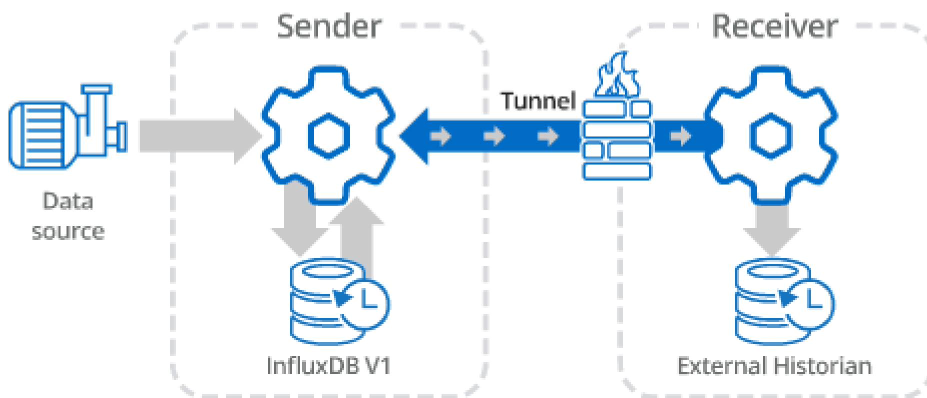


Configuration

- **Sending DataHub instance** is a Tunnel Slave that initiates the connection.
- **Receiving DataHub instance** is a Tunnel Master that receives the connection.

External Historian 5 - Tunnel (Pull)

The DataHub instance on the receiving side pulls data from the external historian on the sending side across the tunnel, and stores it in the external historian on the receiving side. The historian on the sending side must be InfluxDB or an ODBC database with the proper configuration. The historian on the receiving side can be any supported historian. See Tunnel (Pull).



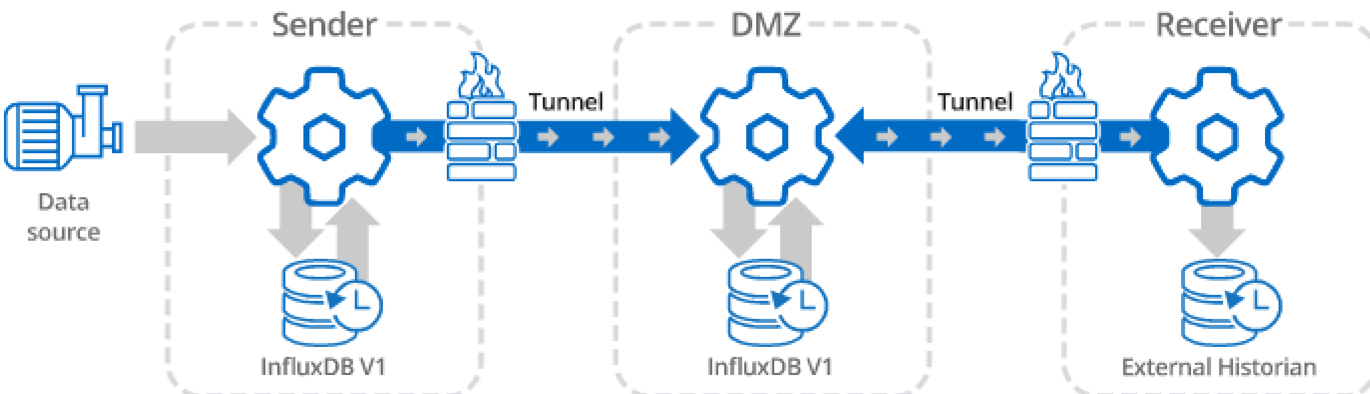
Configuration

- **Sending DataHub instance** is a Tunnel Master that receives the connection.
- **Receiving DataHub instance** is a Tunnel Slave that initiates the connection.

External Historian 6 - Tunnel through DMZ

This scenario daisy chains a tunnel push and a tunnel pull through a DMZ. The DataHub instance on the sending side pushes data to the DataHub instance on the DMZ, which stores it in InfluxDB. At the same time, the DataHub instance on the receiving side pulls the data from the DMZ DataHub instance and stores it in its historian, the final destination. This high-security configuration allows you to keep firewalls on both the sending and receiving side closed. See Using a DMZ.

The historians on the sending side and the DMZ must both be InfluxDB. The historian on the receiving side can be any supported historian.



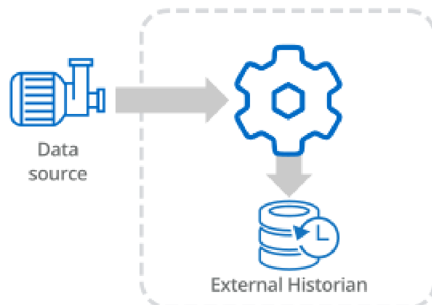
Configuration

- **Sending DataHub instance** is a Tunnel Slave that initiates a connection.
- **DMZ DataHub instance** is a Tunnel Master that receives the connections.
- **Receiving DataHub instance** is a Tunnel Slave that initiates a connection.

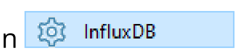
Connecting

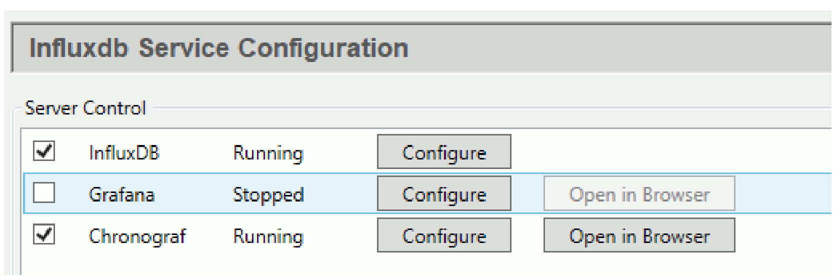
All scenarios for the DataHub External Historian begin with a connection from a DataHub instance to a historian. To follow these examples we recommend using InfluxDB v1 because it ships and installs with the DataHub Full archive, and it is the best option for store and forwarding.

Here's how to configure a connection.



Preliminaries

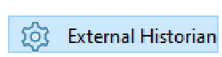
1. Ensure that the DataHub program is installed and running.
2. In the DataHub Properties window, go to the InfluxDB option  and check the boxes for InfluxDB and Chronograf, and click **Apply**.

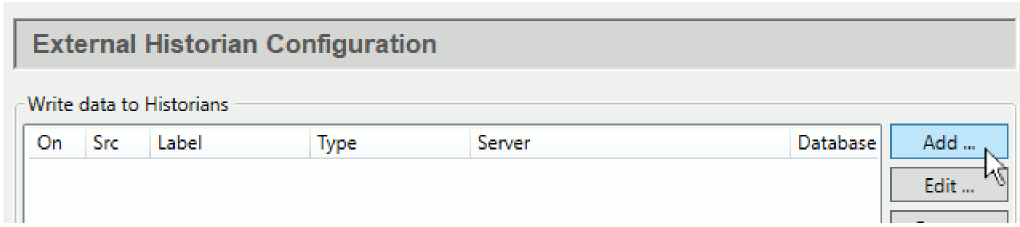


The online product documentation for InfluxDB and Chronograf can be found here.

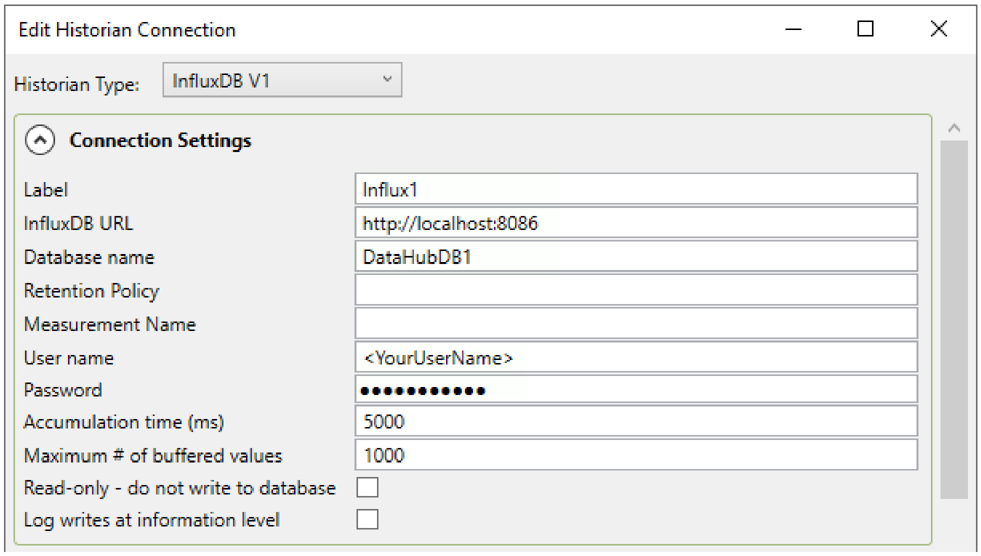
3. Start DataPid, and check the Data Browser to ensure that its data is updating.

External Historian

1. In the DataHub External Historian option  click the **Add** button.

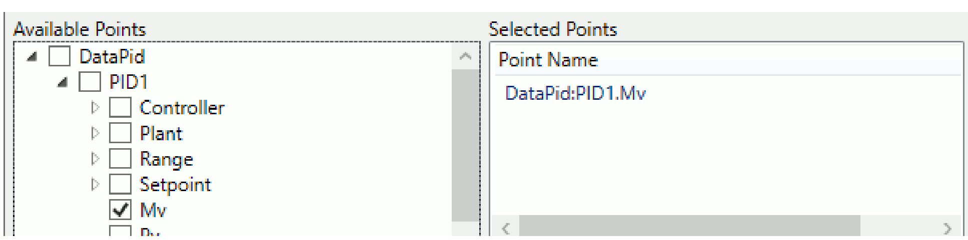


2. In the Edit Historian Connection window, configure a local InfluxDB connection as follows:



If you don't have a user name or password for InfluxDB, you can leave those fields blank. If you have previously installed InfluxDB independently of the DataHub program installation, then you'll need to use your existing InfluxDB URL.

3. In **Available Points** select just the `Mv` point in the `DataPid` domain, under `PID1`. You can add more points later, if you'd like.



The point `DataPid:PID1.Mv` will appear in **Selected Points**.

When finished, click **OK** and **Apply**. You have now created an InfluxDB database and are collecting a history of values for the `DataPid:PID1.Mv` point.

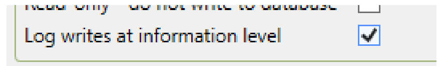
Checking Updates

It is possible to check updates using the DataHub Event Log.

1. Select your connection in the **Write data to Historians** list and click the **Edit** button

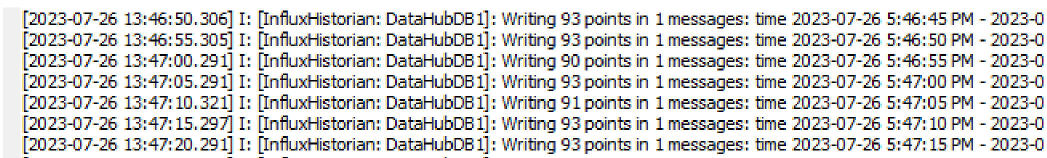
to open it.

2. In the **Connection Settings**, check the **Log writes at information level** box, and click **OK** and **Apply**.



If this box is not checked, this information is only displayed in the Event Log when its **Debug** option is selected.

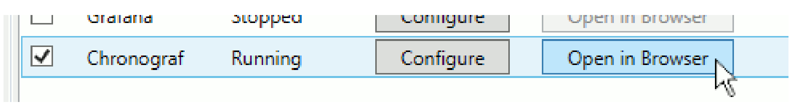
3. Open the Event Log to view data updates.



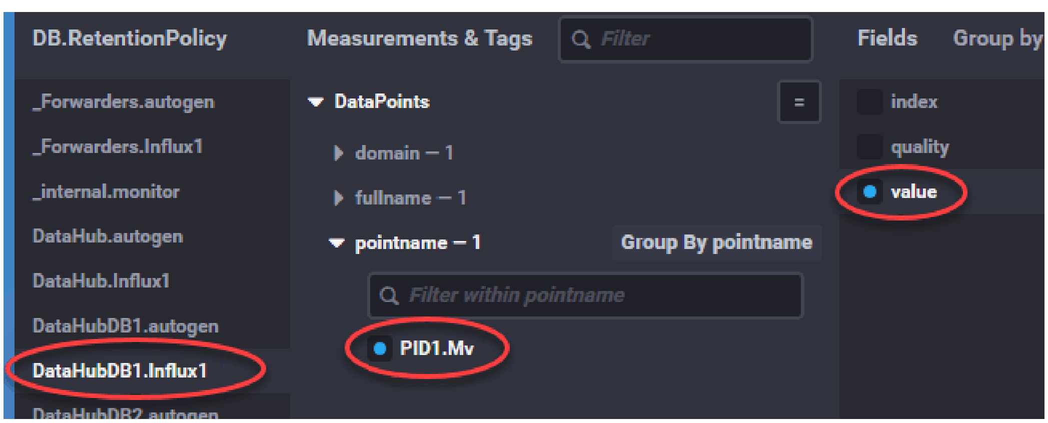
Check Chronograf

You can check Chronograf to view updates to the InfluxDB database.

1. In the InfluxDB option, ensure that both InfluxDB and Chronograf are running, and click the Chronograf **Open in Browser** button.



2. Go to **Dashboards** and click **+ Create Dashboard**, then **+ Add Data**.
3. Choose **DataHubDB1.Influx1**, in **DataPoints** choose **pointname** then **PID1.Mv**.



4. Under **Fields** select **value**.

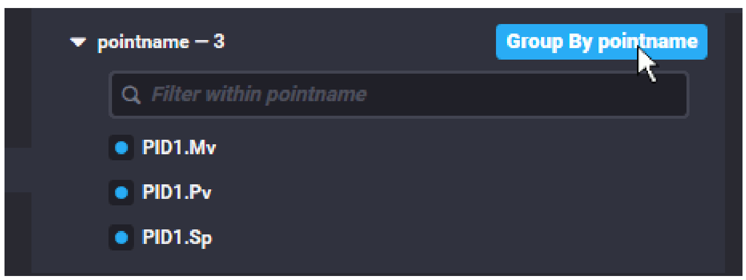
You should start to see some data appear in the trend at the top of the display. You can change the dashboard name from `Untitled Graph` to `Source (DH1) Logged to Influx1`, and click the green checkbox to save the dashboard.

Please refer to the Chronograf documentation for more details.

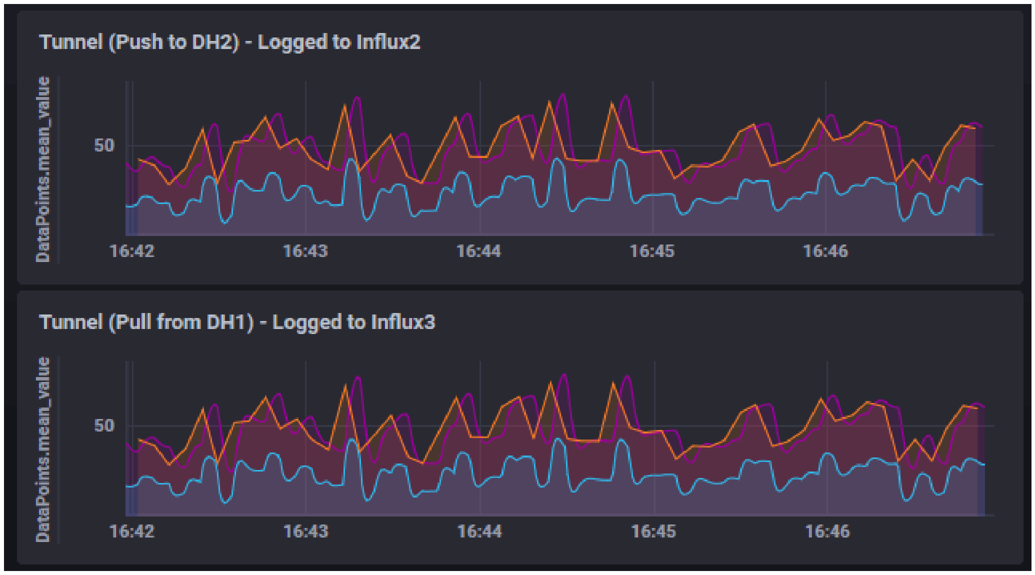
Adding Points

You can add more points by simply adding them to the External Historian configuration.

1. Select your connection in the **Write data to Historians** list and click the **Edit** button to open it.
2. In **Available points** select more points, such as `DataPid:PID1.Pv` and `DataPid:PID1.Sp`.
3. When finished, click **OK** and **Apply**. You are now collecting historical data on these points as well.
4. You can check your results in Chronograf. You will need to reconfigure the graph by selecting the two additional points, and turning on the **Group by pointname** option.

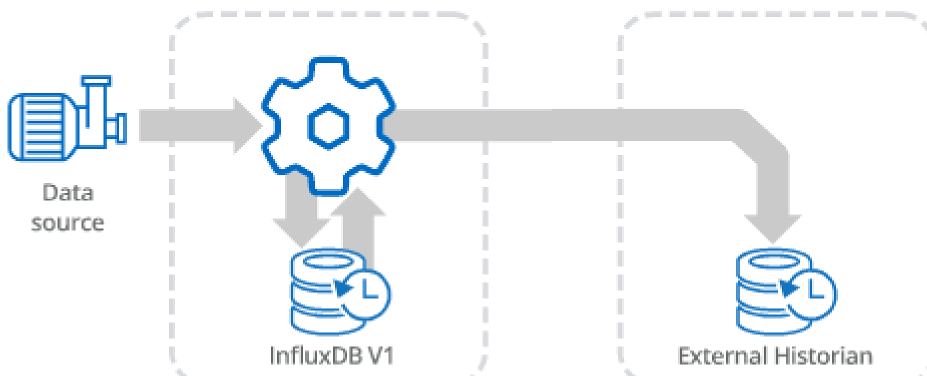


There should now be three trend lines in each display.



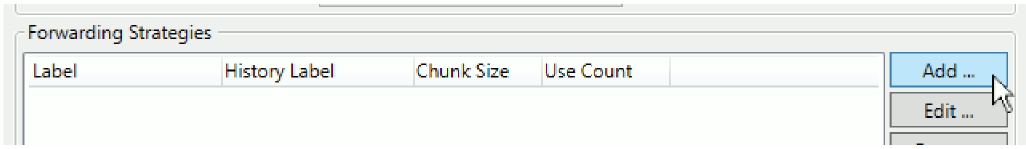
Store and Forward

The External Historian feature supports store and forward capability for networked connections, which helps prevent data loss should connectivity be temporarily suspended. Data is continually collected and stored on a local copy of InfluxDB, and forwarded to the target historian whenever the network connection is or becomes available.

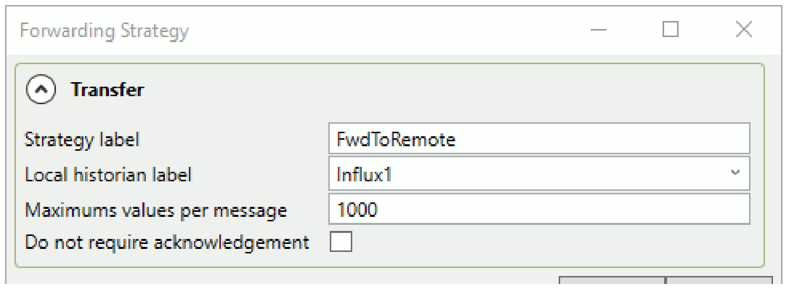


Here is how to configure store and forwarding to a remote historian:

1. Configure a local connection to InfluxDB, as explained in the previous section. This instance of InfluxDB will be used to collect and store the data, and can also be used to access and view the data locally.
2. The External Historian requires a strategy for forwarding the data. In the External Historian option of the Properties window, go to **Forwarding Strategies** and click the **Add** button.

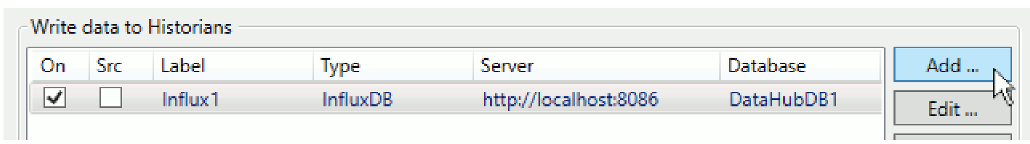


3. For the **Strategy label** enter **`FwdToRemote`**, and set the **Local historian label** to **`Influx1`** because that is the source of the data you will be forwarding.

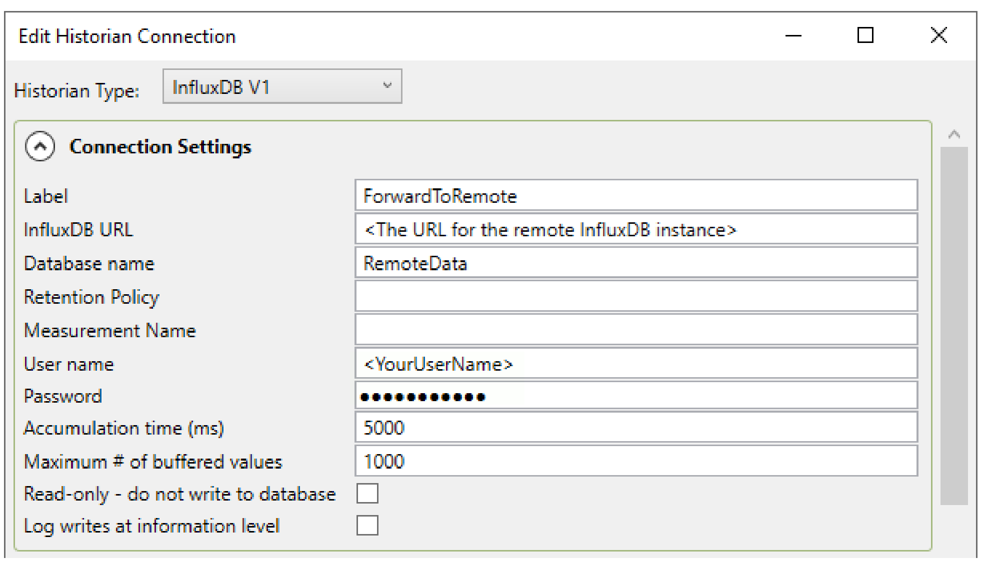


When finished, click **OK** and **Apply**.

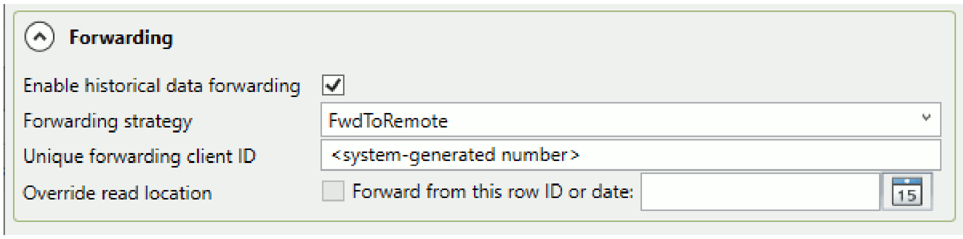
4. Now you need to configure the target historian. In the **Write data to Historians** area click the **Add** button.



5. Choose a historian type, and configure it for the relevant entries specific to your target database. Please refer to Supported Historians for more information on the various options. In this example we are using **InfluxDB V1**.



6. Further down in the same dialog, you will need to configure **Forwarding** by checking the **Enable historical data forwarding** box. For the **Forwarding Stategy** select **FwdToRemote** that you configured above.

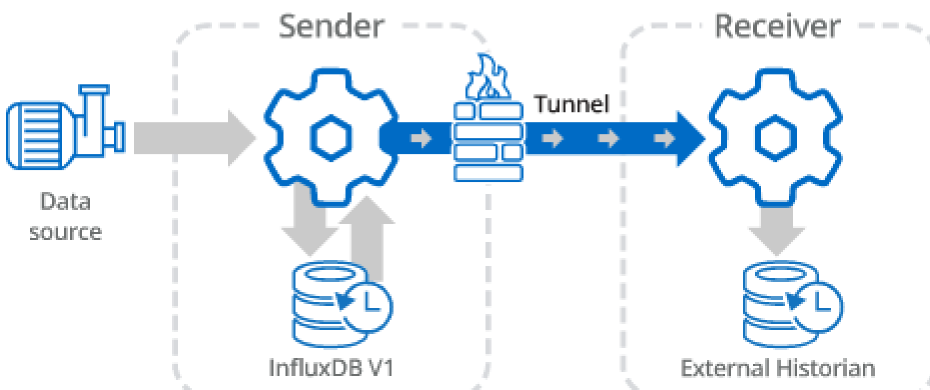


Notice that enabling data forwarding deselects the **Available Points** in the point picker. This is because you will be forwarding all of the points from the data.

7. When finished, click **OK** and **Apply**. Your data should now be forwarding to the remote historian.

Tunnel (Push)

The DataHub program can use its Tunnel/Mirror feature to forward historical data between configured external historians. Like real-time tunneling, historical data tunnelling uses a DataHub instance on each end of the tunnel. One DataHub instance gathers data from a source, and sends it across to the other DataHub instance, which writes it to the historian.



Since each DataHub instance functions independently, you can write data to a local external historian on the sending side, as well as tunnelling it. This lets you store and forward data to maintain a complete data set despite any network problems.

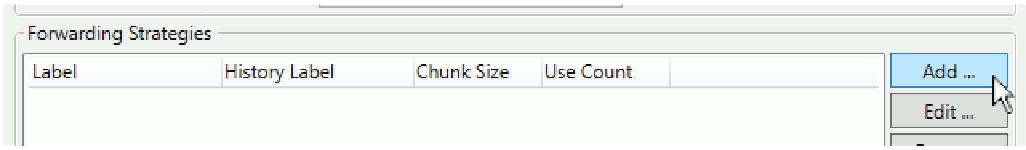
The external historian used for all sending DataHub instances must be InfluxDB, which requires a 64-bit Windows operating systems.

The tunnel itself can be configured either to push data from the sender to the receiver, or to have the receiver pull data from the sender. In this first example we will write the values from a DataPid point to an InfluxDB historian locally, and simultaneously push those values to another InfluxDB historian across the network. The sending DataHub instance will be configured to forward any values lost due to network failure, using data from the local InfluxDB database.

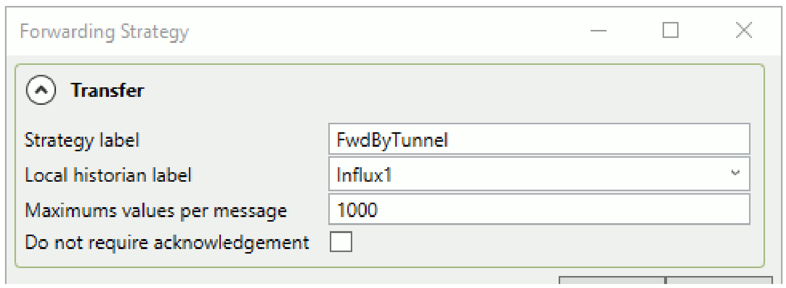
This example assumes that you have successfully configured a connection to InfluxDB as described in Connecting, and continues from there.

Forwarding Strategies

1. In the DataHub External Historian, in **Forwarding Strategies**, click the **Add** button:



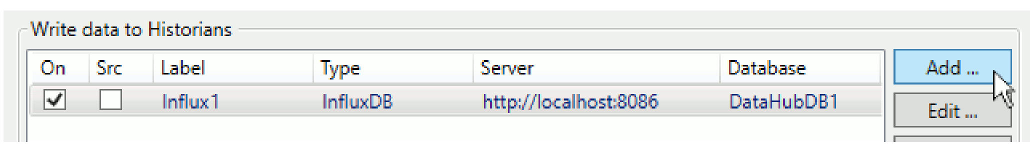
2. Configure a forwarding strategy as follows:



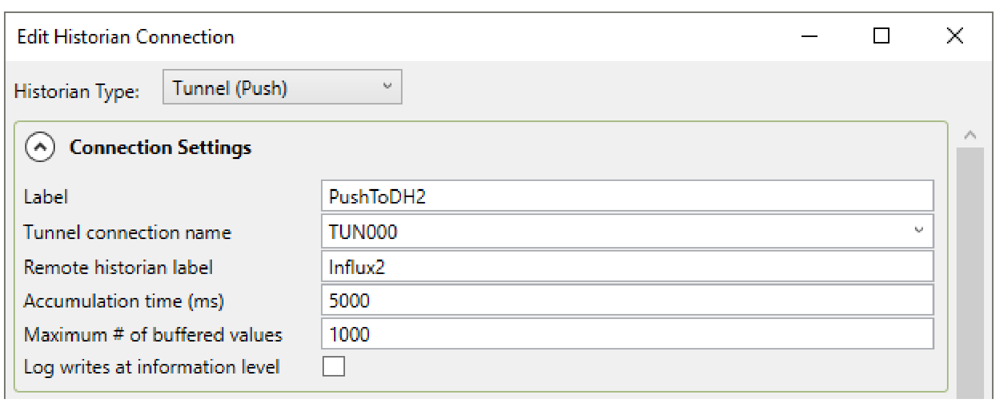
   - **Strategy Label**: **`FwdByTunnel`**
   - **Local historian label**: **`Influx1`**

   When finished, click **OK** and **Apply**. This forwarding strategy will be used in the historian tunnel, which you will configure next.

3. In the **Write data to Historians** area click the **Add** button.



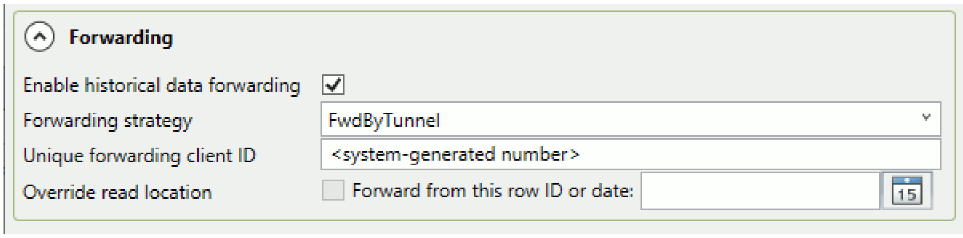
4. Choose a **Tunnel (Push)** connection, and configure it like this:



   - **Label**: **`PushToDH2`**
   - **Tunnel connection name**: **`TUN000`**

- **Remote historian label**: `Influx2`

5. You will also need to configure **Forwarding**, like this:

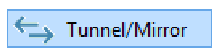


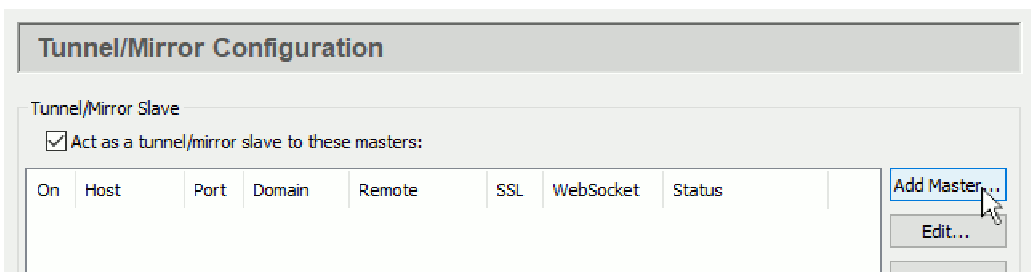
- **Enable historical data forwarding**: **checked**
- **Forwarding strategy**: **`FwdByTunnel`**

Notice that when you check **Enable historical data forwarding**, the **Available Points** are deselected. This is because you will be forwarding all of the points from the data. When finished, click **OK** and **Apply**.

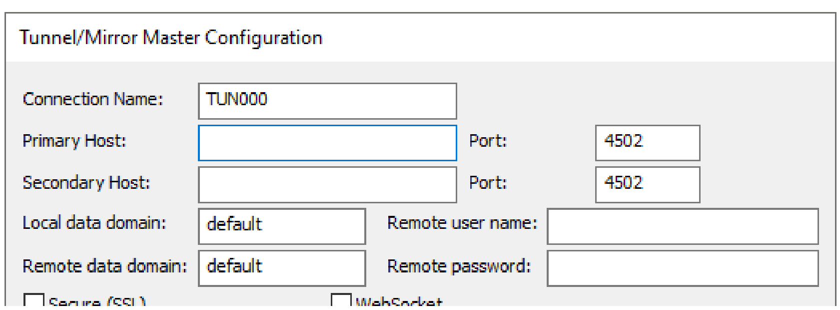
Tunnel/Mirror

To move the data across to the receiving DataHub instance you will need to configure a Tunnel/Mirror connection.

1. In the Tunnel/Mirror option  click the **Add Master** button.



2. Configure the following:



- **Connection Name**: Use the pre-entered value of `TUN000`.
- **Primary Host**: The name or IP address of the receiving side computer.
- **Port**: Keep the default of `4502`.

You can leave all other options at their default settings. When tunnelling external historian data, the local and remote data domain names are not used, and the data flow and connection options are ignored.

3. When finished, click **OK** and **Apply**.

   If the DataHub instance on the receiving side is installed and running, and has its Tunnel/Mirror Master configured for port 4502 (the default), then the tunnel Status should soon change to **Running**.

Now you are ready to configure the receiving side.

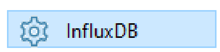
Receiving Side

On the receiving side of this example we will accept a tunnelling connection from the sending DataHub instance, and write values to an InfluxDB database on this computer. The stored values on both InfluxDB databases (sending and receiving sides) will be identical.

Preliminaries

As with the sending side, you will need to:

1. Ensure that the DataHub instance is installed and running on the computer where you want to receive the data.

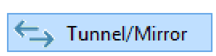
2. Go to the InfluxDB option 

and check the boxes for InfluxDB and Chronograf, and click **Apply**.

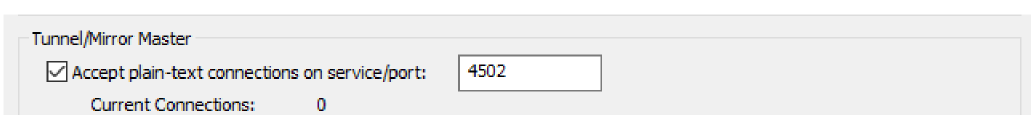
There is no need to run DataPid on this side.

Tunnel/Mirror

To receive the data from the sending DataHub instance you will need to ensure that Tunnel/Mirror Master is configured.

1. In the Tunnel/Mirror option 

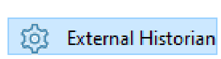
go to the Tunnel/Mirror Master section and make sure that the **Accept plain-text connections** box is checked.



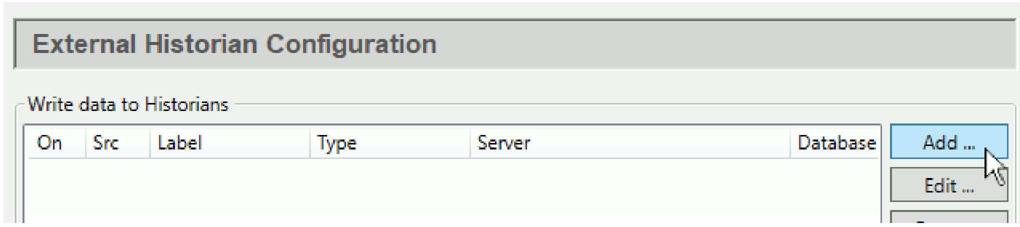
2. Leave the default service/port number at `4502`.

3. Click **Apply**.

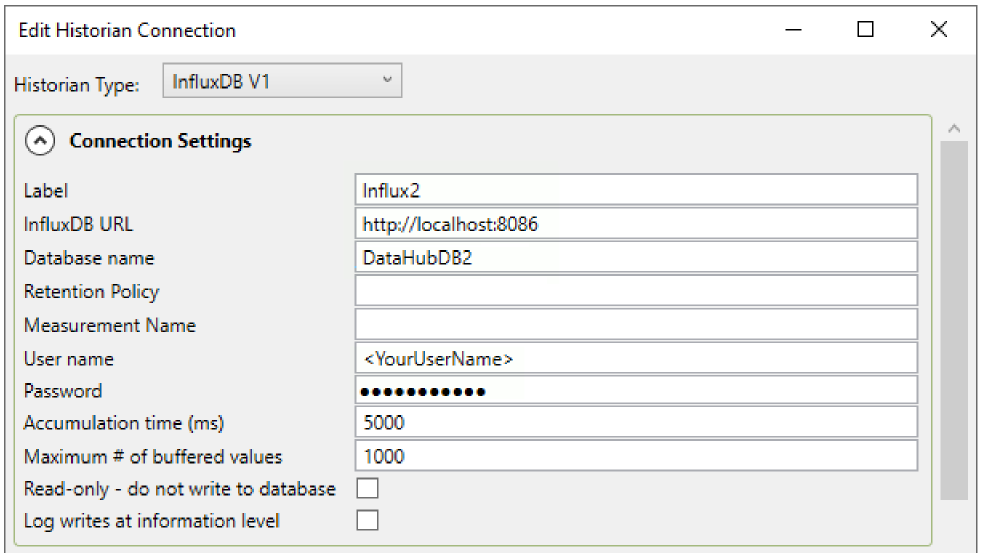
External Historian

1. In the External Historian option 

click the **Add** button.



2. In the Edit Historian Connection window, configure the local InfluxDB connection as follows:



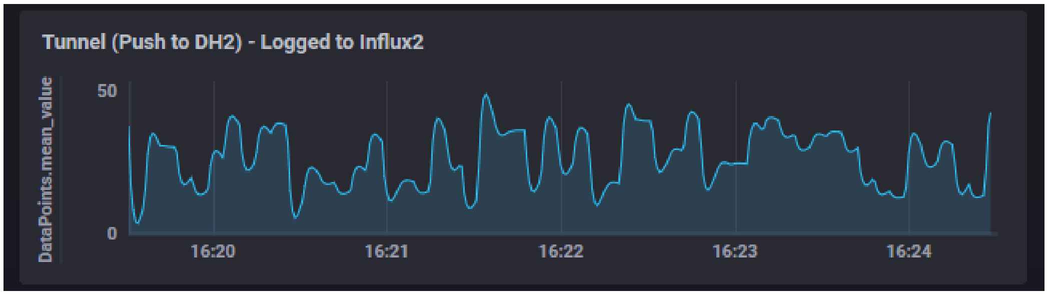
If you have previously installed InfluxDB independently of the DataHub program installation, then you'll need to use your existing InfluxDB URL. And if you don't have a user name or password for InfluxDB, you can leave those fields blank.

When finished, click **OK** and **Apply**. You have now created an InfluxDB database on the receiving side, and are remotely collecting a history of values for the `DataPid:PID1.Mv` point.

3. As on the sending side, you can check Chronograf on this side to view updates to the InflluxDB database.

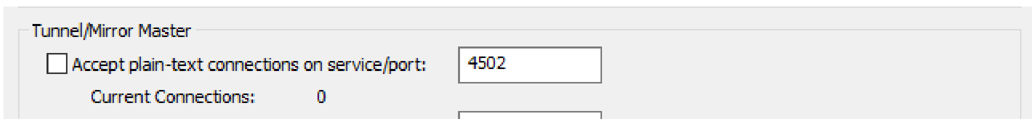
   In Chronograf, go to **Dashboards** and click **+ Create Dashboard**, then **+ Add Data**. Choose **DataHubDB2.Influx2**, in **DataPoints** choose **pointname** then **PID1.Mv**, and under **Fields** select **value**.

   The trend line for the `Mv` point should fill in with data from the sending side.



You can test the store and forward feature as follows:

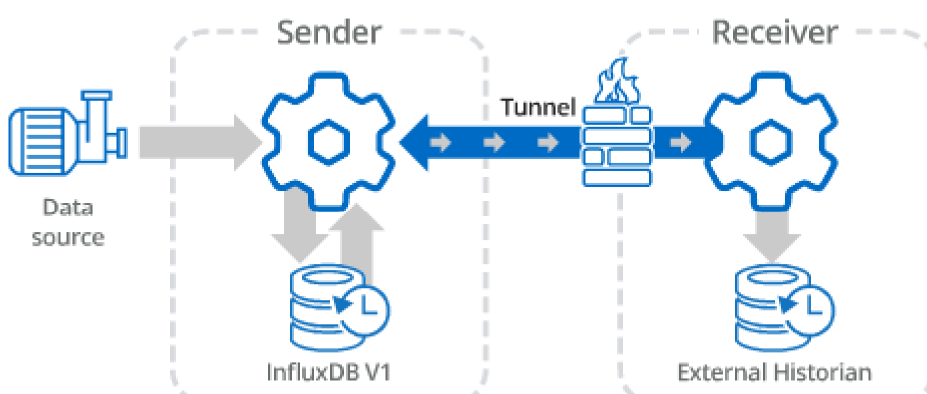
1. In the DataHub Tunnel/Mirror Master option uncheck the **Accept plain-text connections** box and click **Apply**.

   This simulates a network break.
2. Look at your trend in Chronograf. You should see the data stop updating on the receiving side.
3. After 10 or 15 seconds, recheck the **Accept plain-text connections** box and click **Apply**. The lost data should get filled in, and updates continue normally.

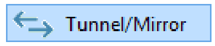
Tunnel (Pull)

So far the tunnelling example has used a **Tunnel (Push)** connection, where the sending DataHub instance pushes data to the receiving DataHub instance. But it is also possible to pull the data from the sending DataHub instance, using **Tunnel (Pull)**. This allows you to make an outbound tunnelling connection from the receiving side, which can be useful in some configurations.

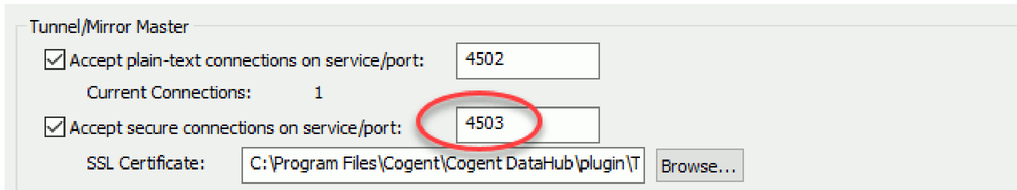


This section builds on the previous two. For the best outcome, we recommend working through those sections first if you have not already done so.

On the Sending Side

In the Tunnel/Mirror option 

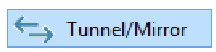
go to the Tunnel/Mirror Master section and make sure that the **Accept secure connections** box is checked, with the default service/ port number `4503`.



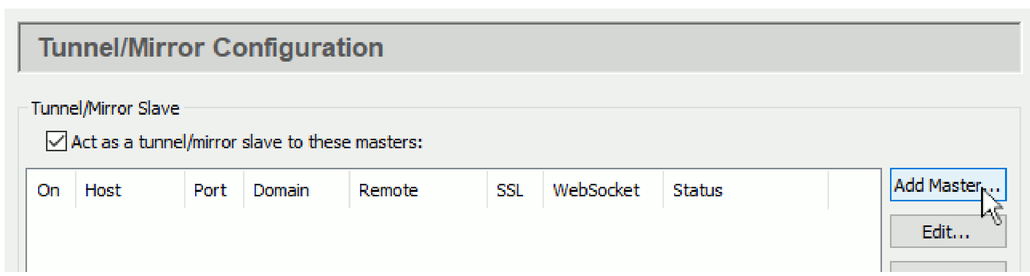
We use this port in this example to demonstrate that this tunnelling works over SSL, and so we can enable and disable each connection independently.

When finished, click **OK** and **Apply**.

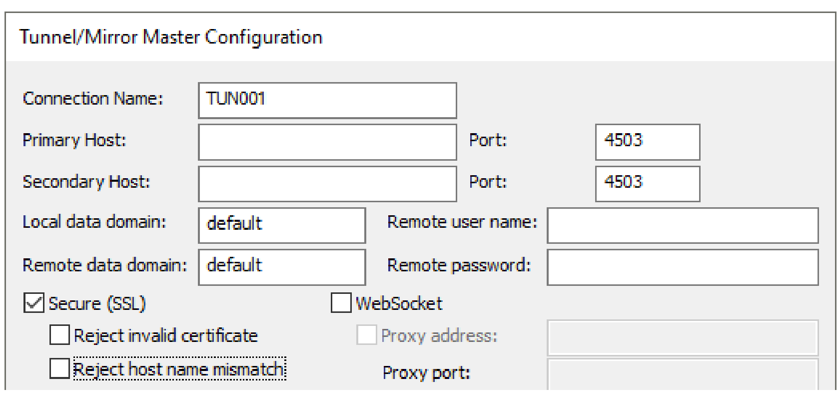
On the Receiving Side

1. In the Tunnel/Mirror option 

click the **Add Master** button.



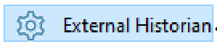
2. Configure the following:



- **Connection Name**: Enter **`TUN001`**.
- **Primary Host**: The name or IP address of the sending side computer.
- **Port**: Set it to **`4503`** to match the SSL port on the sending side.

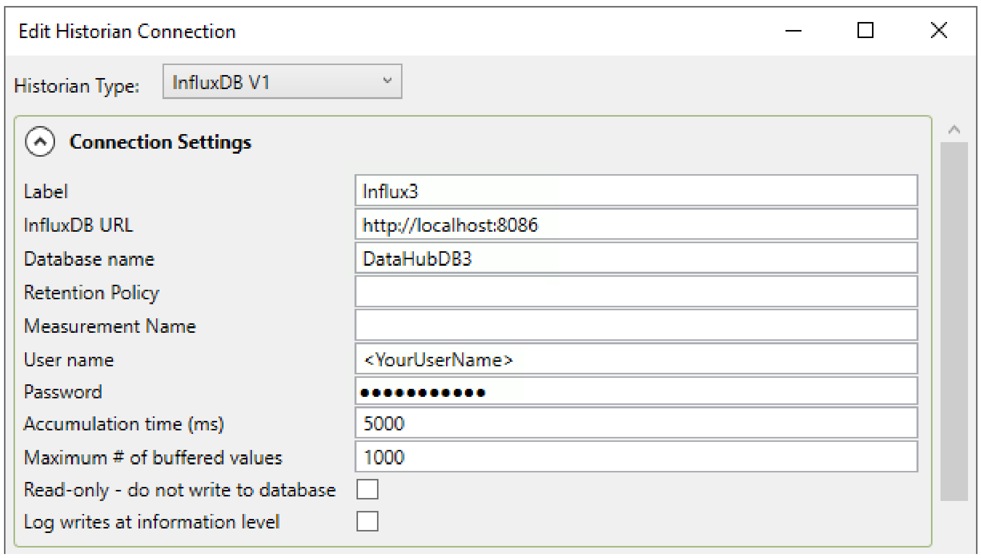
You can leave all other options at their default settings. When tunnelling external historian data, the local and remote data domain names are not used, and the data flow and connection options are ignored.

When finished, click **OK** and **Apply**.

3. To keep this data separate from the Tunnel(Push) connection, you will need to configure a separate InfluxDB database in the **External Historian** option 

.

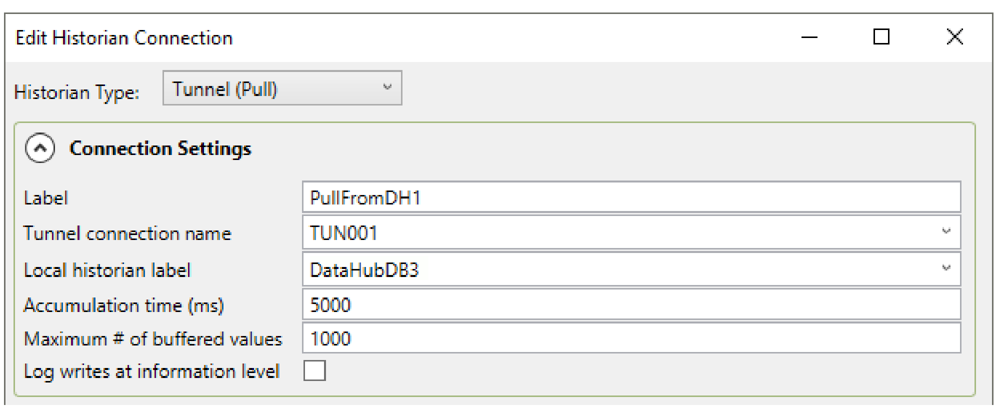
   Click the **Add** button to add an **InfluxDB** connection. For the **Label** enter `Influx3` and for the **Database name** enter `DataHubDB3`.



   This `Influx3` historian will store your **Tunnel (Pull)** separately from your **Tunnel (Push)** connection that logs to `Influx2`.

   Click **OK** and **Apply**.

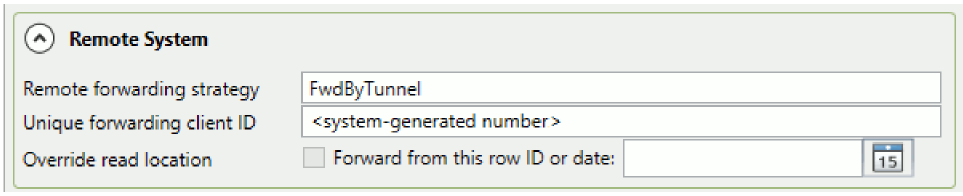
4. Now you need to create the Tunnel(Pull) connection itself. Again from the **External Historian** option, click the **Add** button and add a **Tunnel (Pull)** connection.



   - The **Label** can be something like **`PullFromDH1`**.
   - The **Tunnel connection name** must match what you entered above, **`TUN001`**.

- For the **Local historian label** select **`DataHubDB3`**

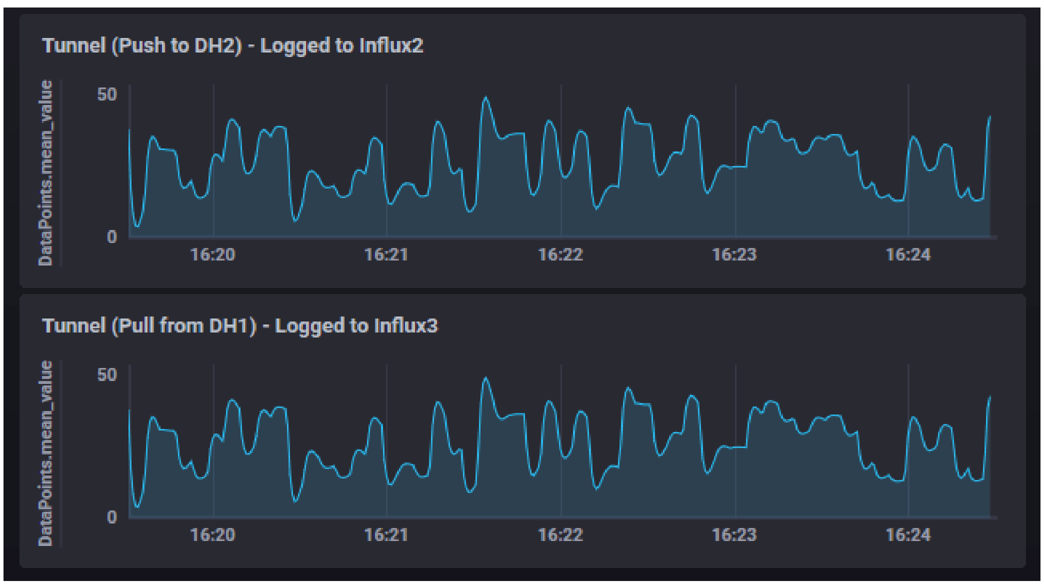
5. In the **Remote System** settings the **Remote forwarding strategy** should be **`FwdByTunnel`**.



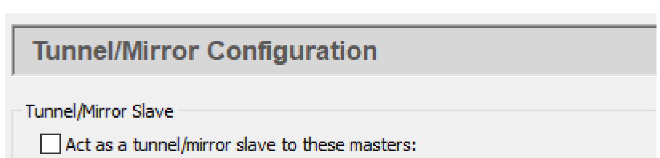
When finished, click **OK** and **Apply**.

The **Tunnel (Pull)** connection should now be functioning.

You can check Chronograf to see the results.



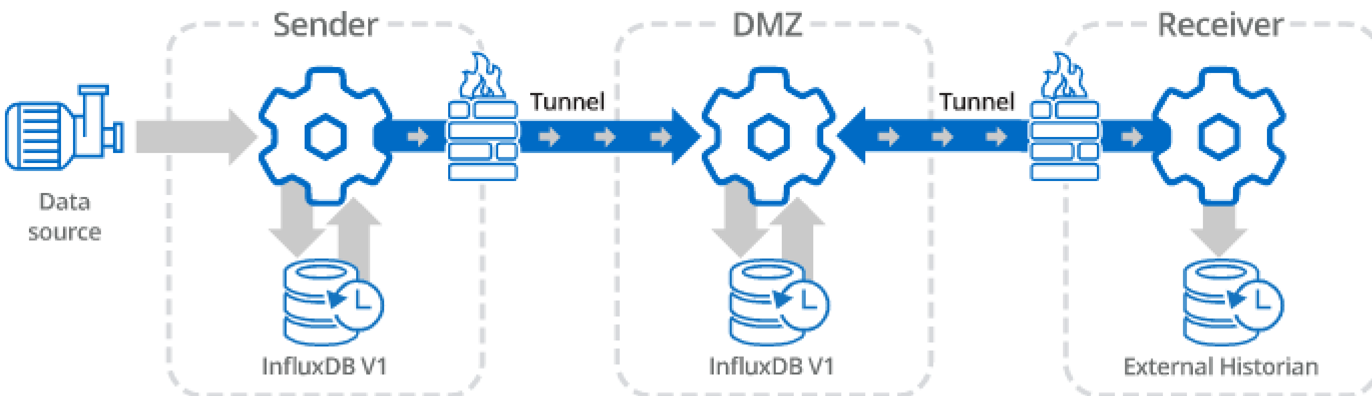
Test the store and forward feature by disabling the Tunnel/Mirror Slave connection on this side for at least 10 or 15 seconds.



You will start to see a gap in the data. When you re-enable the tunnel, the data should fill in, making the two trend lines identical again.

Using a DMZ

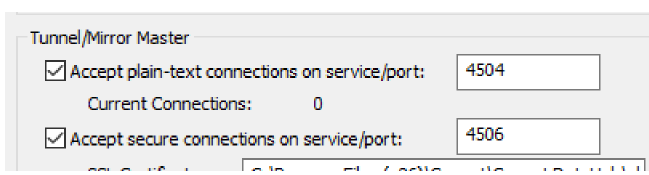
To maximize security for both the sender and receiver, you can use a DMZ to keep firewalls on both sides closed.



On the DMZ computer

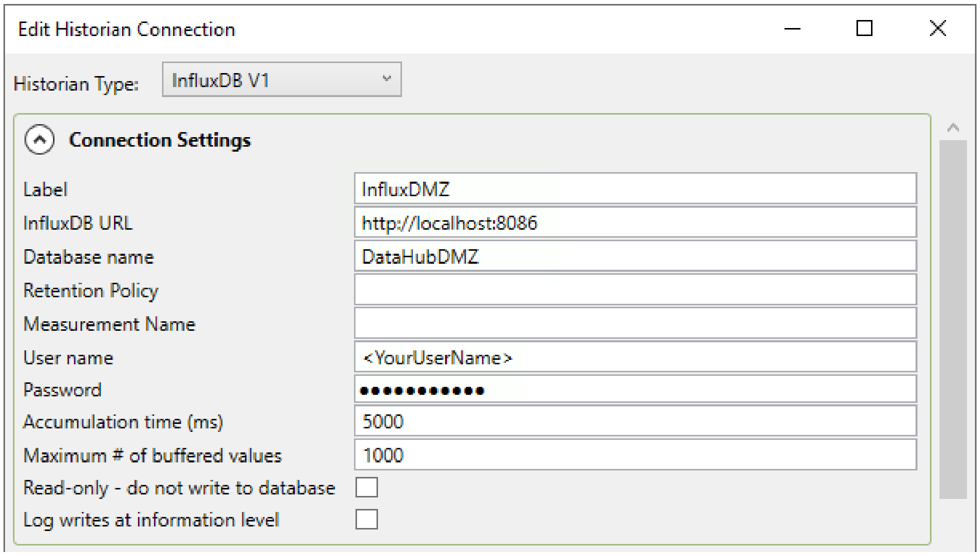
The DataHub instance on the DMZ both receives and sends data. Data comes in via a Tunnel (Push) connection from the sending side DataHub instance. Data goes out via a Tunnel (Pull) connection from the receiving side.

- To receive these inbound connections, you need to ensure that this DataHub instance's Tunnel/Mirror Master is enabled. This time we will use port `4504` for the plain-text Tunnel(Push) connection coming from the sending side to keep it separate from our previous example, and port `4506` for the SSL Tunnel(Pull) connection coming from the receiving side.



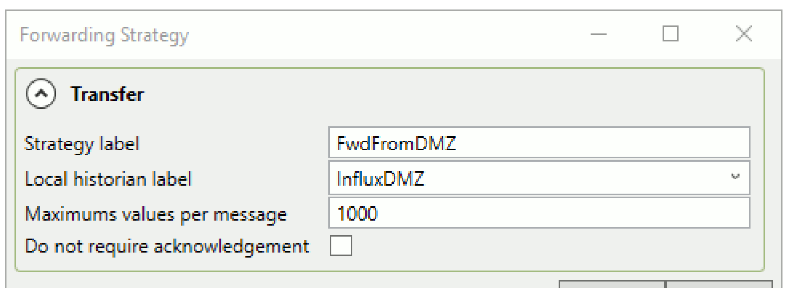
- You will need to configure an InfluxDB database with this DataHub instance's External Historian for receiving, storing and forwarding data. Here's what you need to do:

  1. In the **External Historian** option External Historian click the **Add** button.
  2. Select **InfluxDB**, label this historian connection **`InfluxDMZ`** and configure a new, local database named **`DataHubDMZ`**.



As mentioned previously, if you don't have a user name or password for InfluxDB, you can leave those fields blank. If you have previously installed InfluxDB independently of the DataHub program installation, then you'll need to use your existing InfluxDB URL.

3. In **Forwarding Strategies**, click the **Add** button and configure a **Transfer** named **`FwdFromDMZ`** and choose the `InfluxDMZ` historian that you just created.

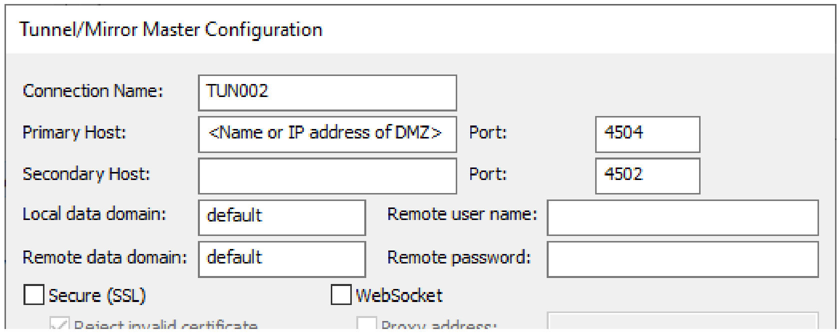


When finished, click **OK** and **Apply**. This forwarding strategy will be used by the Tunnel(Pull) connection from the receiving side.

On the Sending Side

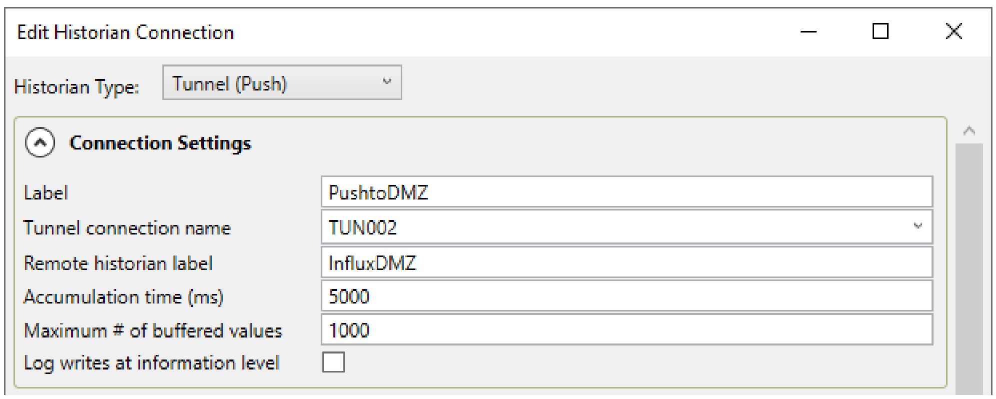
The sending side DataHub instance is configured for a Tunnel (Push) connection, but with a new tunnel and sending to the DMZ historian.

- Create a new Tunnel Slave connection that uses the name or IP address of the DMZ computer. Label this connection **`TUN002`**, use port **`4504`** to match the DMZ DataHub instance, and leave SSL unselected.



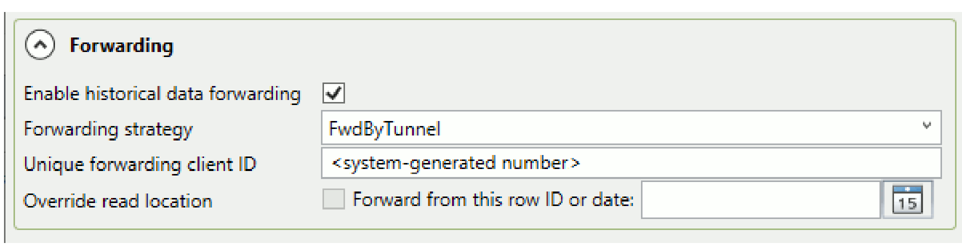
- Create a new External Historian Tunnel(Push) connection.

1. In **Write data to Historians** click the **Add** button and choose **Tunnel (Push)**. Configure it as follows:



   - The **Label** can be **`PushToDMZ`**.
   - For the **Tunnel connection name** select **`TUN002`**.
   - The **Remote historian label** should be **`InfluxDMZ`**

2. For the **Forwarding strategy**, you can continue using `FwdByTunnel` as configured previously:

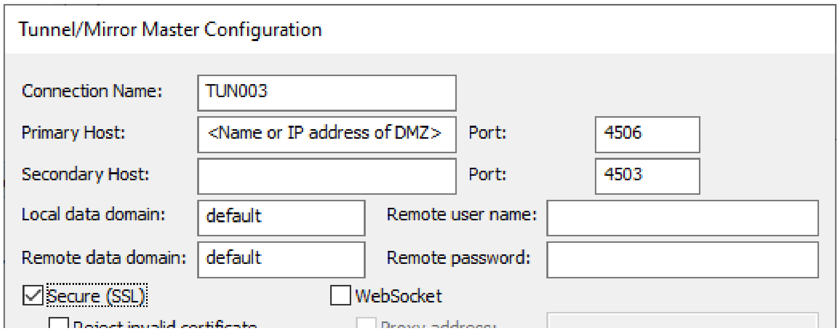


   When finished, click **OK** and **Apply**.

On the Receiving Side

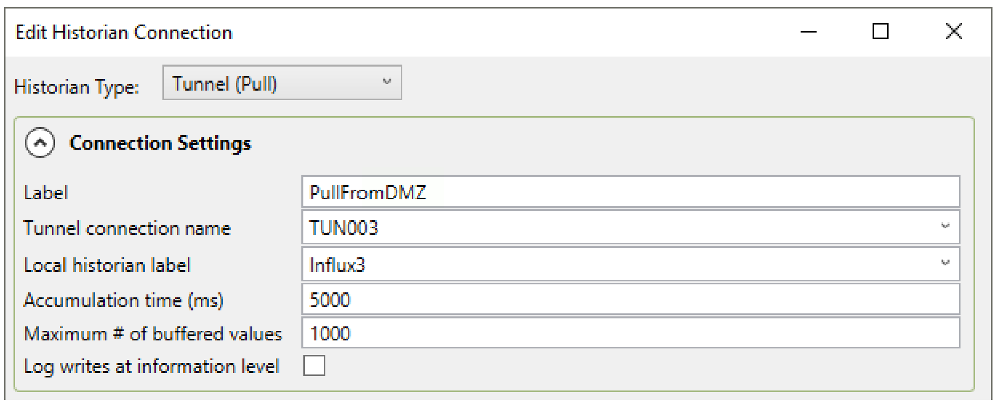
Configure this DataHub instance as you did for Tunnel (Pull) On the Receiving Side, but this time for the DataHub instance running on the DMZ.

- Create a new Tunnel Slave connection that uses the name or IP address of the DMZ computer. Label this connection `TUN003`, use port `4506` to match the DMZ DataHub instance, and check the SSL option.



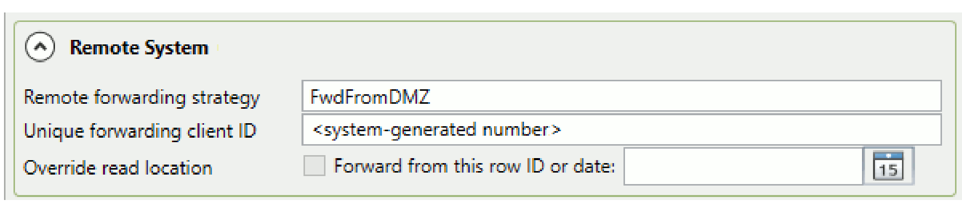
- Create a new External Historian Tunnel(Pull) connection.

1. In **Write data to Historians** click the **Add** button and choose **Tunnel (Pull)**. Configure it as follows:



   - The **Label** can be **`PullFromDMZ`**.
   - For the **Tunnel connection name** select **`TUN003`**.
   - For the **Local historian label** select **`Influx3`**

2. For the **Remote System** options, you should set the **Remote forwarding strategy** to `FwdFromDMZ`



   When finished, click **OK** and **Apply**.

Data from the sending side DataHub instance should now be flowing to the DataHub instance on the DMZ, and from there onwards to the receiving side DataHub instance. You can verify this in the respective Event Logs and/or Chronograf, as explained in the Connectingsection.

Using Security

DataHub Security lets you control access to your DataHub user accounts as well as MQTT, OPC Classic, OPC UA, tunnel/mirror, TCP, and DDE connections, providing authentication and authorization, and support for SSL, LDAP, and TOTP. Here you will find necessary how-to and other information for gaining the most benefit from DataHub Security. For detailed information about each of the Security feature options, please see Securityin the Property window chapter

Getting Started

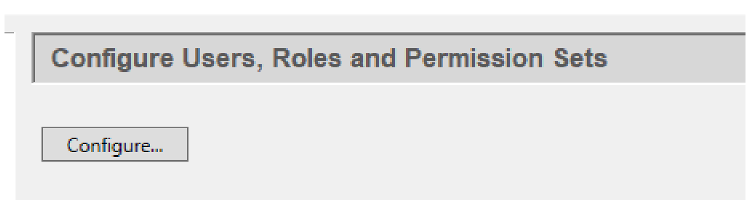
Overview

When configuring security you act as an administrator, restricting access and allowing only authorized connections to the data and functionality of a DataHub instance. Security is administered through several constructs:

- **User** - An identity provided to programs or devices authorizing them to connect to the DataHub instance.
- **Principal** - A login context for a specific user. It consists of two parts:
  1. Connection source (**IP pattern**)
  2. Connection protocol (**Interface**, e.g., TCP, OPC, MQTT)
- **Role** - A collection of permissions for DataHub data and functionality.
- **Permission** - A means of controlling and regulating access to specific DataHub application- and data-level functions.

These security constructs are owned by one of two organizations:

1. The **Internal Organization** is defined and managed by the DataHub instance. It is standard and cannot be changed or edited by the administrator, but its constructs are available for use while configuring users, principals and roles that belong to the Local organization.
2. The **Local Organization** is configured and maintained by the administrator. Think of it as 'your' organization.



Fresh install or migrating?

In version 11 the DataHub security model is entirely different from previous versions, and uses a different database file—`securityV11.`*`nn`*`.sqlite` instead of `settings.sqlite`.

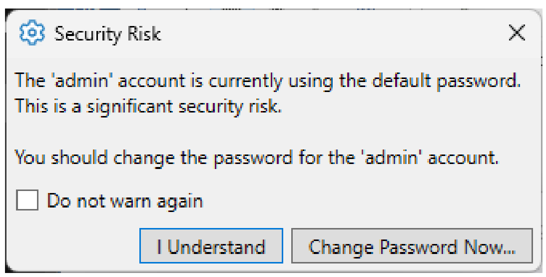
When you run v11 for the first time the DataHub engine creates the new security database file with default entries, and migrates the security data (i.e., users and permissions) from the previously installed version, including special OPC UA security rules.

To carry over permissions from your previous version, the DataHub engine replicates each set in an identically named role with the string "`_migrated`" appended to the name, to distinguish it from the v11 version. For example, `BasicConnectivity` would become `BasicConnectivity_migrated`.

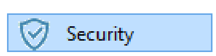
If you revert from v11 back to v10 the v10 security database file remains unchanged, and you will find your settings to be as they were the last time V10 was used.

Changing the admin password

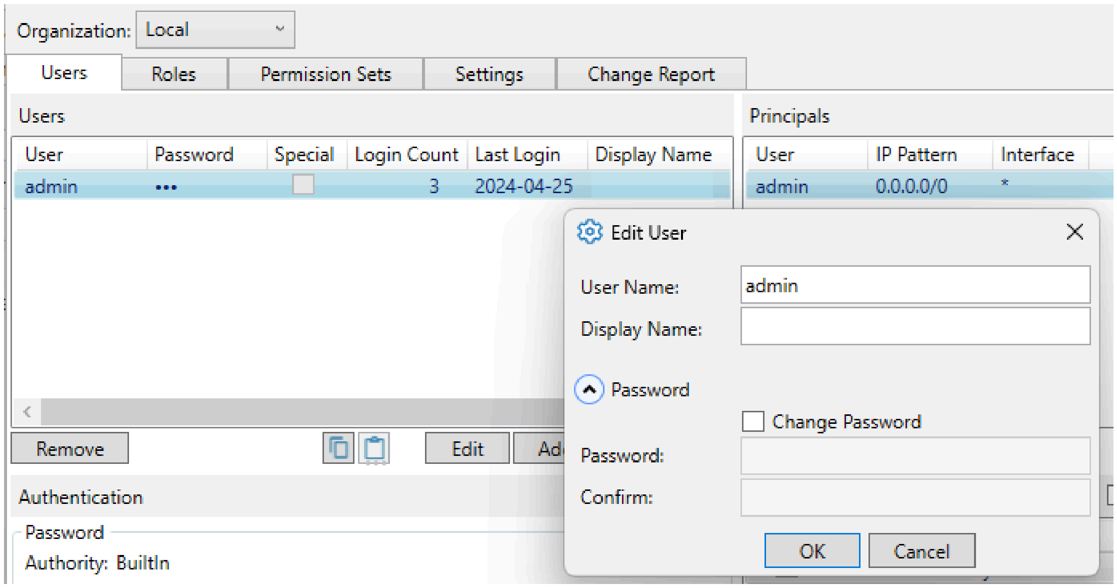
Starting up DataHub v11, you may notice a new pop-up dialog, Security Risk.



This warns you that your DataHub instance is configured with the default password for the admin user, `admin`. To change this:

1. Select the Security option 

 and click the **Configure** button.
2. Set the **Organization** to **Local**, and click the `admin` user.
3. Click the **Edit** button to open the Edit User window.



4. Open the **Password** section and click the **Change Password** button. Enter a new password that is non-trivial (i.e., at least 8 characters, mixed case, and not a capitalized word). This will prevent the warning dialog from popping up.
5. Click **OK** or **Apply** to apply your changes. When you restart your DataHub instance, the warning will no longer appear.

Remote Connections

To meet increased security requirements, anonymous remote (networked) connections in DataHub version 11 and above are not assigned data access roles by default. This applies to the following Internal users:

- **Mirror** - for tunnel slave connections
- **MQTT** - for MQTT client connections
- **OPCUA** - for OPC UA client connections
- **TCP** - for TCP connections, such as when using the DataHub Add-in for Microsoft Excel or the DataHub APIs.

The default roles for local connections are **BasicConnectivity** and **AllDataFullAccess**, while remote connections are given only **BasicConnectivity**. These default settings protect system data from unauthorized remote users, while giving full access to local anonymous connections.

To enable remote data access, the recommended way is to add a new user for each protocol you need, one that has both **BasicConnectivity** and **AllDataFullAccess** roles. When doing so, you should uncheck the **RequireTOTPAuthenticaion** role for that user, since the user is non-interactive and cannot use two-factor authentication. With this new user defined you can make remote slave or client connections by entering its username and password credentials when configuring the connection.

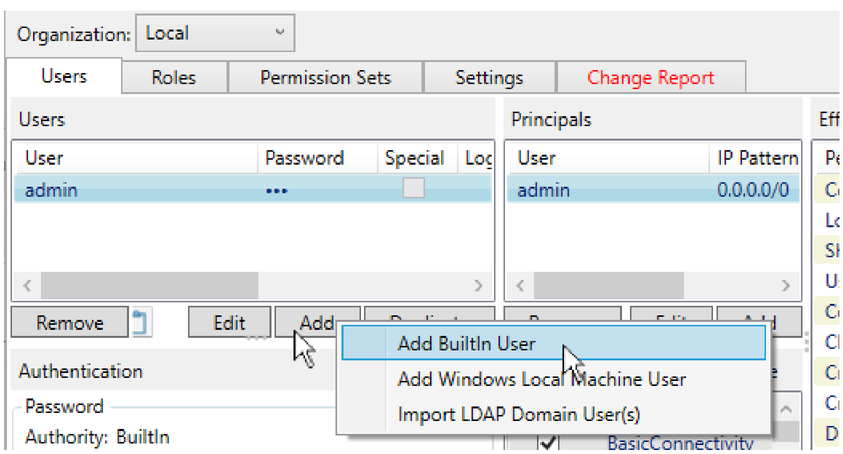
Alternatively, you can allow anonymous access by modifying the remote IP address principal of the internal **Mirror**, **MQTT**, **OPCUA** or **TCP** user so that it has **BasicConnectivity** and **AllDataFullAccess** roles. This is *not best practice* because it bypasses security. To access the internal users, choose **Internal** from the **Organization:** dropdown in the top left corner of the security window.

In either case, it is possible to further restrict access by IP address, interface protocol and data domain. Again, the recommended approach is to create a new user, rather than modify an internal user.

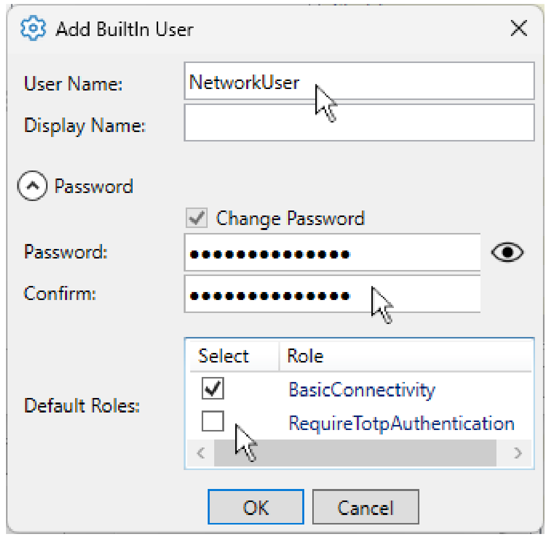
Example

Here is an example for how to add a built-in user essential permissions for remote connections:

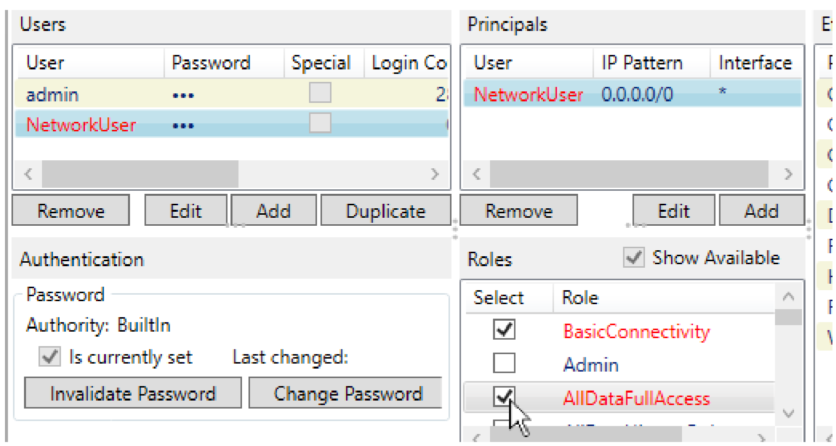
1. In the DataHub Properties window, select the **Security** option and click the **Configure** button.
2. Set the **Organization** to **Local**, and in the **Users** tab, under **Users**, click the **Add** button and select **Add BuiltIn User**.



3. Enter a **User Name** such as **`NetworkUser`** with a password like `Efgh5678`. Uncheck the **RequireTotpAuthentication** box because this will be an automatic, non-interactive connection.



4. Click the **OK** button. The username **NetworkUser** will appear in the **Users** list, as well as in the **Principals** list.



5. Check the **AllDataFullAccess** box to provide read and write permissions on the data. If you do not see that option, check the **Show Available** box.
6. Click **Apply** to apply the changes.

Now any remote user that logs in with the `NetworkUser` username and password will be able to connect and access data for reading and writing. To enhance this essential security by restricting access based on a communication protocol, IP address pattern, or DataHub data domain, please see Restricting Access.

Restricting Access

You can restrict access based on a specific communication protocol, IP address pattern, or DataHub data domain.

Each time a user logs in, the system creates a list of all principals that match the connecting protocol. Within the list, the system selects the closest CIDR (IP address) match. That is, the one with the most bits in the CIDR that match the incoming address. The protocol option of asterisk (*) is always a match. For example, if you have these 2 principals:

```
192.168.0.0/16    MQTT
192.168.0.0/24    MQTT
```

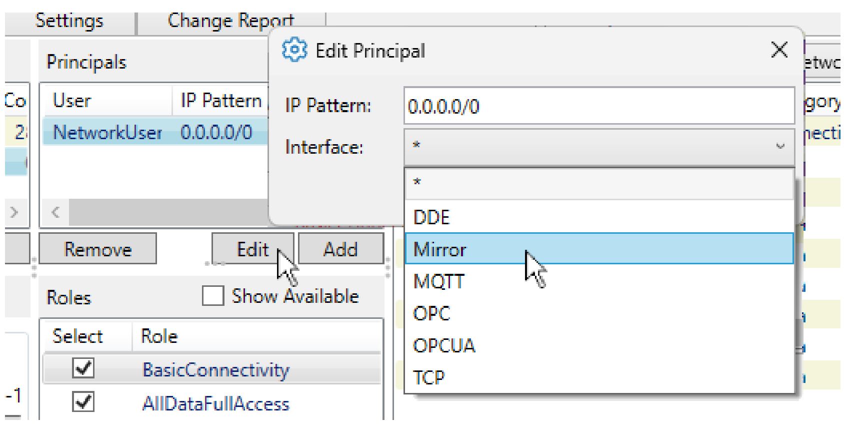
An incoming MQTT connection from `192.168.0.10` would match the second CIDR. An MQTT connection from `192.168.1.10` would match the first CIDR. The system chooses the principal with the closest CIDR match to the incoming address for the incoming protocol.

Additionally, the connection can be restricted to a single data domain or pattern of domains, using a customized role for each principal.

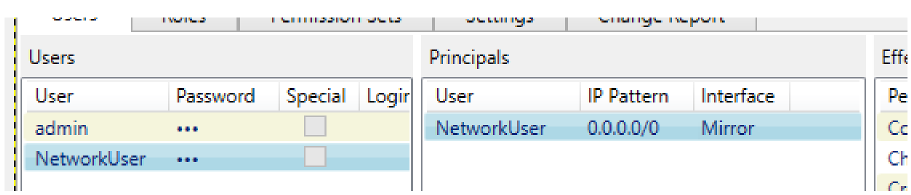
Protocol restrictions

To limit a user to a single communication protocol for accessing data, you need to edit or add a principal for that user. This following example edits an existing principal, based on the example **NetworkUser** user created in the Remote Connections section.

1. Among the **Principals** of the user, select the principal you want to modify and click the **Edit** button.



2. From the **Interface** drop-down list, select a protocol, such as **Mirror**, to restrict this user to only Tunnel/Mirror connections.
3. After making this addition, your `NetworkUser` user would now look like this:



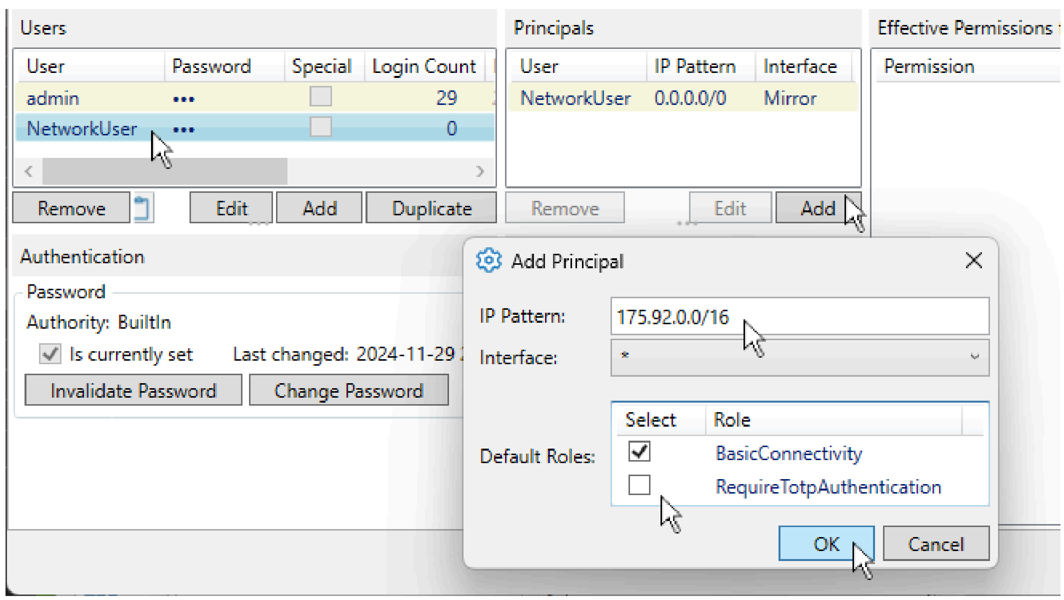
4. Click the **Apply** button to apply the changes.

This restricts all incoming connections from **NetworkUser** to tunnel/mirror connections. The IP pattern of this principal could also be edited, or other principals can be added to this user, to enable other permission scenarios, as explained in the next section.

IP address restriction

To limit a user to an IP address or CIDR pattern, you need to edit or add a principal for that user. The following example adds a new principal, based on the example `NetworkUser` user created in the Remote Connections section.

1. Select the user in the **Users** list, and in **Principals** click the **Add** button.

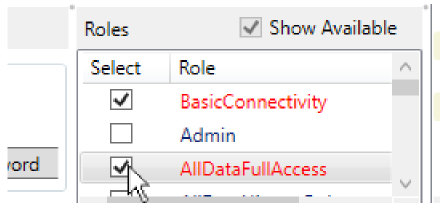


2. Edit the **IP Pattern** from which they can connect. This could be a specific IP address, or a pattern using CIDR notation such as matching the first 16 bits of `175.91.3.15` with the pattern `175.91.0.0./16`. See Users tab - Principals for more details.

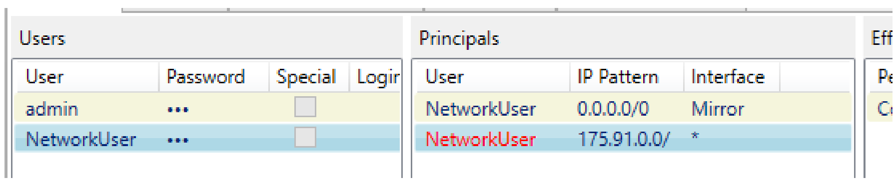
   Since this is a networked connection, it is likely to be non-interactive. If so, you will need to remove the **RequireTotpAuthentication** permission set.

   When you are done, click **OK**.

3. In the **Roles** panel, check the appropriate roles for this principal. For example, the **AllDataFullAccess** role needed for data access is often added for remote connections. To see all available roles, check the **Show Available** box.



4. After making this addition, the `NetworkUser` would now look like this:



5. Click the **Apply** button to apply the changes.

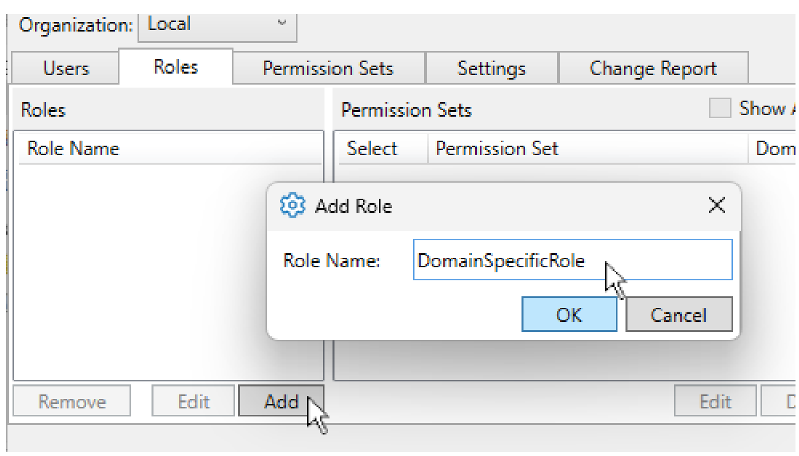
This principal would restrict the `NetworkUser` to connecting only from IP addresses starting with `175.91`. Other principals can be added to a user to enable other permission scenarios.

Data domain restriction

In addition to restricting user access by protocol and IP address, you can also restrict access to the data according to the DataHub data domain. This requires editing an existing role, or creating a new one. We recommend creating a new role, which can be done as follows.

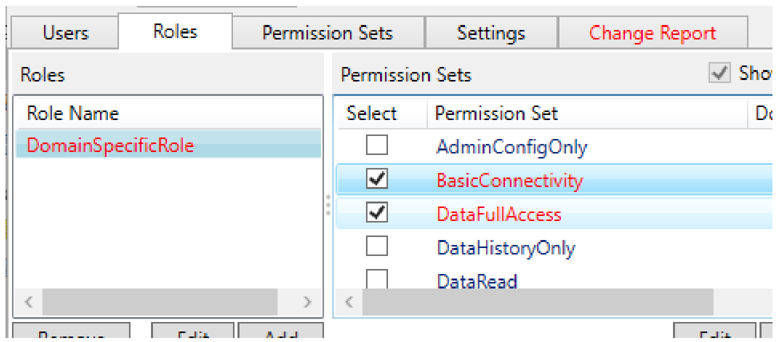
Single domain

1. In the **Security** configuration dialog, select the **Roles** tab and click the **Add** button to add a new role.

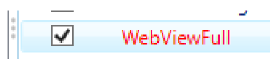


2. Enter a name for the role. For this example we'll call it **DomainSpecificRole**, because we will apply it to just one domain.

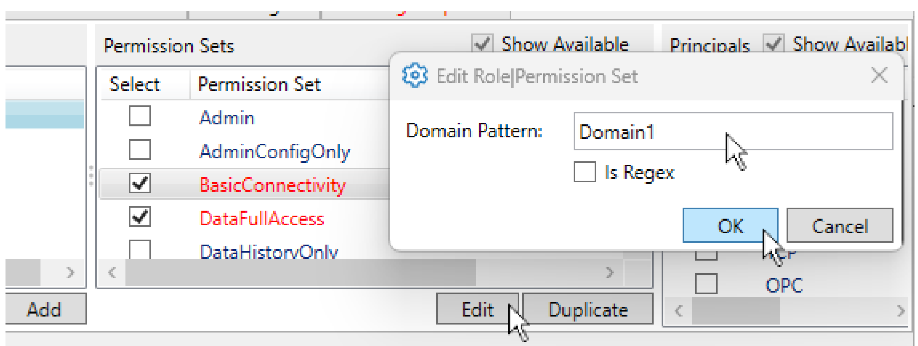
3. Click **OK**.
4. In the **Permission Sets** for the new role, select **BasicConnectivity** and **DataFullAccess**.



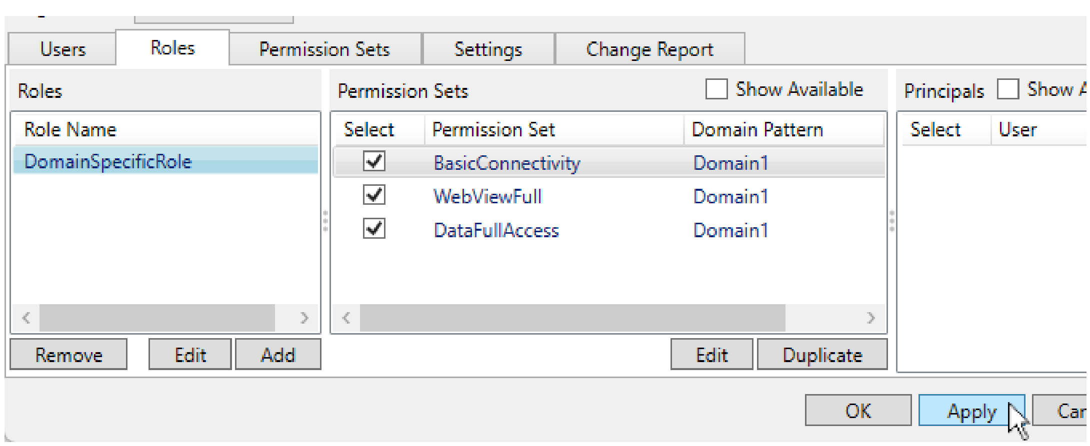
Also select **WebViewFull**, which we can use to test the results.



5. For each of the three permission sets, select it, click the **Edit** button, and enter the pattern `Domain1`.

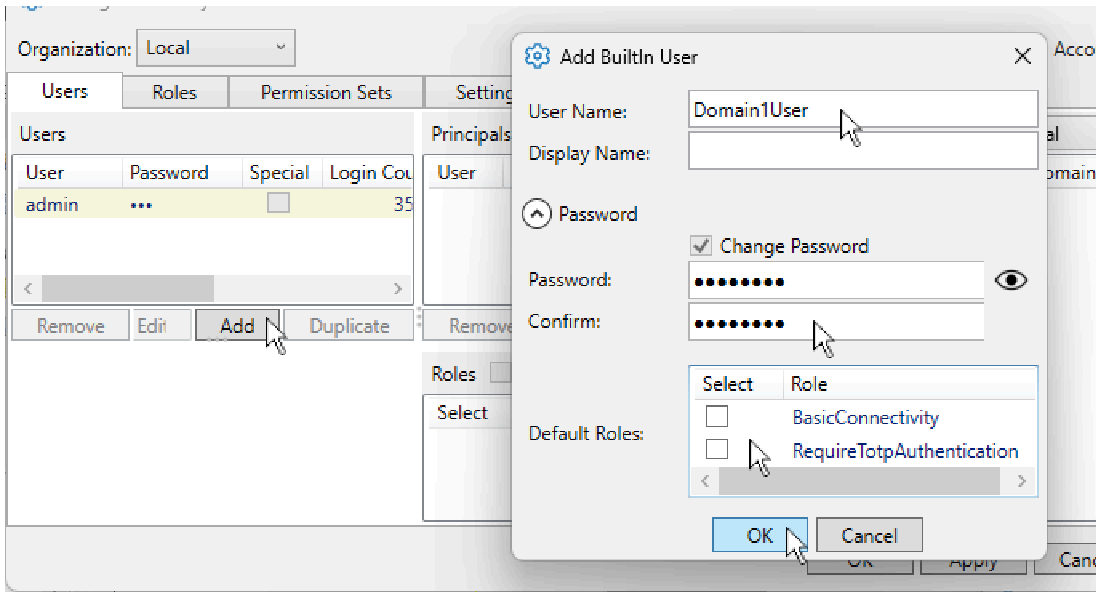


6. All three permission sets should now show a **Domain Pattern** of `Domain1`

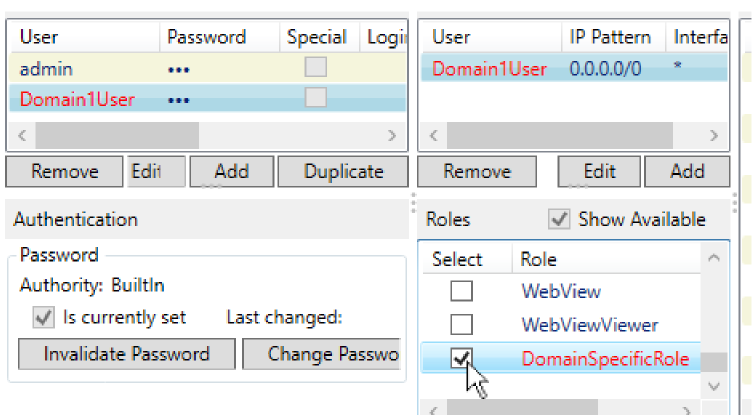


Click **Apply** to apply the changes. Now we need to create a user for this role.

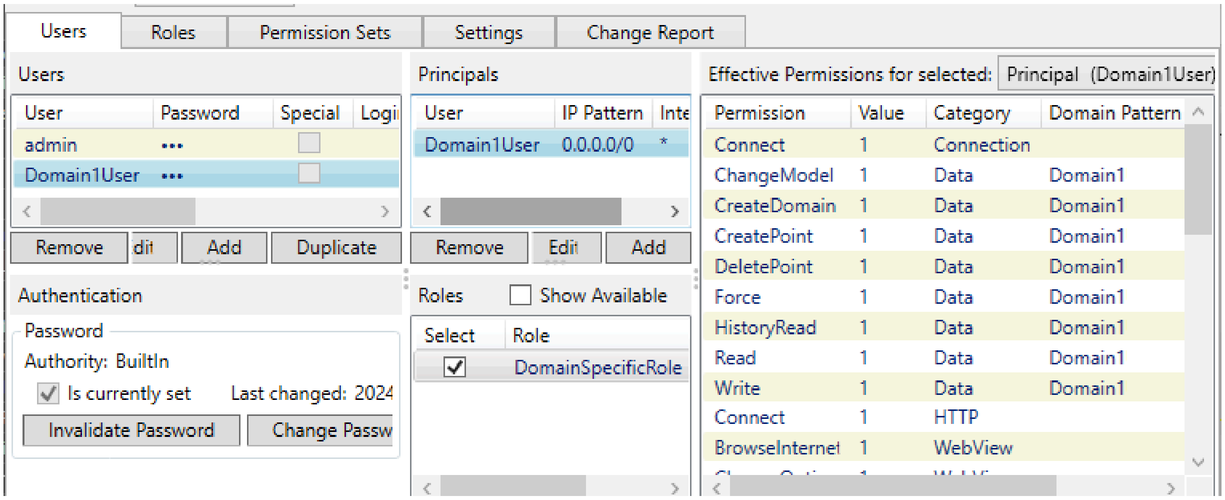
7. In the **Users** tab, click the **Add** button to add a **Built-In** user.



8. Enter the user name `Domain1User` and a password.
9. Uncheck both **Default Roles** boxes and click **OK**.
10. In the **Roles** for this user, select **DomainSpecificRole**. That is the only role you need.



11. Click **OK** and **Apply**. For the **Domain1User**, the list of **Effective Permissions** should now display the **Data** permissions with the **Domain Pattern** of `Domain1`.



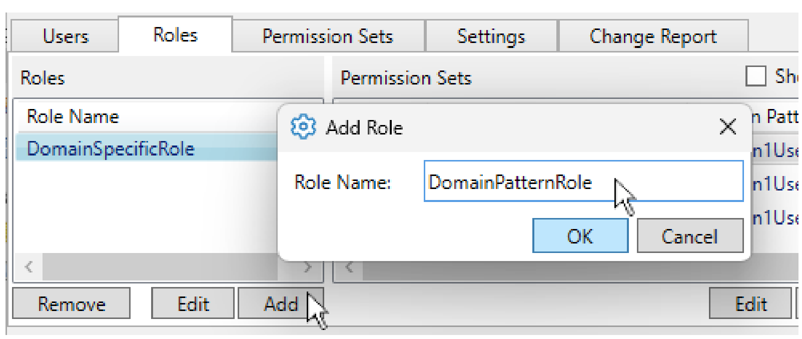
Notice that it also has permissions in the **Connection**, **HTTP**, and **WebView** categories. These are not data-specific, so the domain pattern does not apply.

This completes the basic task of restricting access to data according to one DataHub data domain. Anyone logging onto the system with the `Domain1User` username and password will have read/write access to the data in `Domain1` only.

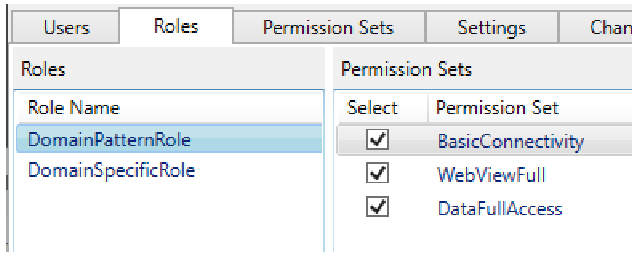
For an example of specifying multiple domains, and for testing the results, please continue with the following steps.

Domain pattern for multiple domains

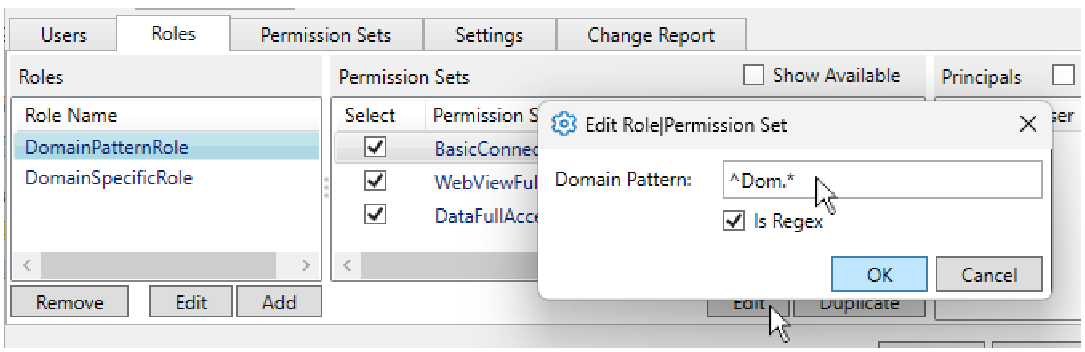
1. As above, we will first add a new role, this time called `DomainPatternRole`.



2. Give this role the same three permission sets, **BasicConnectivity**, **DataFullAccess**, and **WebViewFull**.



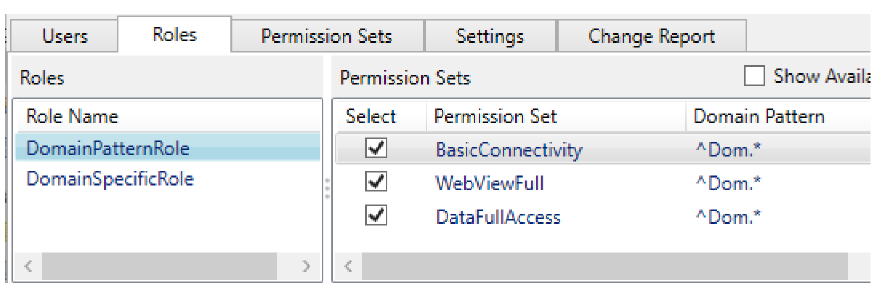
3. But this time for the **Domain Pattern** of each permission set, enter `^Dom.*`, and check the **Is Regex** box.



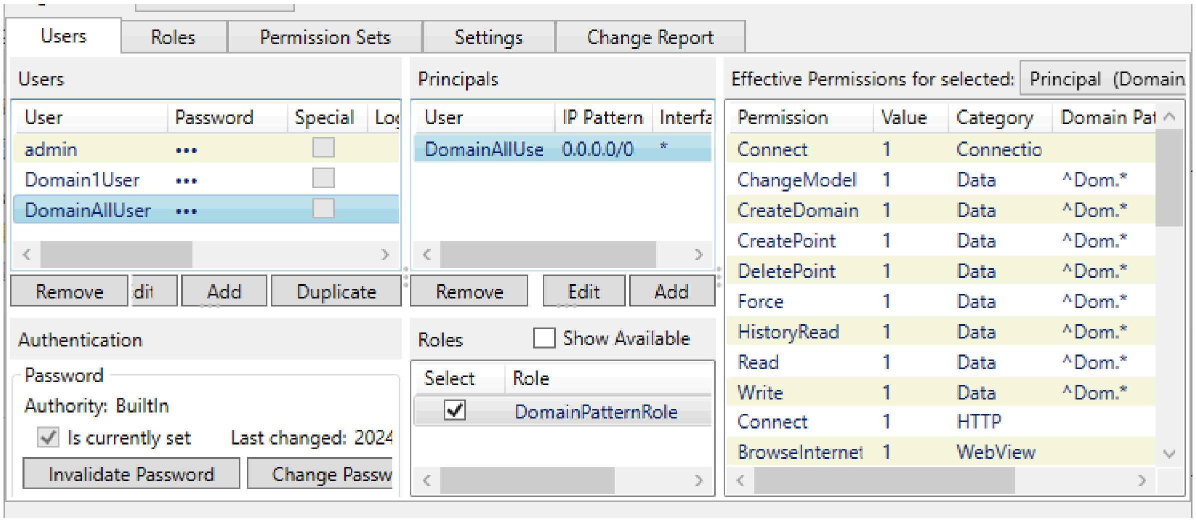
This regular expression syntax will match any domain that starts with the characters `Dom`.

The DataHub program uses .NET Regular Expressions, whose use and syntax can be found here.

4. Click the **Apply** button. The completed role should look like this:



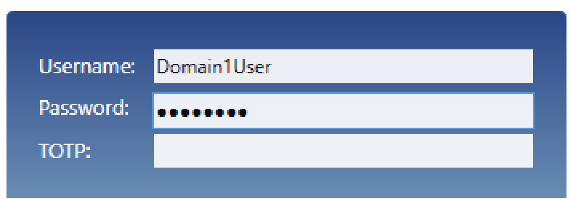
5. Now, add a new user, `DomainAllUser` and give it only the **DomainPatternRole**.
6. Click the **Apply** button. Your `DomainAllUser` should now have the **DomainPatternRole** that allows connections to any domain starting with the characters `Dom`.



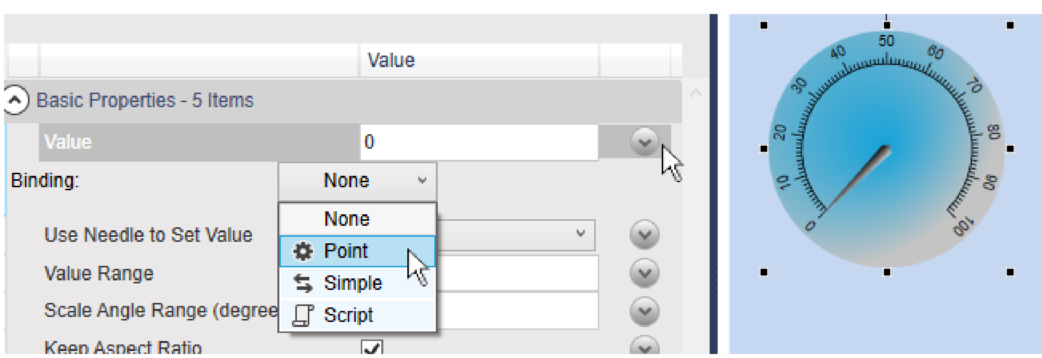
Testing

You can use WebView to ensure that the domains you've specified are the only ones available to the user.

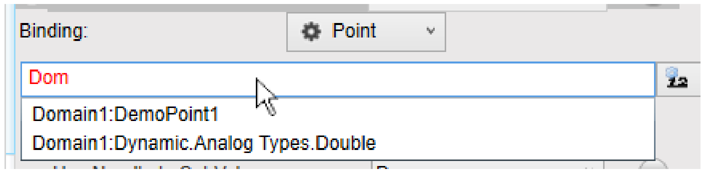
1. Start up WebView and log in with the `Domain1User`.



2. Put a gauge control on the canvas and edit its value property, choosing a **Point** binding.

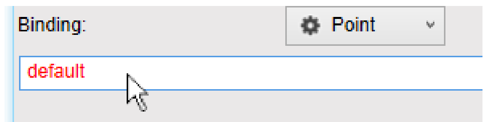


3. Enter the string `Dom` to display a choice of available points.



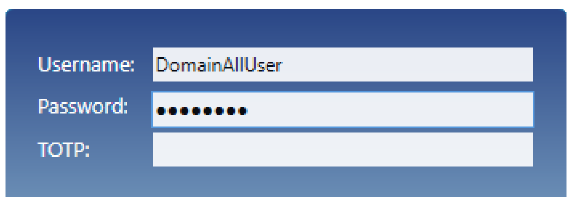
Notice that only points in `Domain1` are on the list.

4. Try another domain. Enter `default` or any other domain name used in your DataHub instance.

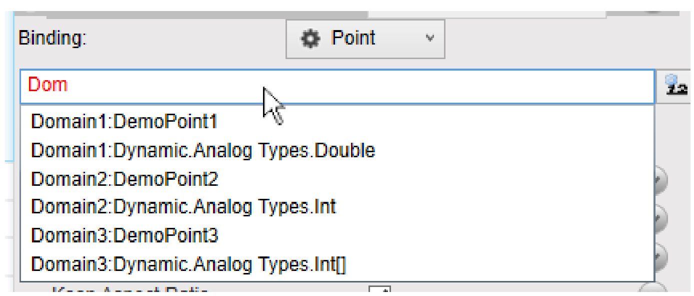


The list should be empty.

5. Now close WebView and try logging in with `DomainAllUser`.



6. Entering `Dom` should now display the points available in any domain that matches the pattern.



This is how to restrict access to specified data domains. Of course, any user can also be restricted by protocol and IP address.

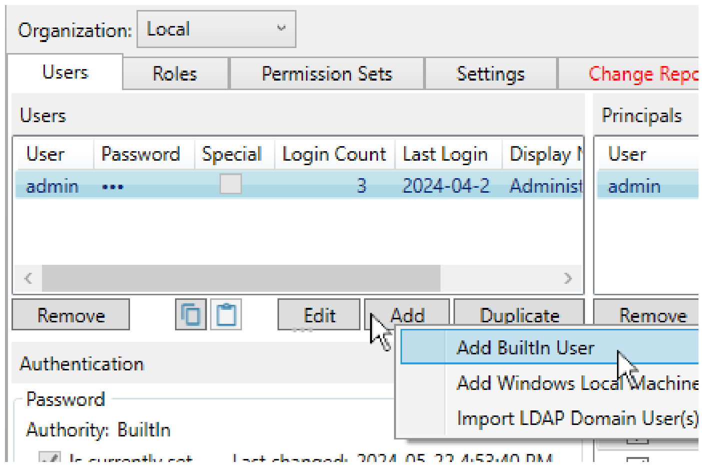
TOTP Authentication

Example: RCUser

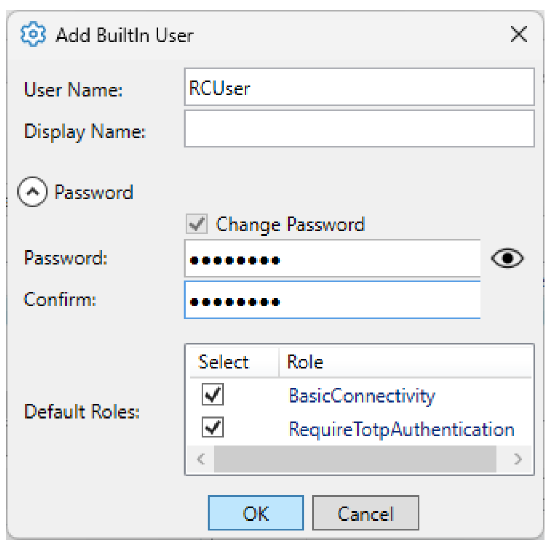
Here we create a user and give it the necessary permissions and TOTP settings to access and use the DataHub Remote Config application.

Add the user

1. In the DataHub Properties window, select the **Security** option and click the **Configure** button.
2. Set the **Organization** to **Local**, and in the **Users** tab, under **Users**, click the **Add** button and select **Add BuiltIn User**.

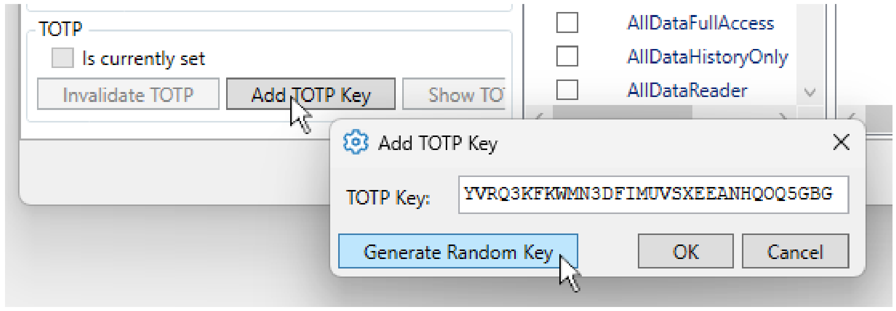


3. Enter a **User Name** of **RCUser** with a password `Abcd1234`.



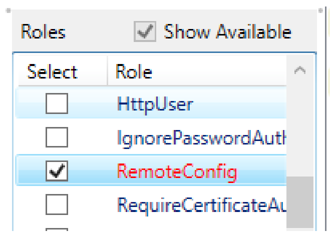
Click the **OK** button. The user name **RCUser** will appear in the **Users** list, as well as in the **Principals** list.

4. In the **TOTP** (time-based one-time password) section below, click the **Add TOTP Key** button, and then click the **Generate Random Key** button.

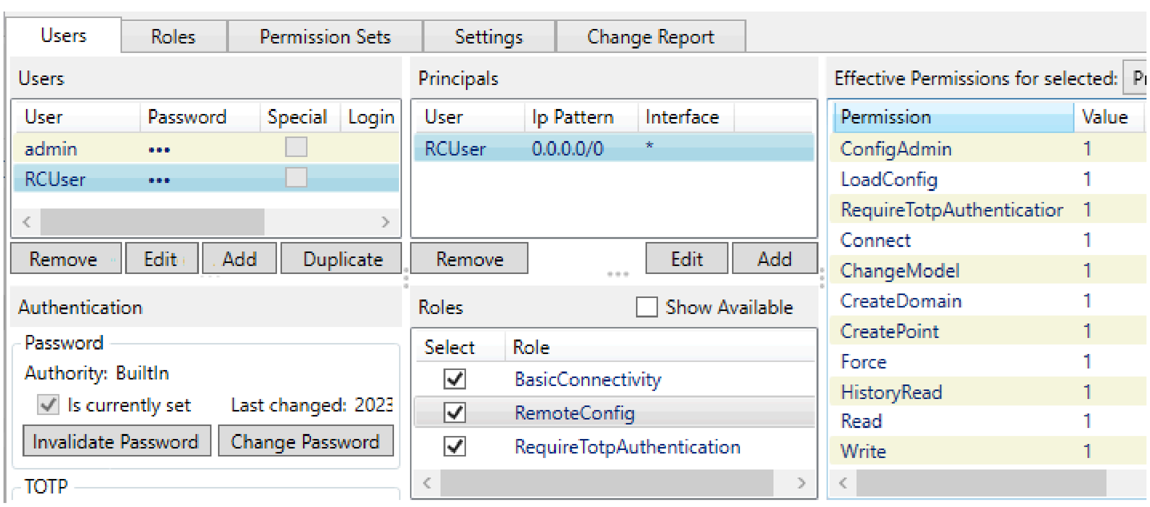


The system will generate a key.

5. In the **Roles** list, scroll down to **RemoteConfig** and click its checkbox on.



6. Click the **Apply** button to apply your changes. You'll now see a total of 3 roles for RCUser. The `BasicConnectivity` and `RequireTotpAuthenticaion` roles were added by default when the user was created.

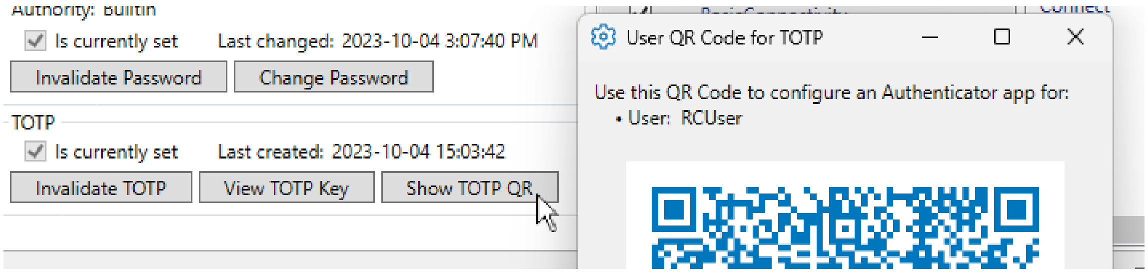


Notice that when you click the **RemoteConfig** role checkbox off and on, the list of **Effective Permissions** in the right-hand column changes. The additional permissions are the ones associated with the RemoteConfig role, showing what the user can do in the Remote Config app. Be sure to leave the checkbox on.

Configure Authenticator app

Since we specified TOTP for the RCUser, we need to configure it. This example will use Microsoft Authenticator as the TOTP app.

1. On your mobile device, open Authenticator and tap **+** to add an account. Select **Work or school account**.
2. Select **Scan a QR code**.
3. In the DataHub Security configuration for RCUser, click the **Show TOTP QR** button.

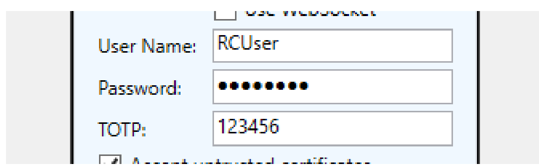


4. Point your phone's camera at the QR code and enable it. Be sure to apply the changes.

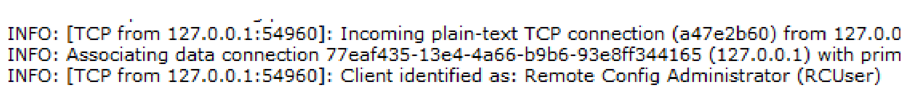
You should now have a **Cogent DataHub** entry with **RCUser** in Windows Authenticator.

Test the results

1. Start the Remote Config app. Enter the username **`RCUser`** and password. Then check your Authenticator app for the six-digit code, and enter that in the **TOTP**field.



2. Once you've entered both the password string and the TOTP code, press the **Enter** button to access the app. You can check the Event Log to verify the authentication of RCUser.


INFO: [TCP from 127.0.0.1:54960]: Incoming plain-text TCP connection (a47e2b60) from 127.0.0
INFO: Associating data connection 77eaf435-13e4-4a66-b9b6-93e8ff344165 (127.0.0.1) with prim
INFO: [TCP from 127.0.0.1:54960]: Client identified as: Remote Config Administrator (RCUser)

3. To check that permissions are being enforced, start the DataPid app. You will see that it connects, but there are permission denied error messages in Event Log like this:

```
Error in input: TCP: plugin-raw-message, ..... Permission denied")
```

4. Click the **View Data** button to open the DataHub Data Browser, and you will see that the DataPid domain is either not listed or not connected.
5. In DataPid, click the **Disconnect** button, enter your DataHub `admin` username and

password, and click the **Reconnect** button.

You should now see DataPid data updating in the Data Browser, and no more errors in the Event Log.

> We used the `admin` credential in this last step to keep the explanation simple. A better approach to pushing data to a DataHub instance is to create a user with specific permissions, as explained in Custom Data Permissions.

Example: WVUser

This scenario enables a WebView user, and uses it to demonstrate credentials and authorization.

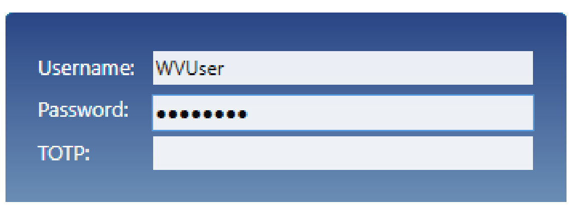
Add the user

> This sections builds on the previous section. Please complete that example before continuing here.

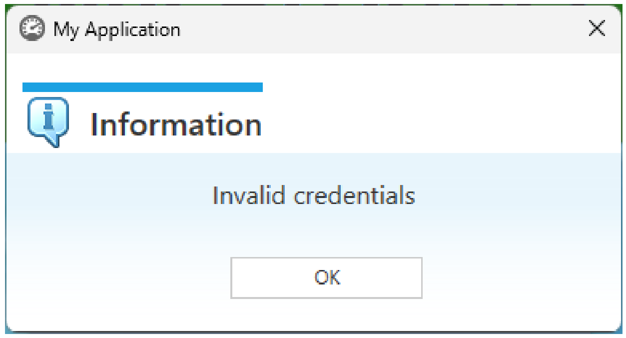
1. In the Remote Config app, go the Security configuration and add a new BuiltIn user called `WVUser` with the password **`Abcd1234`**.
2. Click the **Add TOTP Key** button and **Generate Random Key** and **OK**. Do not add any roles right now. Click **Apply**.
3. Configure your Authenticator app for `WVUser`.

Test Login Credentials and Authorization

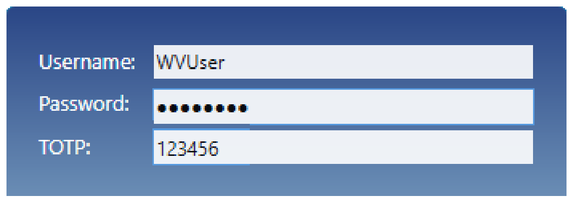
1. Start WebView and log in with `WVUser`. Use only the password string `Abcd1234` without the TOTP code.



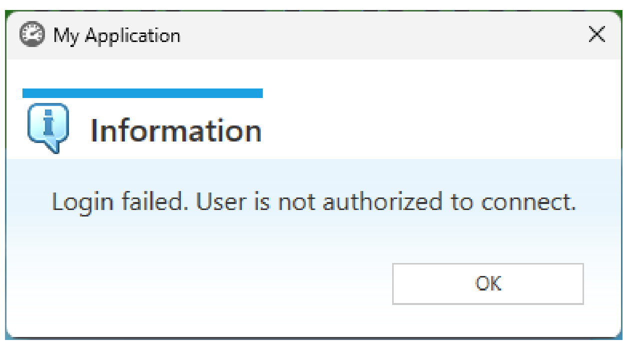
The login will fail, due to invalid credentials.



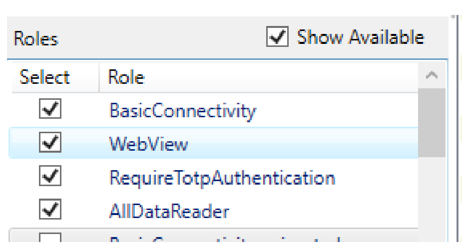
2. Now try logging in using the TOTP code.



The login will fail again, this time due to lack of authorization.



3. In the Security configuration, add the `WVUser` to roles `WebView` and `AllDataReader`. You will need to check the **Show Available** box to show them.



4. Try logging in again. This time you should be able open WebView.

   We can now make one more test. Since we have assigned `WVUser` to the `AllDataReader` role, it should be possible to read data, but not write data back to the DataHub instance.

5. Ensure that DataPid is still running, and load the Circular Gauges page.
6. Switch to Run Mode and try adjusting the set points. You will see that you are not permitted to make any changes, because the `WVUser` does not have write permissions.

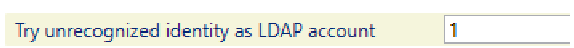
   To allow writing data, you can add `WVUser` to the `AllDataWriter` role or the `AllDataFullAccess` role.

LDAP Authentication

For enterprises that want to use LDAP to administer application security, DataHub software supports the creation of 'proxy' accounts. With the **Import Accounts** dialog, you can import LDAP User or Group accounts. Unlike 'BuiltIn' accounts, which rely upon native DataHub authentication, these LDAP proxy accounts rely upon an external LDAP server for authentication. This allows users to log in with their LDAP user name and password.

During login, the DataHub instance will first check to see if it recognizes the user credential. If it matches a DataHub-defined LDAP User account, it forwards the authentication request to the associated LDAP server. If the LDAP server deems it valid, the DataHub identity will then be granted the permissions associated with the appropriate **User Principal**.

If the DataHub instance does not recognize the user credential, it can also check with known LDAP servers to determine if there is a matching user with LDAP Group membership that matches a DataHub-defined LDAP Group account. This optional check is controlled by the Security setting called **Try unrecognized identity as LDAP account** which is enabled by default.



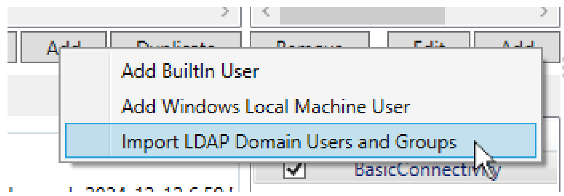
Creating an LDAP Group account proxy in the DataHub configuration allows a user to log in with their LDAP user name and password—even though the DataHub instance knows nothing about the particular credential. If the LDAP server successfully authenticates the login credential, it returns the list of known groups of which that LDAP user is a member. If one of those groups matches a DataHub-defined LDAP Group account, then the user identity effectively impersonates that Group account (or Group accounts) and is granted permissions associated with that DataHub-defined Group account(s).

This allows the DataHub administrator to focus on importing and authorizing LDAP Group accounts and not worry about dozens or hundreds of LDAP User accounts. Since the DataHub instance can forward authentication requests to LDAP and then authorize the user based on DataHub-defined Group account permissions, the LDAP Administrator can subsequently add and remove LDAP users without touching the DataHub security configuration.

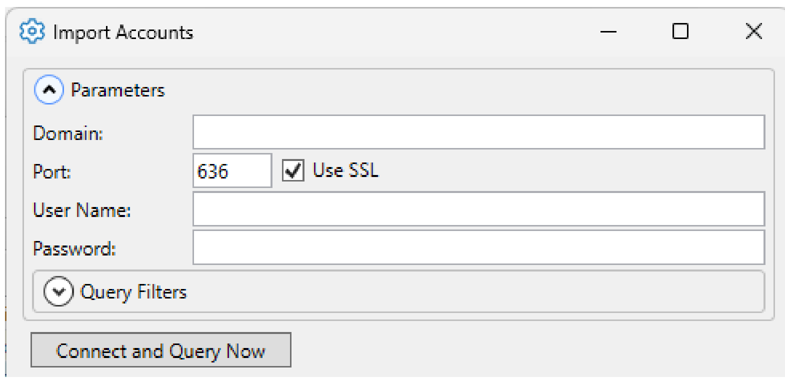
When using LDAP to authenticate DataHub-imported credentials, it is important that the external LDAP server(s) is online and accessible. Otherwise, delays will occur during the authentication process before the DataHub instance eventually handles the timeout and notifies the user.

You create proxy user accounts for an LDAP server using the **Import Accounts** dialog, as follows.

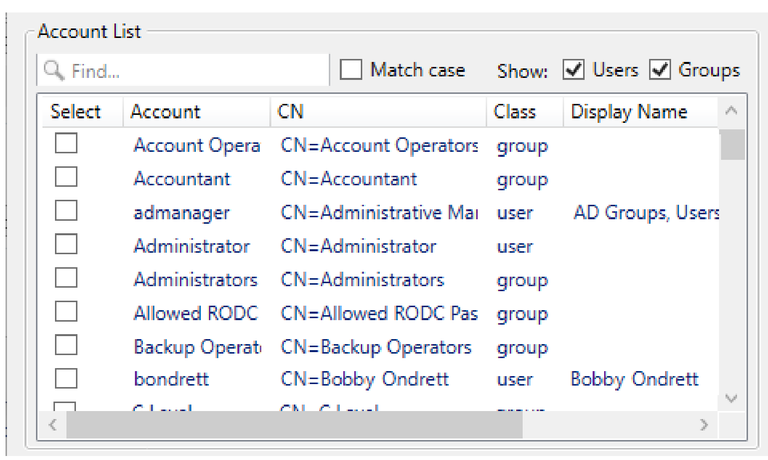
1. In the DataHub Properties window, select the **Security** option and click the **Configure** button.
2. In the **Local** organization, under **Users**, click the **Add** button and select **Import LDAP Domain Users and Groups**.



This opens the **Import Accounts** dialog.

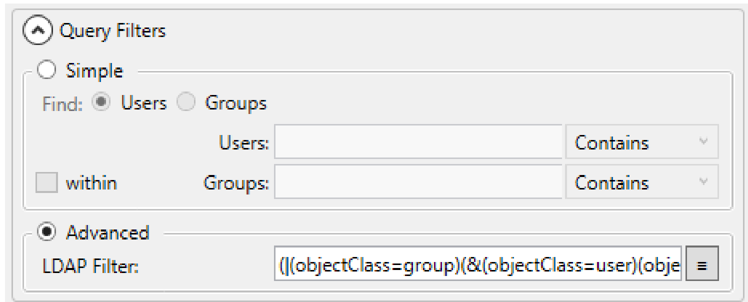


3. Enter the **Domain** and **Port** information as provided by your network security administrator.
4. Enter your LDAP user name and password credential that is authorized to connect to and query the LDAP server.
5. Press the **Connect and Query Now** button to populate the **Account List**.

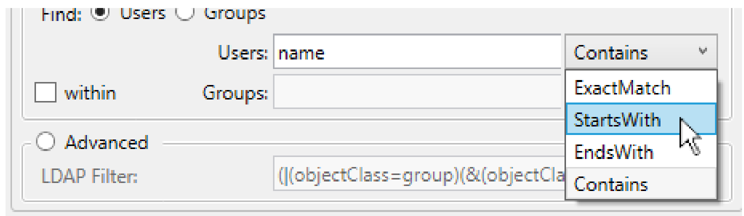


Filtering the List

The **Query Filters** section of the dialog lets you create filters to show specific parts of the list.

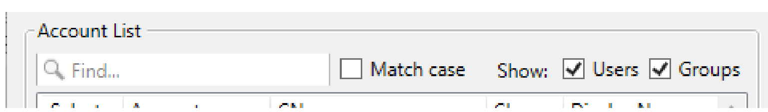


The **Simple** options allow you to filter on just **Users**, just **Groups**, or **Users within Groups**. Entering a string in either box will show just those items that contain that string. You can use the drop-down options on the right to specify an exact match, or starting, or ending with the string you've entered.



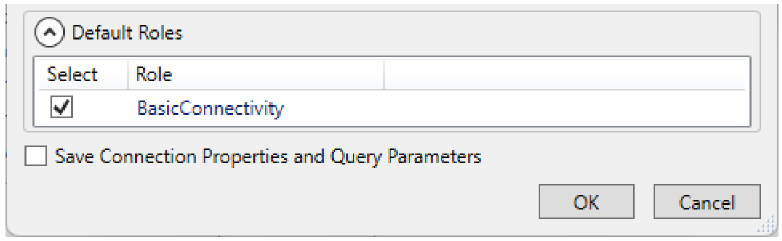
The **Advanced** filter lets you create and apply custom filters, using standard LDAP filter syntax.

In the list itself, you can use the **Find** search bar with its **Match case** and **Show** options to focus in on parts of the list. In most cases, the Simple query filter options should be adequate.



Default Roles

After you have successfully connected to the LDAP server you can assign default roles for all selections.



You can add to the **Default Roles** list in the **Settings** tab by entering additional role names, separated by commas.

Save Connection Properties and Query Parameters

You can check this box to avoid having to re-enter the parameters each time you want to import an account.

Once you have filtered the list and set these options as needed, you can continue.

6. Check the **Select** box for each user or group you would like to import.
7. Press the **OK** button to confirm and close the dialog.

Now any user on the LDAP server that you've authorized has access to the corresponding principles, roles, and permissions.

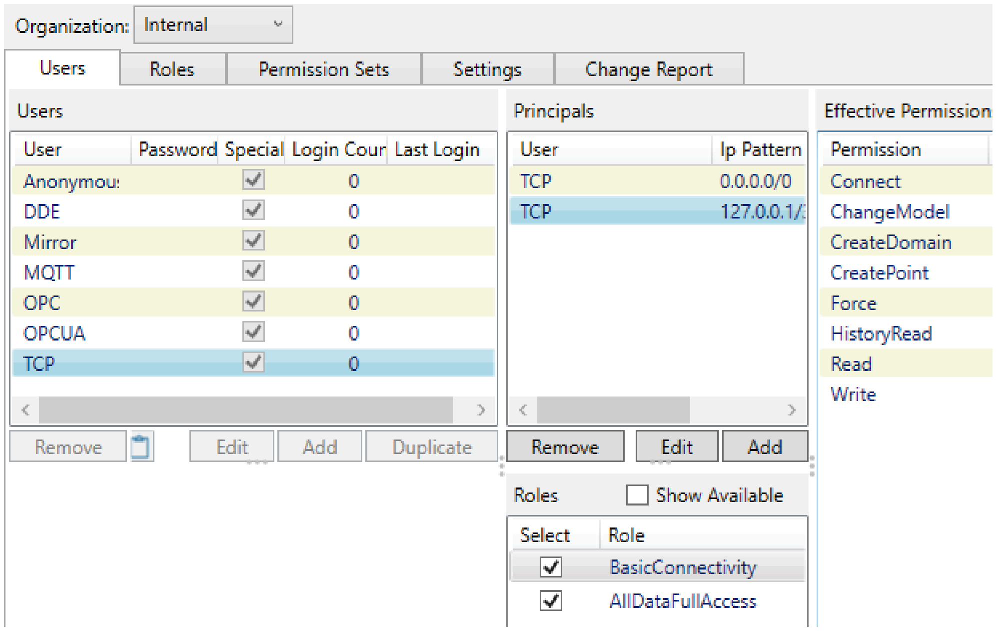
- For imported LDAP User accounts, authentication will be handled by the LDAP server.
- Unrecognized user credentials can be checked against known LDAP servers. If valid, the user identity will effectively impersonate one or more matching DataHub-imported LDAP Group accounts.
- While such accounts are authenticated by LDAP, authorization is still managed by the DataHub instance. That is, the user identity will be granted permissions based on the DataHub-defined role assignments associated with the imported User and Group accounts. You cannot use LDAP to manage DataHub-assigned permissions.

Custom Data Permissions

To demonstrate how to configure custom data permissions, we will use the DataPid program.

Connecting via the internal TCP user

To provide easy access for local TCP connections, there is an internal user, TCP, that allows connectivity and full data access on the local machine.



Since DataPid connects via TCP it can connect and exchange data as the TCP user. You can verify this as follows.

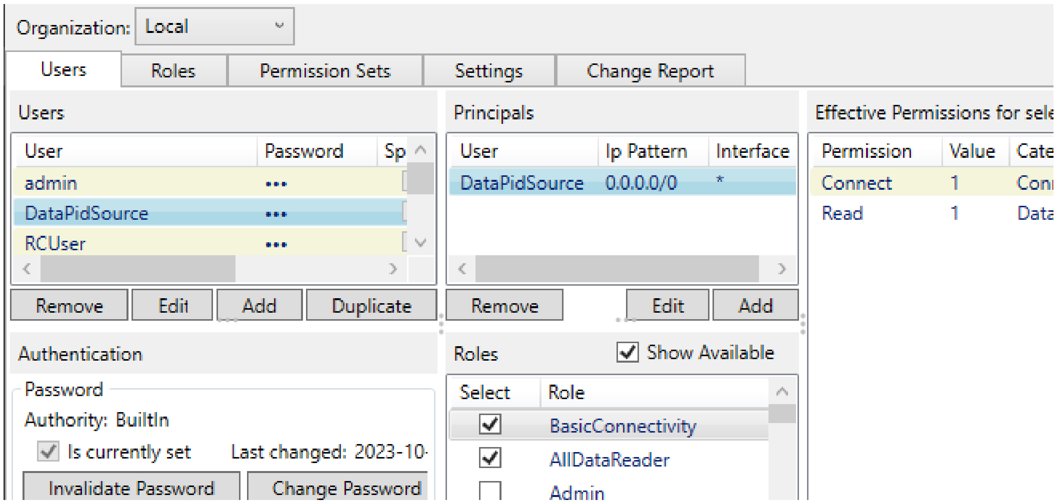
1. Start the DataHub program and DataPid.
2. You should see the following:

   DataPid status: Connected
   DataHub Event Log: shows incoming TCP connection established
   DataHub Connection Viewer: TCP Incoming connection established with username TCP
   DataHub Data Browser: DataPid data is updating.

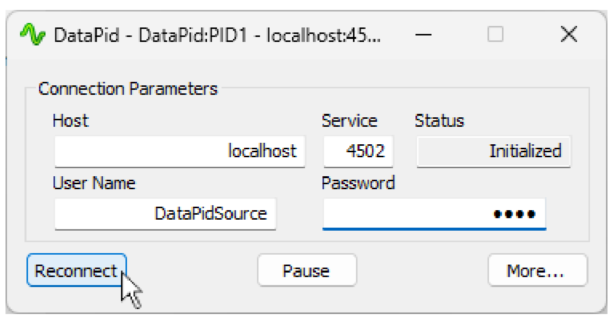
Custom user with permissions limited by role

Now we will use DataPid to demonstrate how to restrict access to the DataHub instance by creating a custom user with limited permissions.

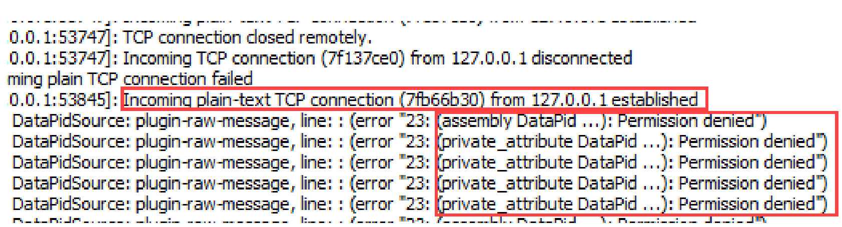
1. In the Local organization, create a BuiltIn user called `DataPidSource` with a password `test`.



2. Disable the role `RequireTotpAuthentication` and enable the role `AllDataReader`, leaving just the two roles `BasicConnectivity` and `AllDataReader`.
3. Apply the changes.
4. Disconnect DataPid, and reconnect using the `DataPidSource` username and `test` password.



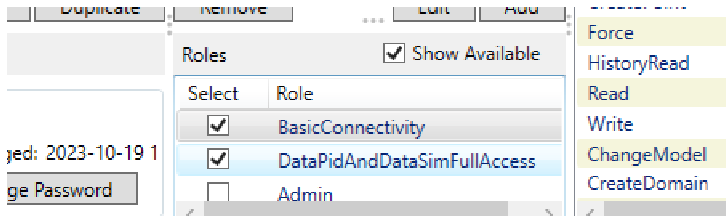
In the Event Log, you will see that the connection was established but permissions to create assemblies, sub-assemblies, and attributes (like data points), were denied.



Expanding permissions by changing roles

Now we will add a special role (`DataPidAndDataSimFullAccess`) designed to enable full permissions on the DataPid and DataSim domains. This special pre-defined role can be used an example for creating your own custom data permissions for specific data domains or data domain patterns.

1. Edit the DataPidSource user by disabling the `AllDataReader` role and enabling the `DataPidAndDataSimFullAccess` role.



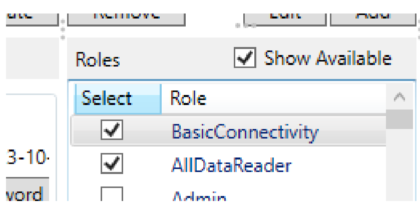
2. Apply the changes.
3. Disconnect and reconnect DataPid, still using the `DataPidSource` username and `test` password.

You should now see no error messages in the Event Log, and the data for DataPid should be updating in the Data Browser.

Restricting permissions by principal

It is also possible to restrict access by principal, such as the user's URL or data protocol. Here we will create a separate principal to restrict all DataPid updates except through TCP connections from localhost.

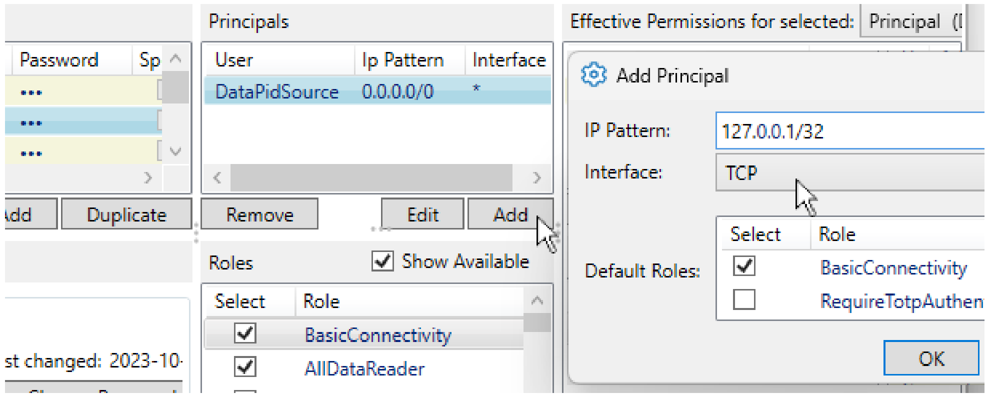
1. Ensure that the DataPidSource user is still selected, then disable the `DataPidAndDataSimFullAccess` role and enable the `AllDataReader` role.



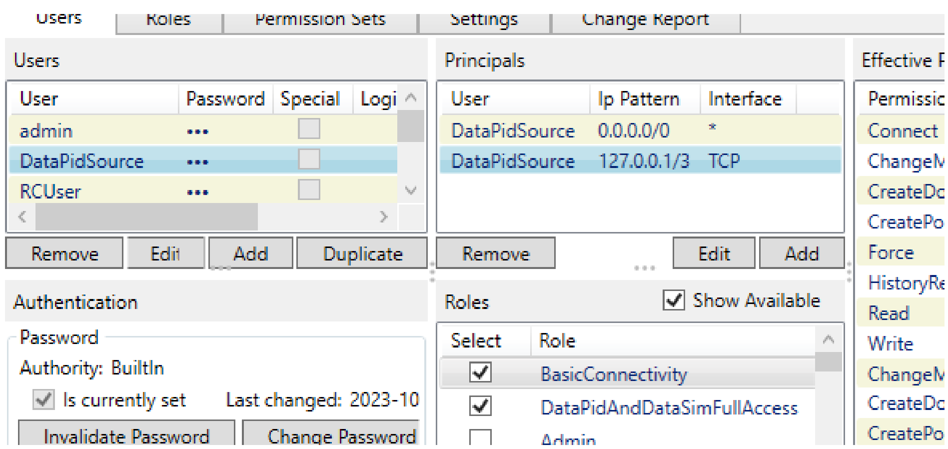
2. Apply the changes, then disconnect and reconnect DataPid, using the `DataPidSource` username and `test` password.

   You will now see error messages in the Event Log, and the DataPid data will stop updating in the Data Browser. All updates to DataPid data are now restricted.

3. Back in Security configuration, go to the **Principals** pane for DataPidSource and click the **Add** button to add a new principal.



4. Enter `127.0.0.1/32` for the IP address, and select `TCP` for the interface. Then click **OK**.
5. For this new principal, enable the `BasicConnectivity` and `DataPidAndDataSimFullAccess` roles.



Notice that the `DataPidAndDataSimFullAccess` roles provides effective permissions for the DataPid and DataSim domains.

6. Apply the changes, then disconnect and reconnect DataPid, using the `DataPidSource` username and `test` password.

You should now see no error messages in the Event Log, and the data for DataPid updating in the Data Browser. The DataPidSource user can still connect to this DataHub instance from anywhere, but is now unable to update DataPid data except when connected from localhost.

MQTT per-topic permissions

This option applies DataHub Security features to configure granular access control on portions of the MQTT topic space. It specifies an ordered collection of rules, where each rule specifies the permissions for a role on a per-topic or per-topic-pattern basis. Every principal that is a member of that role receives the configured permissions. Permissions are applied in the order they appear in the list, with the exception of user and client name patterns, which are always applied after topic names and topic patterns. The first matching rule will determine the permissions for any PUBLISH (write) or SUBSCRIBE (read) requests made on a connection.

Topics may contain wildcards following the MQTT topic syntax. A + character in the topic path matches a specific segment in the topic, and a # character matches all topics that start with the segments preceding the # character. See the MQTT specification for more details.

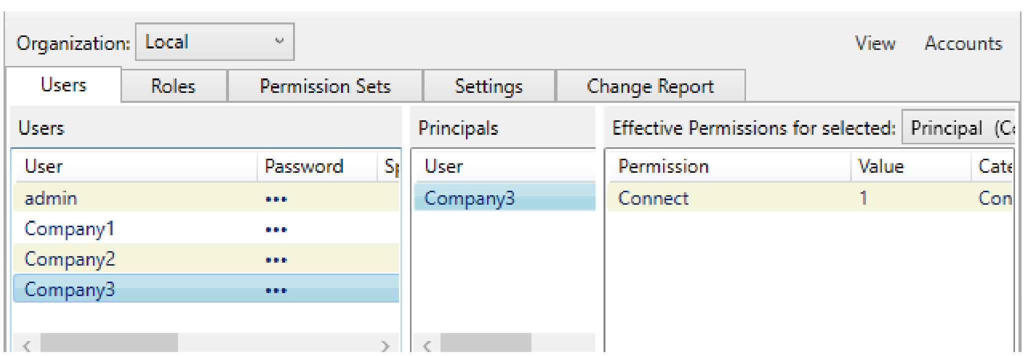
In addition, you can supply user and client name patterns. The string **%u** will be replaced with the username supplied for this connection. The string **%c** will be replaced with the MQTT client ID for this connection. Rules that include the **%u** and **%c** patterns will be evaluated after all other topic patterns, in the order that they appear in the list.

If no rule matches a request, the request is denied.

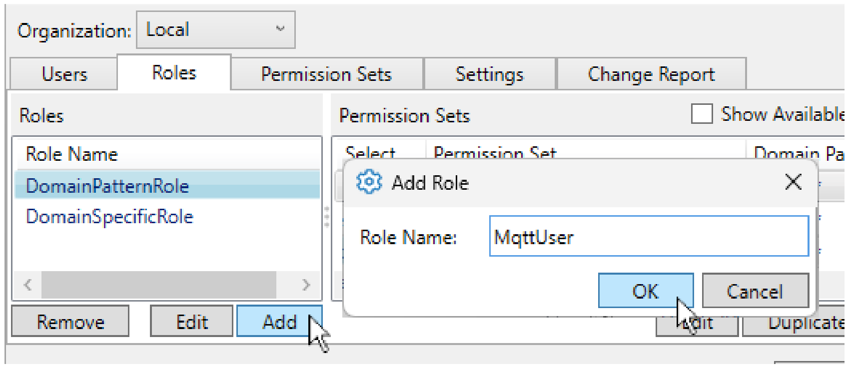
Example

Here is an example of a user-based rule. Designated users at each of three companies need access to the data for their company only. This configuration will give each user private access to the portion of the MQTT topic tree for their own company.

1. In the DataHub Properties window, select the **Security** option and click the **Configure** button.
2. Set the **Organization** to **Local**, and in **Users**, add or make sure you have are a few users to work with, like **Company1**, **Company2**, and **Company3**.

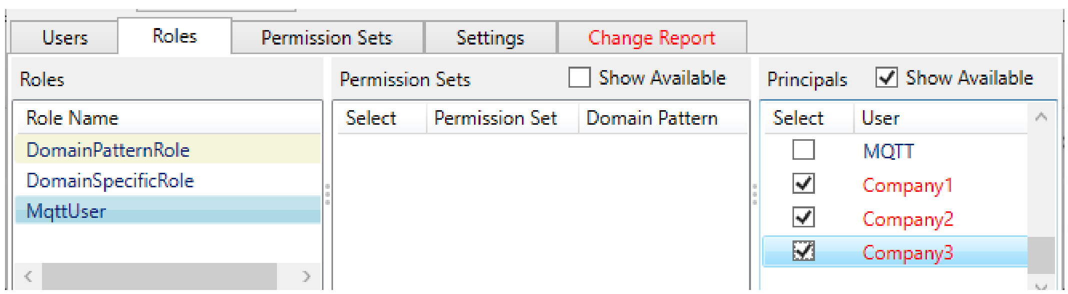


3. In the **Role** tab, under **Roles**, click the **Add** button and enter **MqttUser** for the role name.



Click **OK** to add the role.

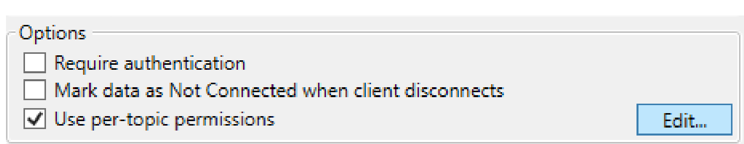
4. In **Principals** check the **Show available** box and select the names of the companies you wish to allow for the **MQTTUser**.



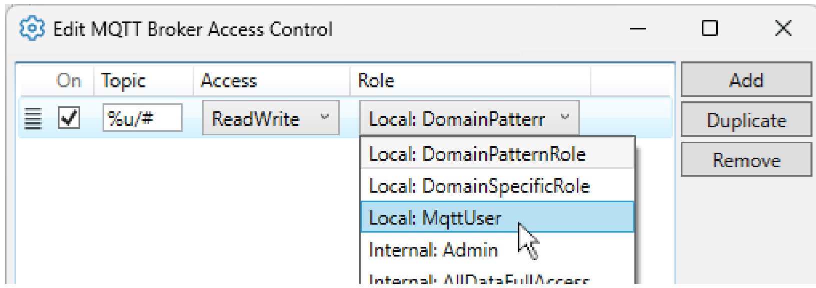
You do not need to add permissions to this role. Any MQTT permissions assigned here will be ignored when per-topic permissions are enabled. If you want to associate any non-MQTT permissions with this role, you can check the **Show Available** button to display the options, and choose what you need.

Click **OK** to save your work.

5. Go to the MQTT Broker configuration, and in Options, check the **Use per-topic permissions** box. Then click the **Edit** button to open the **Edit MQTT Broker Access Control** dialog.



6. Configure the following per-topic permissions:
   - **Topic:** `%u/#`
   - **Access:** `ReadWrite`
   - **Role:** `MqttUser`



Now each designated MQTT user has private access to the part of the MQTT topic tree that starts with their login name.

SSL Encryption

The DataHub program offers SSL encryption for Tunnel/Mirror, MQTT, and for making HTTPS connections to WebView or the Web Server. The SSL implementation uses the default SSL-3 encryption cipher: DHE-RSA-AES256-SHA, which is a 256-bit encryption method.

SSL Certificates and Firewalls

An SSL certificate is required to use SSL encryption on a DataHub instance. A default SSL certificate is installed with the DataHub program, or you can use your own certificate.

The certificate in the DataHub installation is a self-signed certificate with an expired end-date. This makes the certificate invalid when checked by the client side of the connection, which is intentional. It is impossible for us to ship a valid certificate. A valid certificate must be issued for the particular domain name or IP address that is hosting the server, and we cannot predict what that will be on your system. In addition, if we ship a certificate it will contain the private key, and anybody else who downloads and installs the DataHub program will also have the same private key. This means that using a certificate that is bundled into the DataHub installer will not protect you from malicious attacks—it will not provide reliable identification of the server, and it will not provide trustworthy encryption. Anybody with access to the certificate and Wireshark can decrypt the entire SSL conversation.

The reason we provide the DataHub self-signed SSL certificate is so that you can easily make encrypted connections from within a trusted environment, where you require encryption but don't want to manage and renew certificates on each of your DataHub installations. Because the SSL certificates are checked by the client side of the connection (the side that is initiating the connection), we provide options in the DataHub program to ignore invalid certificates, which in turn allows you to use the self-signed SSL certificate we ship with the DataHub program. For Tunnelling, these options are in the configuration of the Tunnel Slave connection. For applications that connect to the DataHub Web Server such as WebView and Remote Config, the options to ignore invalid certificates are provided on the login screens where you enter your username and password. For MQTT, this option is in the **Use SSL** option of the Authentication configuration.

If you are working in an untrusted environment and are required to have a valid SSL certificate on a DataHub instance, then you must either generate your own certificate using a trusted certificate authority, or get a certificate from a trusted public certificate authority like Verisign or Comodo. In this case you would then configure the DataHub instance to use your trusted certificate and you would disable the options to ignore invalid certificates when making a WebView, MQTT, Tunnel, or Remote Config connection, as applicable.

Firewall Ports

The DataHub program lets you specify which ports it will use for tunnelling/mirroring over a network. Firewalled ports can be secured, because if you open a port on the firewall, any program that attempts to connect on this port will need to be able to communicate with a DataHub instance that is listening on that port. As long as authentication is used for tunnelling, even a user who attempts to connect using another DataHub instance will need to have access to a valid username and password.

Editing OpenSSL ciphers and options

It is possible to edit the OpenSSL ciphers and options that the DataHub program uses, for those features that are coded in C++. Currently this includes tunnelling connections via the Tunnel/Mirror feature, HTTP connections via the Web Server, and MQTT client and server.

There are three registry entries available, all of type `REG_SZ` (string):

```
HKEY_LOCAL_MACHINE\Software\Cogent\Cogent DataHub\OpenSslCiphers
HKEY_LOCAL_MACHINE\Software\Cogent\Cogent DataHub\OpenSslOptions
HKEY_LOCAL_MACHINE\Software\Cogent\Cogent DataHub\SslMethod
```

`OpenSslCiphers` is an OpenSSL cipher string that determines which ciphers are available to a connection. It applies to both client and server connections. It defaults to:

```
ECDHE-ECDSA-AES128-GCM-SHA256:ECDHE-RSA-AES128-GCM-SHA256:ECDHE-ECDSA-
AES256-GCM-SHA384:ECDHE-RSA-AES256-GCM-SHA384:ECDHE-ECDSA-CHACHA20-POL
Y1305:ECDHE-RSA-CHACHA20-POLY1305:DHE-RSA-AES128-GCM-SHA256:DHE-RSA-AE
S256-GCM-SHA384:DHE-RSA-CHACHA20-POLY1305:ECDHE-ECDSA-AES128-SHA256:EC
DHE-RSA-AES128-SHA256:ECDHE-ECDSA-AES128-SHA:ECDHE-RSA-AES128-SHA:ECDH
E-ECDSA-AES256-SHA384:ECDHE-RSA-AES256-SHA384:ECDHE-ECDSA-AES256-SHA:E
CDHE-RSA-AES256-SHA:DHE-RSA-AES128-SHA256:DHE-RSA-AES256-SHA256:AES128
-GCM-SHA256:AES256-GCM-SHA384:AES128-SHA256:AES256-SHA256:AES128-SHA:A
ES256-SHA
```

`OpenSslOptions` lets you define additional options for client and server SSL connections. The options string consists of a collection of OpenSSL configuration file options separated by bar (**|**) characters. The set of options depends on the version of OpenSSL. All the Options listed in the SUPPORTED CONFIGURATION FILE COMMANDS section of the OpenSSL SSL_CONF_cmd documentation are currently available.

For example, to limit the connection to only use TLS 1.2, and to force the connection to use the server's cipher preference, the options could be:

```
Protocol=TLSv1.2,-TLSv1.1,-TLSv1,-SSLv2,-SSLv3|Options=ServerPreference
```

`SslMethod` lets you define a specific SSL method more conveniently than using `OpenSslOptions`. The MQTT broker and client ignore `OpenSslOptions` and use only `SslMethod` if it is defined. `SslMethod` is a `REG_SZ` (string) that can have one of the following values:

- `tls` indicates TLS 1.0
- `tlsv1.1` indicates TLS 1.1
- `tlsv1.2` indicates TLS 1.2
- `tlsv1.3` indicates TLS 1.3

If `SslMethod` is defined but is not one of the above, then the connection will fail.

Modifying SSL Security Levels

The DataHub program currently uses TLS version 1.3 by default for both outgoing and incoming connections. The SSL libraries are upgraded as needed to maintain security against all known TLS attack vectors. The DataHub program will use TLS 1.0, TLS 1.1, or TLS 1.2 if the other participant in the connection requires it.

If you are connecting different versions of the DataHub program, at some point you may discover that a DataHub instance using an older version of SSL is no longer compatible, and cannot connect to a DataHub instance that uses a newer version of SSL. Should this happen, we encourage you to upgrade all DataHub instances to the latest release.

However, we realize that upgrading existing installations is not always an option. In these cases it may be possible to configure a tunnel connection by modifying the SSL security level of the newer version of the DataHub program. This can be done by adjusting the OpenSslOptions registry entry as described in Editing OpenSSL ciphers and options.

OpenSSL changes for v11

DataHub v11 uses OpenSSL 3.3, a change from previous versions that use OpenSSL 1.1. OpenSSL 3 requires certificates to have stronger keys than in previous versions, so when DataHub v11 is acting as an SSL client it will reject connections to servers using weak certificates.

This is a breaking change. If you are using tunnelling, MQTT or web server functions in a DataHub application, you may need to re-generate the certificates for any DataHub installation being upgraded to v11 from an earlier version. If you intend to connect DataHub v11 to older versions, you may also need to upgrade the SSL certificates on the older versions.

The sample certificate, `datahub.pem`, that is installed with the DataHub installation has been changed in v11 to use a stronger key. This certificate is not valid - it is self-signed, possibly expired and issued to an invalid DNS name. If you are running older versions of DataHub software with the sample certificate, you can copy datahub.pem from a v11 installation to an earlier DataHub installation to re-establish the connection.

If you have generated your own server certificates then you may not be affected by this change. Most certificate generators default to an acceptable key length and hashing algorithm. If your generated certificate is weak, you will need to generate a new one.

If the DataHub v11 tunneller rejects a certificate because its key is weak, you will see a message similar to this in the DataHub Event Log:

```
[2024-06-25 05:47:06.977] I: [TCP to TUN000 into domain]:
SSL Certificate failure: 66: depth 0:
EE certificate key too weak:
/C=CA/ST=Ontario/L=Georgetown/O=Cogent Real-Time Systems Inc./OU=
Developers/CN=developers.cogentrts.com/emailAddress=support@cogent.ca
```

Look for the failure message, `EE certificate key too weak`.

If you cannot upgrade the certificate on a server for some reason, you can modify the configuration in the client to accept invalid certificates:

- In the DataHub Tunnel/Mirror Slave SSL configuration, un-check the options **Reject invalid certificates** and **Reject host name mismatch**.
- In the DataHub MQTT Client Authentication configuration, check the option **Accept invalid certificates**.

OPC UA connections are not affected by this change.

Permissions for the DataHub Command Set

Each time a DataHub instance receives a command from a client, it checks the client's user permissions. Before executing the command, the DataHub instance compares the user's permissions to the permissions required to run the command (shown in the table below). If the user has the necessary permissions, the command is executed, otherwise an error message is returned.

Command Name	Permissions Required
acksuccess	None
add	Data/Write
alias	Data/ChangeModel
aliaspattern	Data/ChangeModel
alive	None
append	Data/Write
assembly	Data/ChangeModel
attribute	Data/ChangeModel
auth	None

Command Name	Permissions Required
auth_clone	None
authreload	Admin/ConfigAdmin
auto_create_domains	Admin/ConfigAdmin
auto_timestamp	Admin/ConfigAdmin
bridge	Data/Write Admin/ConfigAdmin
bridge_remove	Admin/ConfigAdmin
bridge_remove_pattern	Admin/ConfigAdmin
bridge_transform	Admin/ConfigAdmin
cforce	Data/Write Data/Force
cread	Data/Read Data/CreatePoint
create	Data/CreatePoint
create_domain	Data/CreateDomain
creport	Data/Read Data/CreatePoint
cset	Data/Write Data/CreatePoint
cwrite	Data/Write Data/CreatePoint
debug	Admin/ConfigAdmin
defaultprop	Data/ChangeModel
delete	Data/DeletePoint
div	Data/Write
domain	Data/CreateDomain
domain_bridge	Admin/ConfigAdmin
domain_bridge_enable	Admin/ConfigAdmin
domain_bridge_prefer	Admin/ConfigAdmin
domain_bridge_refresh	Admin/ConfigAdmin
domain_bridge_remove	Admin/ConfigAdmin
domains	Connection/Connect
dump	Admin/ConfigAdmin
echo	Data/Write
enable_bridging	Admin/ConfigAdmin
enable_connect_server	Admin/ConfigAdmin
enable_dde_client	Admin/ConfigAdmin
enable_dde_server	Admin/ConfigAdmin
enable_domain_bridging	Admin/ConfigAdmin

Command Name	Permissions Required
enable_opc_client	Admin/ConfigAdmin
enable_opc_server	Admin/ConfigAdmin
enable_scripting	Admin/ConfigAdmin
error	None
exit	Admin/Shutdown
flush	Admin/ConfigAdmin
force	Data/Write Data/Force
format	Connection/Connect
get_client_stats	Admin/ConfigAdmin
get_domain_stats	Admin/ConfigAdmin
get_json	Data/Read
get_license_stats	Admin/ConfigAdmin
heartbeat	None
ignore	Data/Read
ignore_old_data	Admin/ConfigAdmin
include	Admin/LoadConfig
include_add	Admin/LoadConfig
instance	Data/ChangeModel
load_config_files	Admin/LoadConfig
lock	Data/Write
log_file	Admin/ConfigAdmin
log_file_flags	Admin/ConfigAdmin
log_file_max	Admin/ConfigAdmin
log_file_status	Admin/ConfigAdmin
log_point_origin	Admin/ConfigAdmin
log_to_file	Admin/ConfigAdmin
mirror_master	Admin/ConfigAdmin
mirror_master_2	Admin/ConfigAdmin
monitor_connections	Admin/ConfigAdmin
monitor_events	Admin/ConfigAdmin
monitor_scripts	Admin/ConfigAdmin
mult	Data/Write
point	Data/Write

Command Name	Permissions Required
private_attribute	Data/ChangeModel
property	Data/ChangeModel
quality	Data/Write
read	Data/Read
readid	Data/Read
report	Data/Read
report_all	Data/Read
report_domain	Data/Read
report_errors	Data/Read
save_config	Admin/ConfigAdmin
secure	Data/Write
set	Data/Write
set_access	Data/ChangeModel
set_authoritative	Data/Write
set_canonical	Data/ChangeModel
set_json	Data/ChangeModel
set_meta	Data/ChangeModel
show_data	Admin/ConfigAdmin
show_debug_messages	Admin/ConfigAdmin
show_event_log	Admin/ConfigAdmin
show_icon	Admin/ConfigAdmin
show_properties	Admin/ConfigAdmin
show_script_log	Admin/ConfigAdmin
subassembly	Data/ChangeModel
tcp_service	Admin/ConfigAdmin
timeout	None
transmit_insignificant	Admin/ConfigAdmin
type	Data/ChangeModel
unalias	Data/ChangeModel
unaliaspattern	Data/ChangeModel
undelete	Data/CreatePoint
unreport	Data/Read
unreport_domain	Data/Read

Command Name	Permissions Required
version	None
warn_of_license_expiry	Admin/ConfigAdmin
write	Data/Write

OPC-specific commands	Permissions Required
enable_opc_client	Admin/ConfigAdmin
enable_opc_server	Admin/ConfigAdmin
OPCAddItem	Data/Write
OPCAttach	Admin/ConfigAdmin
OPCDetach	Admin/ConfigAdmin
OPCInit	Admin/ConfigAdmin

DDE-specific commands	Permissions Required
DDEAdvise	Data/Write
DDEConnect	Admin/ConfigAdmin
DDEInit	Admin/ConfigAdmin
DDEService	Admin/ConfigAdmin
DDEUnadvise	Data/Write
DDEUnadvisePoint	Data/Write
EnableDDEServer	Admin/ConfigAdmin

Passwords

The authentication information for passwords is stored in a database in the configuration directory in a non-reversible encryption. They are secure and non-recoverable. If a user forgets his password, it cannot be retrieved or regenerated.

When a password is associated with a mirror/tunnel connection, it is stored unencrypted in the DataHub configuration folder. It is good security policy to deny access to this file to untrusted users.

When a password is transmitted across the network, it is transmitted in plain text. This is necessary to accommodate the variety of clients that could generate an authentication request. If the network is itself insecure, it is advisable to use a VPN (Virtual Private Network) or enable SSL for mirror/tunnelling to encrypt the network traffic.

Tunnelling Security - Best Practices

Installation

Each DataHub installation should only be writeable by system administrators. Users should only have read permissions on the installation directories. The default installation folder is within the `C:\Program Files\` tree, which already has these permission settings.

Configuration Folder

Every running DataHub instance reads and stores its configuration in a configuration folder. This folder can contain sensitive information like user names and passwords. In addition, the configuration folder determines which scripts will run when the DataHub instance starts, and those scripts have access to the operating system and file system. The configuration folder should be configured to allow read and write access only to system administrators and the user credential under which the DataHub instance will run. The default configuration folder is located within the `C:\Users\` tree, which already has reasonable permission settings.

On the Tunnel Master

You must allow Remote Connections in Security for any incoming connections over the network.

1. In Tunnel/Mirror Master options:
   - Disable **Accept plain-text connections on service/port**.
   - Install a valid certificate issued by a recognized certification authority (CA). Use either a third-party CA like Verisign, or create your own CA. Install the certificate into the Windows Trusted Root Certification Authorities certificate store on this machine.
2. In the Web Server options, if you plan to connect via WebSocket:
   - Select **Use secure sockets (SSL)**.
   - Select your SSL certificate file in the **SSL certificate file** entry field. It is OK to use the same certificate that you used in Tunnel/Mirror Master options (above).

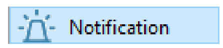
On each Tunnel Slave

1. Install your CA certificate (see above) into the Windows Trusted Root Certification Authorities certificate store on this machine.
2. For each connection:
   - Enable **Secure (SSL)**.
   - Enable **Reject invalid certificate**.
   - Enable **Reject host name mismatch**.

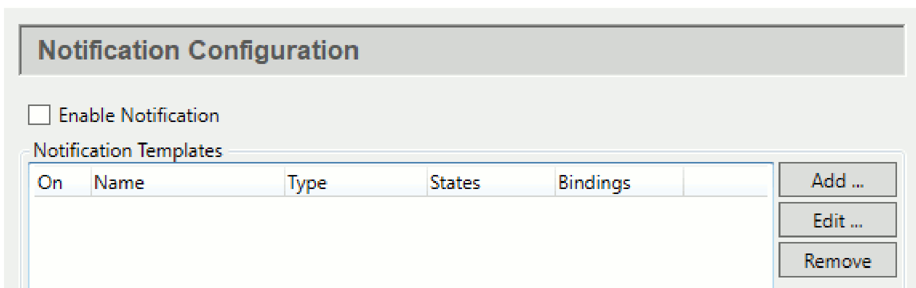
- Specify the **Remote user name** and **Remote password** as configured in the Tunnel Master Security Permissions (see above).

Making Notifications

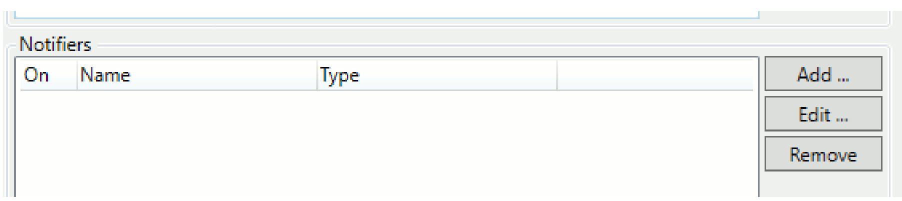
The Notification feature allows you to configure notifications for any data in the DataHub program, and send them by email, SMS, or social media applications. You configure notifications by defining templates for different states and conditions in your system, associating them with notifiers, and binding them to data. The various aspects of a notification are interrelated, and can be configured in several ways.

The easiest way to start using the Notification feature is by following an example. In the DataHub Properties window, select **Notification**. 

This will open the Notification Configuration:

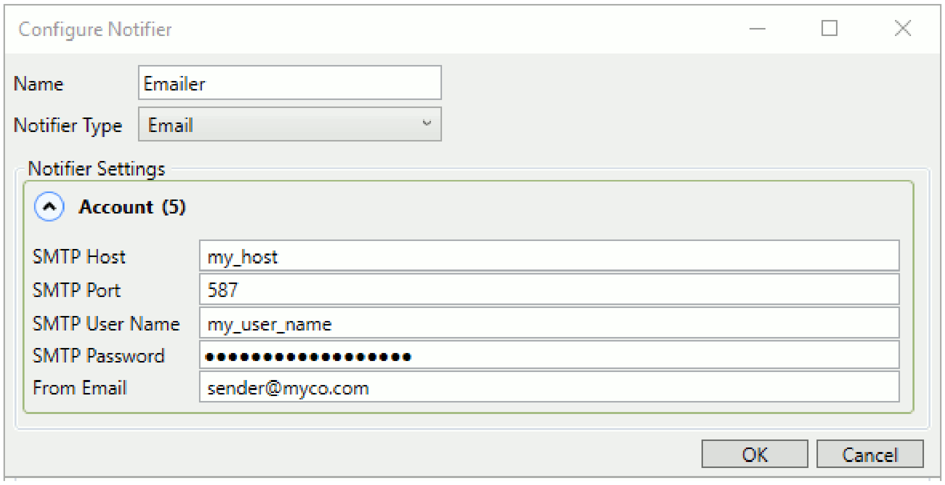


The top area of this interface is for working with templates, which typically is done most frequently. However, for your initial configuration, you will first need to add at least one notifier, in the **Notifiers** section.



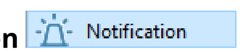
Configure a Notifier

1. In the **Notifiers** section, click the **Add** button to open the Configure Notifier window:

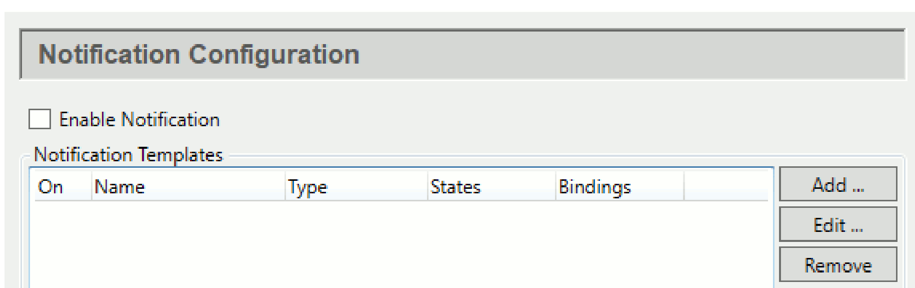


2. For the **Name** of our notifier, enter `Emailer`, and for the **Notifier Type**, select **Email**.
3. Enter the appropriate information for the email account you will use to send notifications.
4. Click **OK** and **Apply**. Now you have an email notifier, and are ready to define a template.

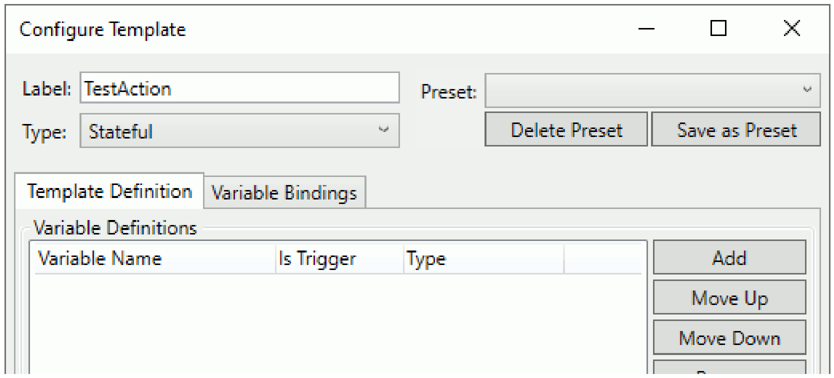
Define a Template

1. Ensure that you are at the DataHub Properties **Notification** 

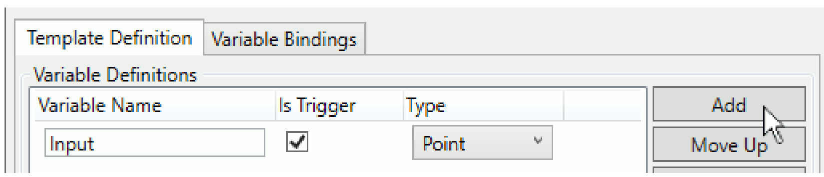
Configuration and that you have already configured a Notifier.



2. In **Notification Templates** click the **Add** button to open the Configure Template window.



3. For the **Label**, enter a name for this template, like `TestAction`.
4. For **Type**, choose **Stateful**. (Please see the Notification Type reference for information on this and other options.)
5. Click the **Add** button to add a new variable definition.

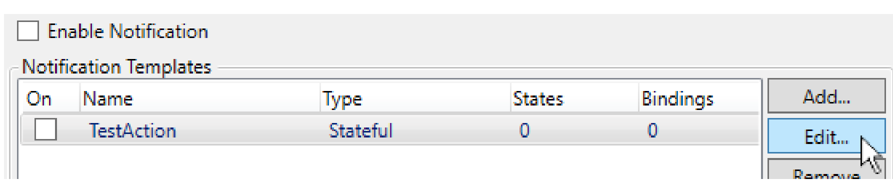


Enter the name `Input` for the **Variable Name**, and ensure that both the **Is Trigger** box is checked and the **Type** is set to **Point**.

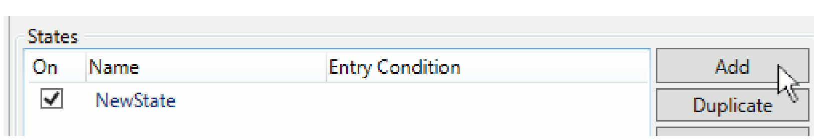
6. Click the **OK** button to save the variable.

Now you are ready to create a state with a couple of corresponding scripts.

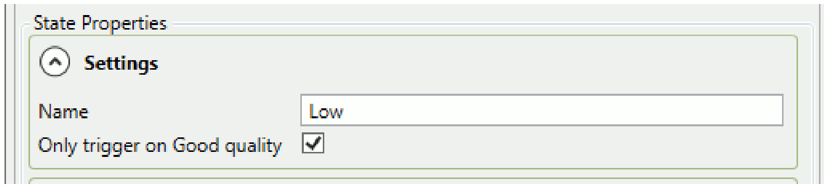
1. In the **Notification Templates** list, highlight the **TestAction** you just created, and click the **Edit** button to reopen the Configure Template window.



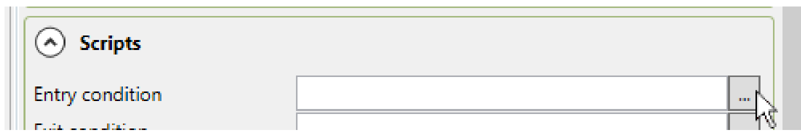
2. In States, click the **Add** button to create a new state.



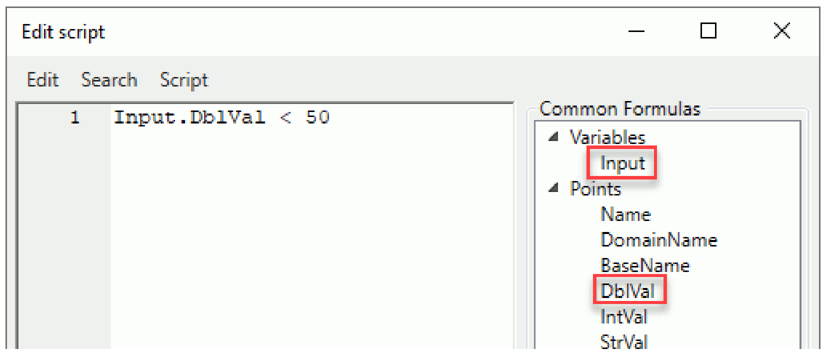
3. Down below, in **State Properties**, **Settings**, change the name from `NewState` to `Low`.



4. In **Scripts**, **Entry condition**



click the button with the three dots to open the Edit Script window:



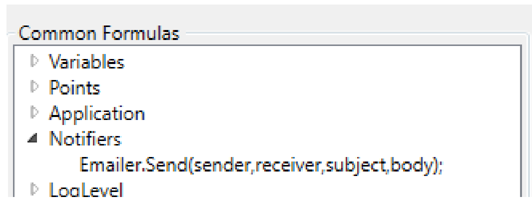
The scripting language is S-Sharp, which is documented here.

5. Enter the formula: `Input.DblVal < 50`. Notice that the `Input` variable is listed in the right-hand panel. Also in that panel are the attributes of DataHub points. Since your `Input` variable is a DataHub point, you have access to those variables. In this case, for example, `Input.DblVal` is the value of the point, as a double.
6. Click the **OK** button to save the script.
7. Again in **Scripts**, click the 3-dots button for the **OnEntry script**.
8. Create an on-entry script by entering the following in the script composition area:

```
var subject = Input.Name + " is low.";
var body = Input.Name + " = " + Input.DblVal;
Emailer.Send(null,"myname@myco.com",subject,body);
```

This script will send an email to `myname@myco.com` with the subject line stating that the value of whatever DataHub point gets assigned to this template is low, and containing a single line showing the name and value of that point. The formula for the

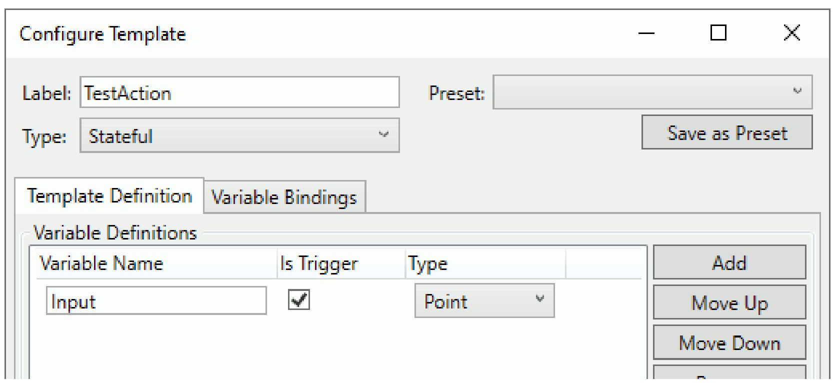
`Emailer.Send` function can be found in the **Common Formulas** panel of the Edit Script window, under **Notifiers**.



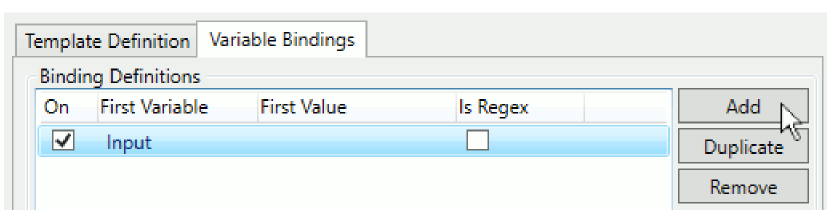
9. Click the **OK** button to save the script. You are now ready to bind a variable.

Bind a Variable

1. In the Notification option of the DataHub Properties window, select the `TestAction` template that you defined previously, and click the **Edit** button to open the Configure Template dialog.

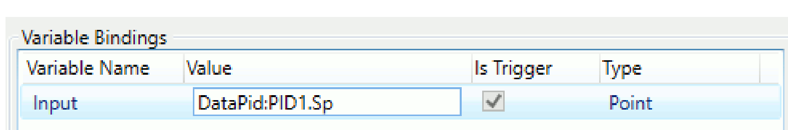


2. In the **Variable Bindings** tab, click the **Add** button.



This will create a new binding definition set, and open a new entry in the **Variable Bindings** list, below.

3. Enter the DataHub point name `DataPid:PID1.Sp`.



4. Click the **OK** button to save the binding.

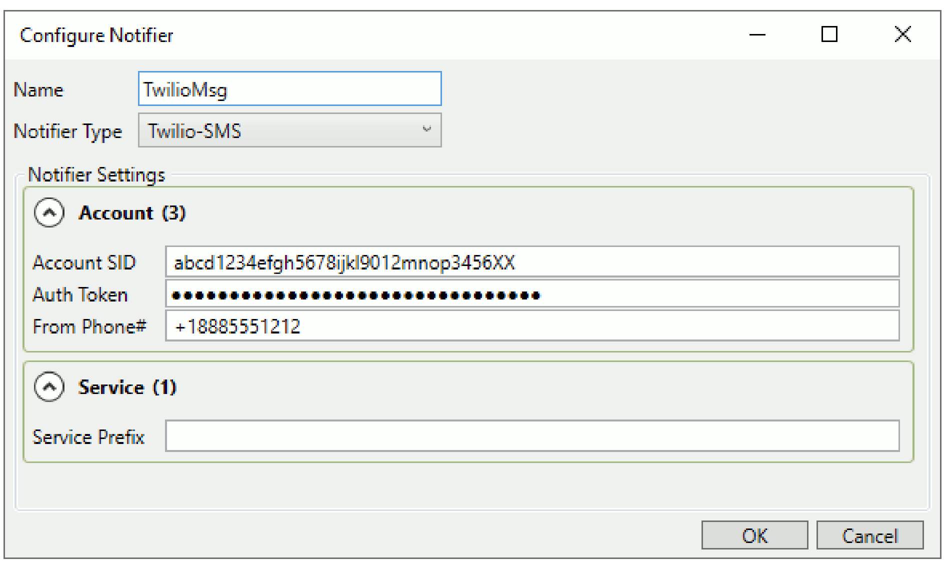
You have now bound a variable to your notification template. This means that the point `DataPid:PID1.Sp` will be substituted for the variable `Input` in all conditions and scripts that make up the template. To test, you need to enable the Notification feature and let the DataHub point value trigger it.

1. Back in Notification Configuration, ensure that the **Enable Notification** box is checked, and click the **Apply** button.
2. Start the DataPid data simulation program. This will change the value of the `PID1.Sp` point at random between 0 and 100 every 5 seconds.
3. Each time the point value drops from above 50 to below 50, you should receive an email at the address you specified in your template script (*`myname@myco.com`*).

Twilio

You can use the Twilio service to send notifications via SMS and WhatsApp, simply by adding a Twilio notifier.

1. If you don't already have a Twilio account, register for one, taking note of the account SID, authorization token, and phone number that you receive.
2. In the Notification Configuration option of the Properties Window, go to the **Notifiers** section and click the **Add** button to open the Configure Notifier window.



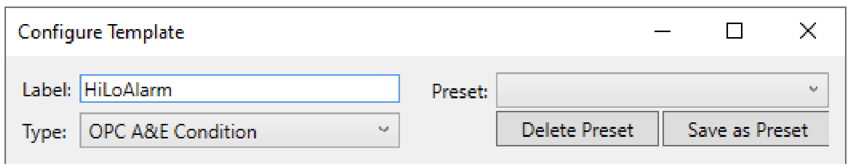
3. Enter the **Account SID**, **Auth Token**, and **From Phone#** for your Twilio account.
4. Click **OK** and **Apply**.

You can now specify TwilioMsg as a notifier for any notification template that you define.

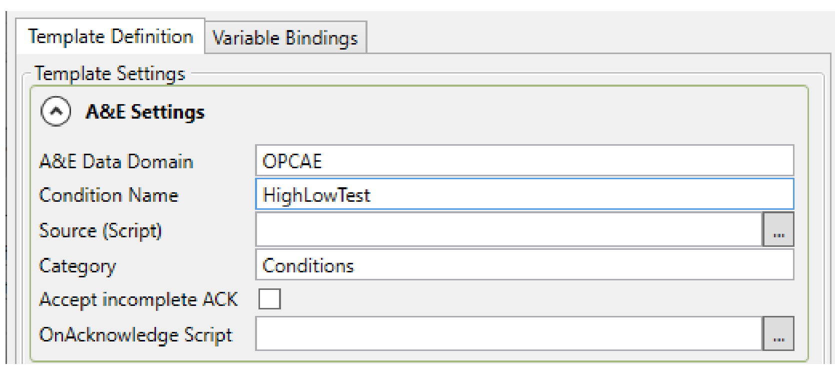
OPC A&E

The previous sections explain how to create a simple notification. In this section and the four that follow we create a more sophisticated template that produces OPC A&E condition events.

1. In the **Notification Templates** section, click the **Add** button to open the Configure Template window.



2. For the **Label**, enter a name for this template, like `HiLoAlarm`.
3. For **Type**, choose **OPC A&E Condition**. This will activate the **Event Settings**
4. In the **A&E Settings**, enter the following:



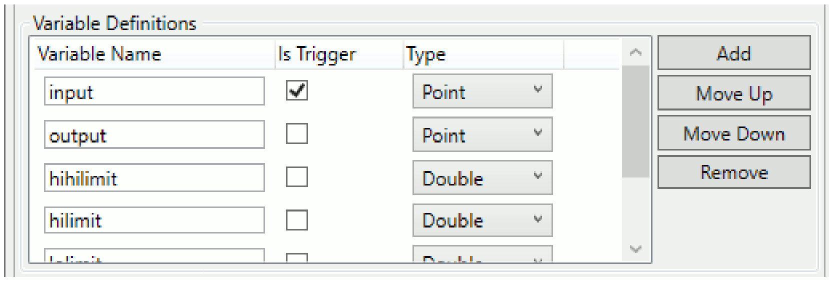
- **A&E Data Domain**: OPCAE
- **Condition Name**: `HighLowTest`
- **Source (Script)**: (leave blank)
- **Category**: `Conditions`
- **Accept incomplete ACK**: `(leave unchecked)`

For the time being you can leave **OnAcknowledge Script** blank. We'll come back to that later. Now you are ready to add multiple variables.

Multiple Variables

A typical notification could have a number of states, like High, High-High, Low, Low-Low, etc. Rather than assigning specific values for each of these, the template lets you create variables for them, so that you can redefine them once for all notifications using this template, if necessary. Here's how to create the variables:

1. In the HiLoAlarm template we created previously, in the Configuration Template window, go to the **Variable Definitions** section.



2. Use the **Add** button to create the following variables:

Variable Name	Is Trigger	Type
`input`	Yes	**Point**
`output`	No	**Point**
`hihilimit`	No	**Double**
`hilimit`	No	**Double**
`lolimit`	No	**Double**
`lololimit`	No	**Double**

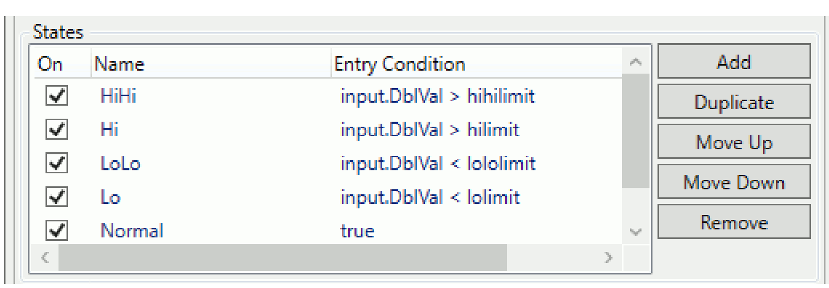
You can use the **Move Up** and **Move Down** buttons to rearrange the list.

Now you can create states for these variables.

Multiple States

This example compares the value of an "`input`" point to one of 5 possible states, and writes the value of an integer between `-2` and `2` to a DataHub point named "`output`". The variables in this example were defined previously in Multiple Variables.

1. In the HiLoAlarm template's Configuration Template window, go to the **States** section.



2. Add the following states and scripts:

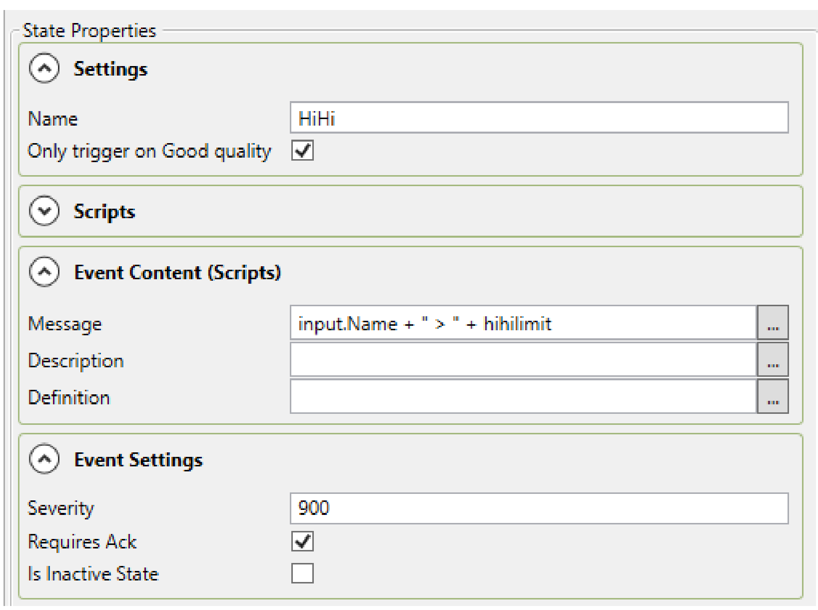
On	Name	Entry Condition	OnEntry Script
Yes	`HiHi`	`input.DblVal > hihilimit`	`app.WritePoint(output, 2);`
Yes	`Hi`	`input.DblVal > hilimit`	`app.WritePoint(output, 1);`
Yes	`LoLo`	`input.DblVal < lololimit`	`app.WritePoint(output, -2);`
Yes	`Lo`	`input.DblVal < lolimit`	`app.WritePoint(output, -1);`
Yes	`Normal`	`true`	`app.WritePoint(output, 0);`

You can use the use the **Move Up** and **Move Down** buttons to rearrange the states in the list. The order is important because the states are evaluated from top to bottom. Notice, for example, that **LoLo** is listed before **Lo**, and that **Normal** is at the end. This causes the evaluator to first check the highs in order from most extreme to the least extreme. Then it checks the lows from most extreme to the least extreme. If none of those is true, then it returns normal, which is always true.

A&E Event Settings

In addition to state settings, OPC A&E has several event settings.

1. Go to the **State Properties** section:

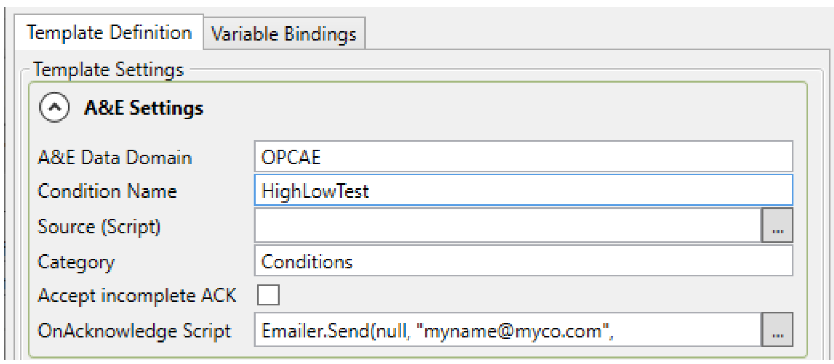


2. Configure these as follows:

Name	Message	Severity	Req. Ack	Inactive
`HiHi`	`input.Name + " > " + hihilimit`	`900`	Yes	No
`Hi`	`input.Name + " > " + hilimit`	`700`	Yes	No

Name	Message	Severity	Req. Ack	Inactive
LoLo	`input.Name + " < " + lololimit`	900	Yes	No
Lo	`input.Name + " < " + lolimit`	700	Yes	No
Normal	`input.Name + " is normal"`	1	No	Yes

3. You can also enter an **OnAcknowledge Script** in the **Event Settings** of the **Template Definition**:



For example:

```
Emailer.Send(null, "myname@myco.com", cond.Acknowledger +
" has acknowledged alarm on " + input.Name,
input.Name + " = " + input.DblVal);
```

This code is written here in three lines to fit the document. It should be all one line in the actual script.

This script tells the DataHub instance to send an email whenever an alarm gets acknowledged.

With the event settings complete, you are now ready to add some Regular Expressions to your notification.

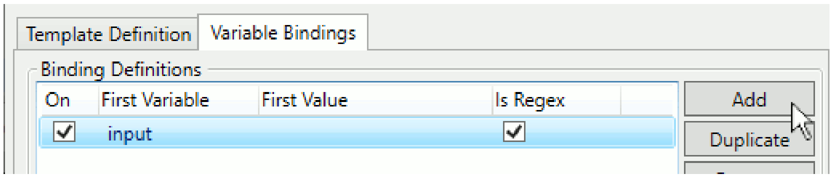
Regular Expressions

In previous sections we added some variables, with corresponding states and scripts. Instead of assigning single values to all of the variables, we can use *regular expressions* for some of them, to allow alarms to be generated from multiple points with similar names.

Regular expressions are a way that programmers use place-holders and wild cards in a variable name so that it can refer to multiple names at one time. The DataHub program uses .NET Regular Expressions, whose use and syntax can be found here.

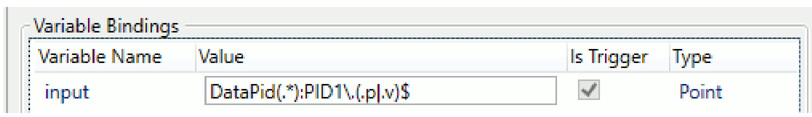
1. Go to the **Variable Bindings** tab and click the **Add** button. This will add a new binding

definition to the Binding Definitions list, and show you the first variable (`input`).



The *first variable* is used to create regular expressions for the binding definition. Any additional variables in the binding definition can access matches within the regular expressions for the first variable.

2. Check the **Is Regex** box.
3. In the **Variable Bindings** enter the following for the **input** variable:

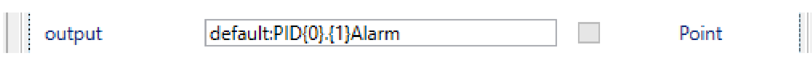



```
DataPid(.*):PID1\.(.p|.v)$
```

This regular expression selects any point with the following characteristics:

- `DataPid(.*):` chooses any data domain that starts with `DataPid`
- `PID1\.` chooses the `PID1.` branch.
- `(.p|.v)` selects any single letter, followed by `p` or `v`. In this case, it will select `Sp`, `Mv`, or `Pv`.
- `$` ends the expression.

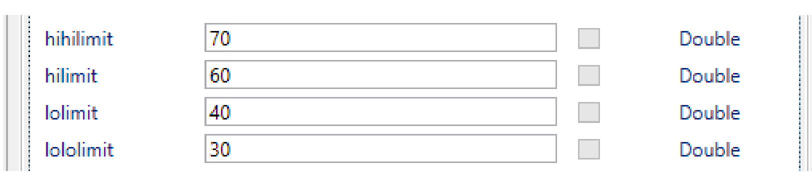
4. For the **output** variable enter:




```
default:PID{0}.{1}Alarm
```

The numbers within the curly brackets `{ }` will bring in whatever value corresponds within the parentheses `( )` in the `input` variable, in order. That is, the `0` matches the content of the first set of parentheses, the `1` matches the content of the second set, and so on.

5. For the rest of the variables, the limits, you can enter constant values.



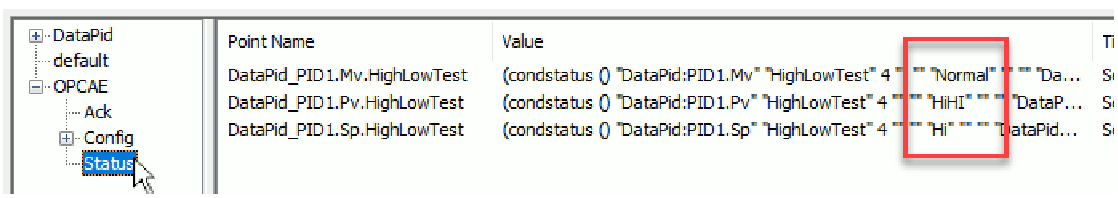
For example, `70` and `60` for the `hihilimit` and `hilimit`, and `40` and `30` for the `lolimit` and `lololimit`.

6. In the **Regex Explorer** section you can test your regular expression.

Enter a point name that you think matches the regular expression, such as `DataPid:PID1.Pv` in the **First Variable** field. If your regular expression is correct, you should see how that entry will appear for all of the related variables.

This completes the OPC A&E example. To test:

1. Click the **OK** button to return to the Notification Configuration window.,
2. Check the **Enable Notification** and **HiLoAlarm** boxes and click **Apply**.
3. Start DataPid.
4. In the Data Browser, open the **OPCAE** tree and click on **Status**.



You should see the values of the `*HighLowTest` points changing between `HiHi`, `Hi`, `LoLo`, `Lo`, and `Normal`.

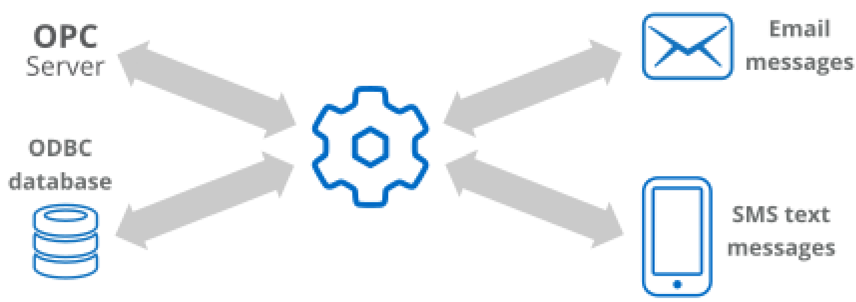
If you have installed the DataHub OPC A&E plug-in, you can view these alarms with any OPC A&E client application.

It is also possible to view OPC A&E alarm data in DataHub WebView's Alarm List control.

Email and SMS

Introduction

The DataHub program lets you send emails and SMS text messages, triggered by a DataHub event such as a point value change, or by a timer. The emails and messages can be in plain text or HTML format, and they can contain current values for any data point in a DataHub instance.



With this feature of the DataHub program you can:

- Send SMS text messages to cell phones when an alarm event is triggered.
- Design end-of-day reports that are delivered to managers' email accounts each morning.
- Provide managers with regular email updates of production targets.
- Emails can contain data from OPC servers, ODBC databases and other sources.
- Eliminate errors associated with manually writing production reports.
- Have a DataHub instance collect vital report information, format it as an Excel spreadsheet and then email the file to key people for review.

How it works

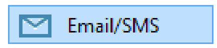
The DataHub program has a built-in mailing program. DataHub scripts tell the program what messages to send, to whom, and when to send them. A typical mailing script contains instructions to send an email in plain text, HTML format using ASP, or both. The example script, `MailTest.g` contains examples of both methods. You can run this script to test the mailer, and then use the examples that follow to send your own messages.

The sections in this chapter show you how to:

1. Configure the mailer.
2. Send a test email message.
3. Send your own email messages.
4. Send SMS messages.
5. Create HTML email messages.

Configuring the Mail Server

Before you can send email from a DataHub instance, you will need to configure the DataHub mail server program, as follows:

1. With a DataHub instance running, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Email/SMS**. 

Enter the information that you want to use for sending the email. This can be the same as the SMTP server listed in your email client program.

SMTP Server:

The name of the SMTP server.

Port:

The SMTP port number (typically this is port 25).

Sender Email:

The email address of the sender. This will appear in the `From` field of the email. The address can be in either of these two forms:

- **`username@datadomain.com`** will be displayed as `username@datadomain.com` in the email reader (client).
- **`User Name <username@datadomain.com>`** will be displayed as `User Name` in the email reader (client).

User name:

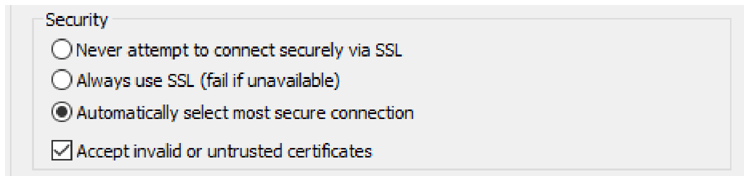
The log-in name you use to access this SMTP account.

Password:

The applicable password.

You will need to know your email account user name and password in order to have the DataHub instance successfully send to the outgoing SMTP Server. If you have problems, then look in the DataHub Script Log to view any error messages. Typically, problems are due to incorrect user name and password.

3. In the **Security** section:



Choose one of the three SSL options, and specify whether you want to accept invalid or untrusted security certificates.

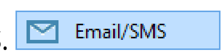
4. Click the **Apply** or **OK** button to submit your entries.

The DataHub mailer is now ready to use. If you haven't already done so, we suggest sending a test message as explained in the next section.

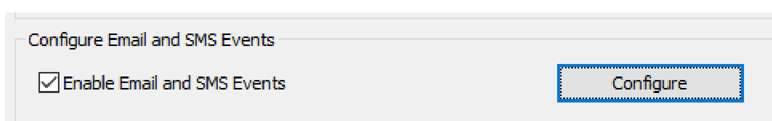
Sending a Test Message

Once you have configured the mail server you can configure and send a test email. Here's how:

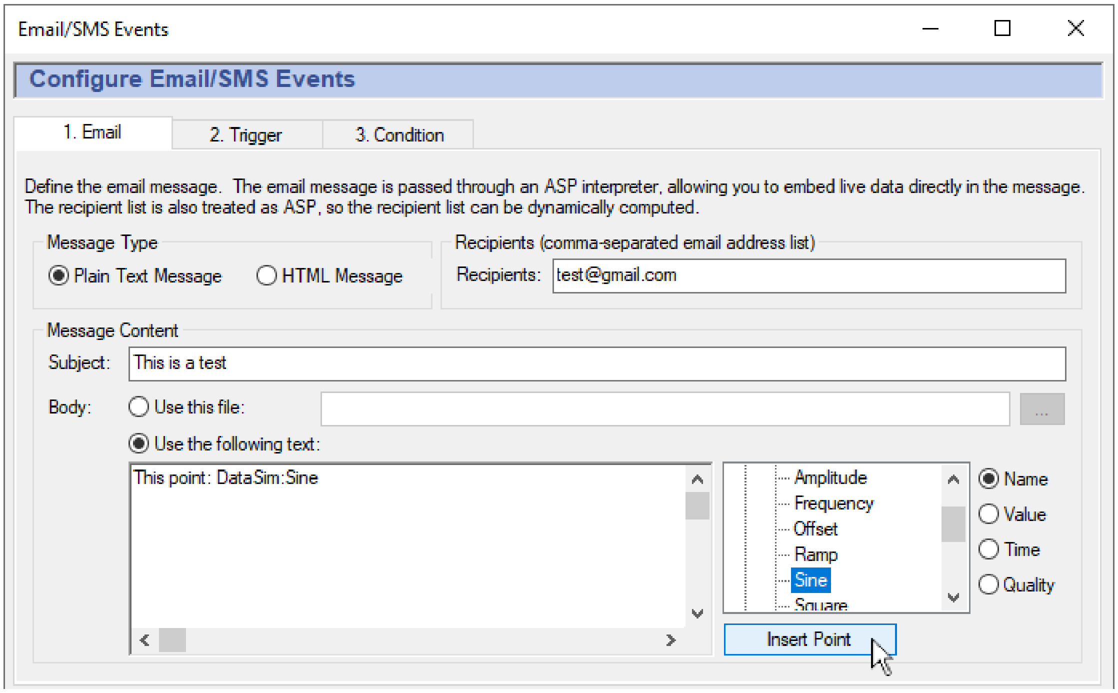
Open the Email/SMS Events window

1. In the Cogent DataHub Properties window, select **Email/SMS**. 

2. In the **Configure Email and SMS Events** section press the **Configure** button.



This opens the Email/SMS Events window:



Define the Email Message

1. Select the **1. Email** tab.
2. For the **Message Type**, choose **Plain Text Message**.
3. Enter a recipient email address in the **Recipients** box. You can enter several addresses, separated by commas.
4. Enter a subject in the **Subject** box.
5. For the **Body**, choose **Use the following text:**.
6. Start the DataSim program if it isn't already running, and ensure that it is connected to the DataHub instance.
7. In the point-picker list on the right, expand the `DataSim` data domain and select the point named `Sine`.
8. Click the **Name** button to the right of the point-picker list.
9. In the text entry field, type the following:

```
The point
```

10. Click the **Insert Point** button. Your text display should now look like this:

```
The point DataSim:Sine
```

11. Press **Enter** and continue typing:

```
The point DataSim:Sine
had a value of:
```

12. Click the **Value** button and then click the **Insert Point** button. Your text display

should now look like this:

```
The point DataSim:Sine
had a value of: <%=$DataSim:Sine%>
```

13. Press **Enter** and continue typing:

```
The point DataSim:Sine
had a value of: <%=$DataSim:Sine%>
at the time:
```

14. Click the **Time** button and then click the **Insert Point** button. Your text display should now look like this:

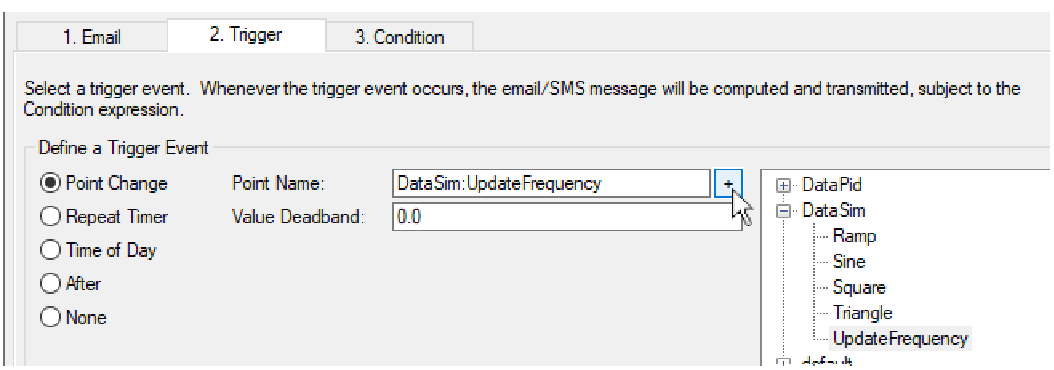
```
The point DataSim:Sine
had a value of: <%=$DataSim:Sine%>
at the time: <%=PointTimeString(#$DataSim:Sine%)>
```

The message is ready. Now you can assign a trigger and set a condition.

Assign a Trigger

For this example, we will trigger the action on the `DataSim:UpdateFrequency` point.

1. Select the **2. Trigger** tab.
2. From the point selector, expand the `DataSim` data domain and select the point `UpdateFrequency`.
3. Click the **+** button to the right of the **Point Name** field. The point name `DataSim:UpdateFrequency` should fill in for you.



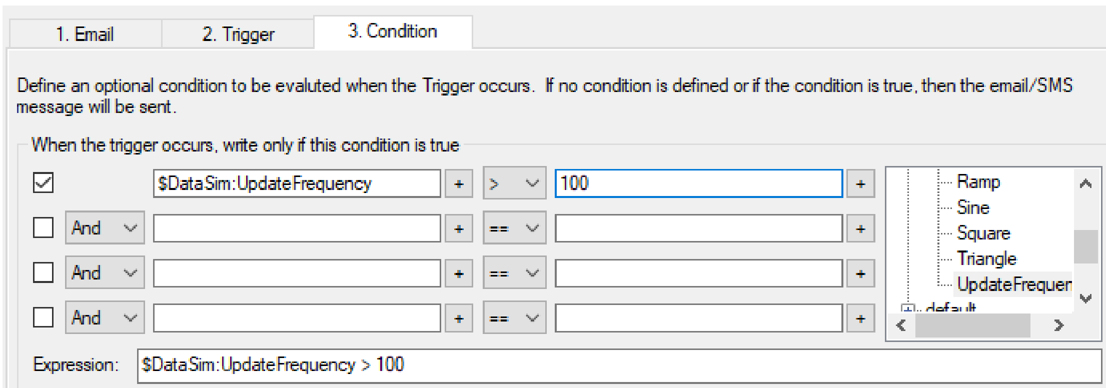
You can choose any point for the trigger, including the point that gets written, such as `DataSim:Sine` in our example. For more information about triggers, please refer to the section called "Assigning a Trigger".

Set a Condition and Configure the Action

For this example, let's limit the trigger on the `DataSim:UpdateFrequency` point to changes only to values over `100`.

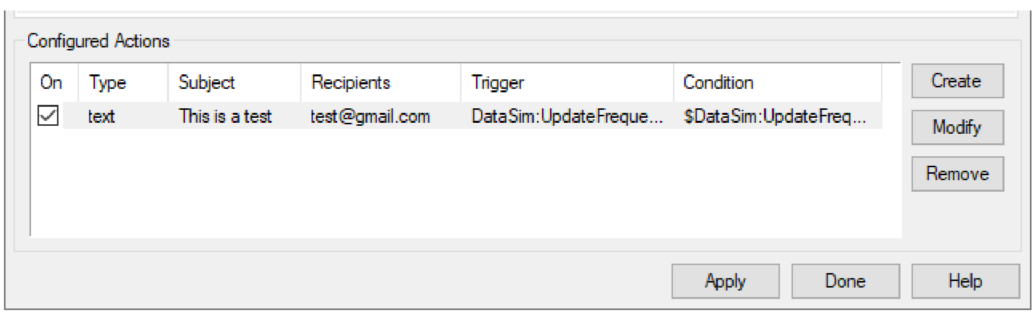
1. Select the **3. Condition** tab.

2. Click the checkbox in the first row.
3. From the point selector, expand the `DataSim` data domain and select the point `UpdateFrequency`.
4. Click the **+** button in the left column. The text `$DataSim:UpdateFrequency` should fill in the box.
5. From the drop-down box, choose the > operator.
6. In the right column, enter the number `100`. Your screen should now look like this:



You have set the condition. The expression at the bottom shows what will be passed to Gamma, the internal scripting engine of the DataHub program.

7. Go down to the **Configured Actions** box and click the **Create** button.



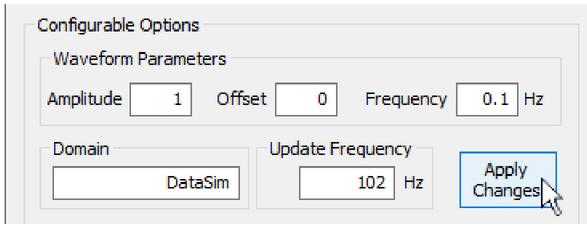
A new configured action should appear in the list. This is a summary of what you have done. When a configured action is selected in this list, you can make changes in any of the tabs and modify it using the **Modify**. You can also duplicate a configured action using the **Create** button, or remove it with the **Remove** button. For more information about configured actions, please refer to the section called “Configured Actions”

8. Click the **Apply** button to activate the configured action. Now let's see how it all works.

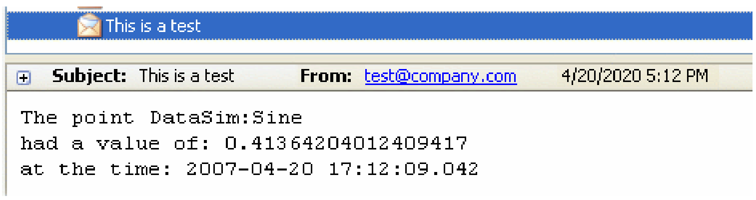
Trigger and Send an Email

The action you just configured causes the DataHub instance to send an email any time the DataSim Update Frequency is changed to a value greater than 100. To test the script, you'll need to trigger it by changing that value in the DataSim.

1. In DataSim, press the **More...** button to view the **Configurable Options**
2. Change the **Update Frequency** to a number greater than `100` and click the **Apply Changes** button to commit the change.



3. Check the email account of the recipient. You should have received a message that looks like this:

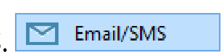


   Each time you enter a new **Update Frequency** value greater than `100` in the DataSim, the DataHub script will send a similar message.

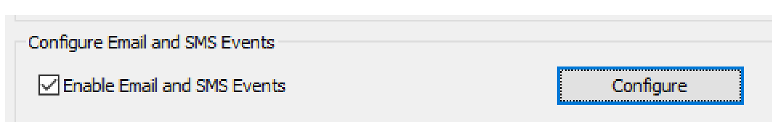
You have just configured and tested an action that sends an email with the name, value, and timestamp of the `Sine` point in the `DataSim` data domain whenever the value of the `UpdateFrequency` point changes to a value over 100. Now you can configure other emails to send your own text messages or HTML pages. The remaining sections in this chapter explain the interface in more detail

Defining the Email Message

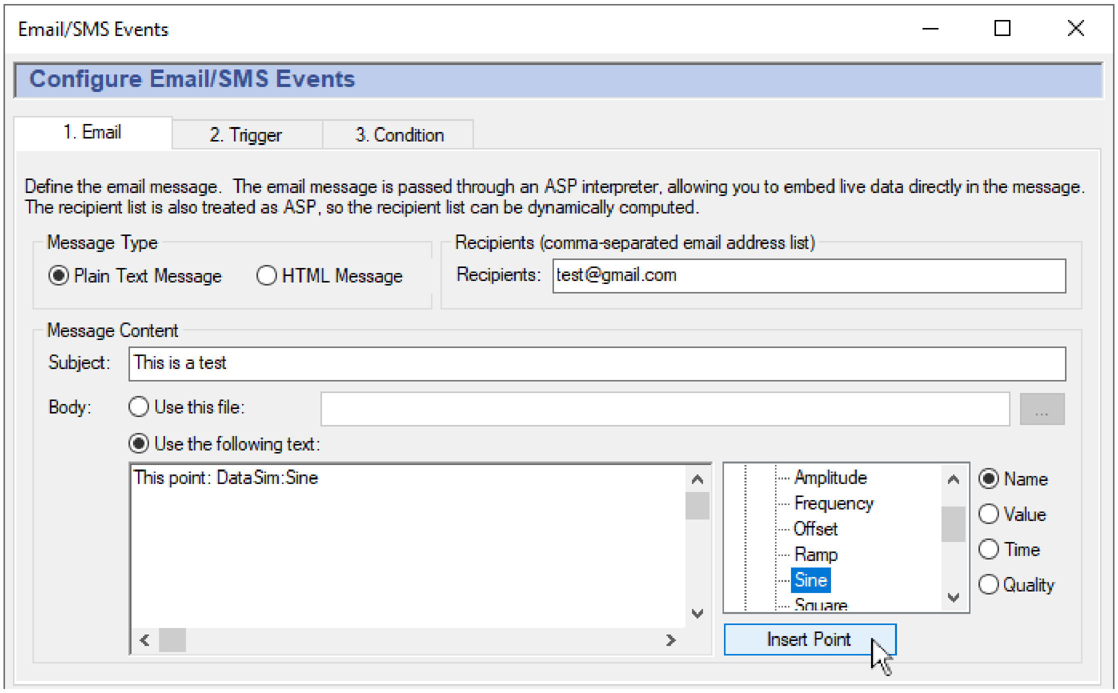
To send an email you need to determine the type of email message, its recipients, title, and message body. This is done from the Email/SMS Events window, which you can access in this way:

1. In the DataHub Properties window, select **Email/SMS**. 

2. In the **Configure Email** section press the **Configure** button.



3. Select the **1. Email** tab and configure your email as explained below.



Message Type

- **Plain Text Message** sends the text of the message as written in the source file or entered in this interface. Data point values will be assigned at the time the message is sent.
- **HTML Message** sends the source file or entry in this interface as an HTML file. Data point values will be assigned at the time the message is sent.

Recipients

This can be a single email address, or a list of email addresses where each address is separated by a comma. Addresses can be in either of these two forms:

- `username@datadomain.com`
- `User Name <username@datadomain.com>`

It is also possible to create a dynamic list of recipients, as explained in the section called “Dynamically Changing Email Subjects and Recipients”.

Message Content

- **Subject** Enter the subject of the message.
- **Body** You can use a message from a file, or compose one in the editing box.
  - **Use this file:** lets you insert the name of a file that you want to send as the text of your email. This is not an attachment, but rather the body of your message. Press the

... button to browse for the file you need. To see some HTML file examples, please refer to the section called "HTML Message Examples".

- **Use the following text:** lets you write and edit the body of your message. To insert the name, value, timestamp, or quality of the point in the point-picker list, select **Name**, **Value**, **Time**, or **Quality** button as desired. Then click the **Insert Point** button. The DataHub instance will insert into your text the point name with the proper syntax for the desired output in the email.

If you want to send a message from a file, you can still use the text editor with its convenient interface to create it. Write up the message in the editor, then copy and save it to a file.

The value, time, and quality attributes of the DataHub points are accessed by using a special syntax. This is applied automatically in the text editor when you press the **Insert** button. For your reference, the syntax is as follows:

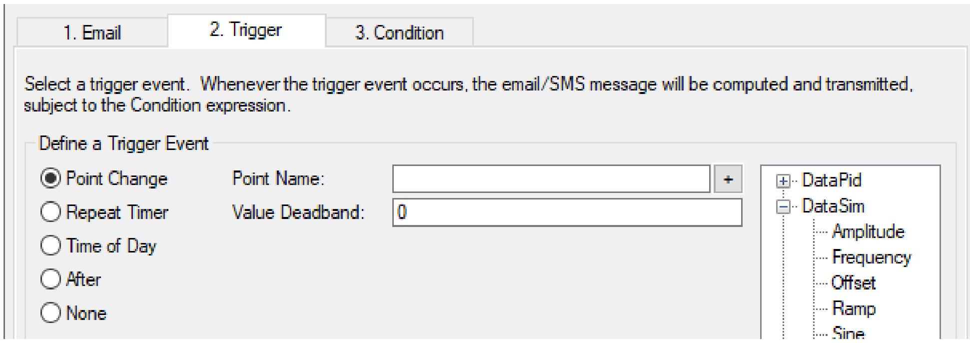
Button	Syntax	Example
Name	`domainname:pointname`	`DataSim:Sine`
Value	`<%= $domainname:pointname %>`	`<%= $DataSim:Sine %>`
Time	`<%= PointTimeString (# $domainname:pointname) %>`	`<%= PointTimeString (# $DataSim:Sine) %>`
Quality	`<%= PointQualityString (# $domainname:pointname) %>`	`<%= PointQualityString (# $DataSim:Sine) %>`

In this syntax, the special characters are used as follows:

Character	Use
`<% ... %>`	The enclosed expression will be evaluated by Gamma, the DataHub scripting language.
`$`	Indicates to Gamma that this is a DataHub point name.
`PointTimeString()`	A Gamma function that returns the timestamp of a DataHub point in an easily readable format.
`PointQualityString()`	A Gamma function that returns the quality of a DataHub point, as a text string.
`#`	Protects the DataHub point from being evaluated by Gamma until the function is called.

Assigning a Trigger

A trigger is an event that causes the email to be sent. A trigger event can be either a point value change, a timer event, or a calendar event. You can assign a different trigger for each email, or an identical trigger to any number of emails. An action can be configured to execute on every trigger event, or you can assign trigger conditions that are evaluated whenever a trigger occurs, to determine if the action should be executed.



The three kinds of triggers are:

- **Point Change** fires whenever a specified trigger point changes.
    1. Type the name of the point into the **Point Name** box, or select the point using the data tree on the right, then click the **+** button.
    2. (Optional) Enter a value deadband if you want to filter out extraneous data. The number you enter will specify a high and low (plus or minus) range. Any value change falling within that range will not cause the trigger to fire. A positive or negative change greater than this value will activate the trigger and cause the email to be sent.

    To create a trigger that gets reset automatically, please refer to An Auto-Resetting Trigger in the section called “Setting Trigger Conditions”.

- **Repeat Timer** fires cyclically, each time the number of seconds elapses.
- **Time of Day** fires at the time you specify. You can enter:
    - A number, indicating a specific value. For example, a `0` in the seconds field would cause the event only on the 0th second of the minute. A `30` would indicate only on the 30th second of the minute.
    - A list of numbers, separated by commas. For example, entering `0,15,30,45` in the minutes field would indicate that the event should fire on the hour and at 15, 30 and 45 minutes past the hour.
    - A range of numbers, separated by a dash. For example, entering `8-18` in the hours field would indicate that the event should fire every hour from 8 a.m. to 6 p.m.. Ranges can be mingled with lists, as in `0,4,8-16,20`.
    - An asterisk (`*`) indicates that the event should fire for every possible value of the field. For example, a `*` in the seconds field would cause the event to fire every second. A `*` in the hours field would cause the event to fire every hour.

    To regularly log a record on specific days of the week, please refer to the [section called “Setting Trigger Conditions”](#).

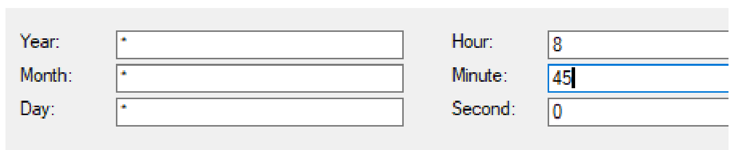
The ranges of the fields are:

Year:	`1970-*`	**Hour:**	`0-23`
Month:	`1-12`	**Minute:**	`0-59`
Day:	`1-31`	**Second:**	`0-59`

The year and month are entered differently here than for the Gamma `localtime` function, as explained in Time Conditions.

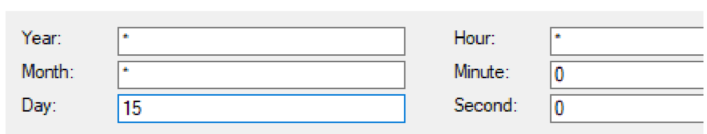
Examples:

- These entries:



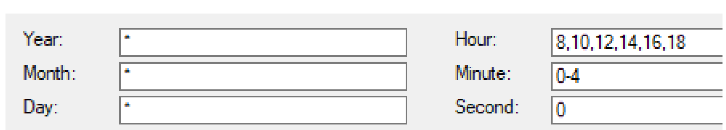
would cause an email to be sent at 8:45 every day, every month, and every year.

- These entries:



would cause an email to be sent every hour on the 15th day of each month, every year.

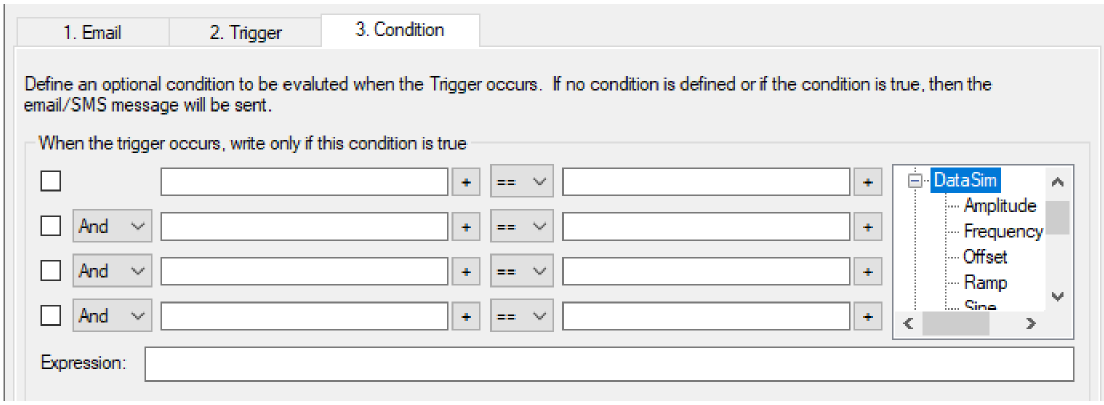
- These entries:



would cause an email to be sent every second for 5 minutes, every two hours between 8 a.m. and 6 p.m.

Setting Trigger Conditions

Each action can have up to four conditions that determine whether an email gets sent when the trigger fires.



Fill in the conditions according to the guidelines below. Check the box next to the condition to apply it. As you make entries, the corresponding *Gamma* code will appear in the display. Gamma is the DataHub program's built-in scripting language. The code that appears in the **Expression** box is the actual code that gets run by the Gamma engine. The order of precedence for "And" and "`Or`" operators (&& and `||`) is first And, then `Or`.

Point Value Conditions

Point names can be entered on either or both sides of the comparison. They can be picked from the data tree list, or typed in. Each point name needs to have a dollar sign ($) in front of it to indicate to the Gamma engine that this is a DataHub point. You can put numerical values into either side of the comparison.

When you enter a point name in a condition field, the current value of the point will be used in the evaluation. For example, you could define a condition that states that whenever the trigger event occurs, the action will only be executed if another point value is within a certain range.

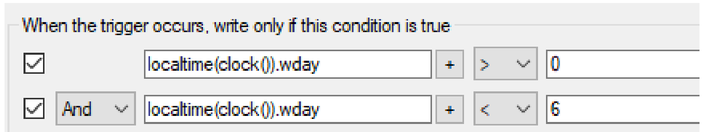
There are three automatic variables available for working with point values:

- `lasttrigger` - the value of the trigger point the last time this trigger was fired.
- `thistrigger` - the value of the trigger point now.
- `lastevent` - the value of the trigger the last time the event was actually executed.

Time Conditions

This provides an additional way to restrict the time, day, month, etc. when a message gets sent. In addition to the options on the triggers, here you have day-of-week condition statements which can give you more flexibility for events based on specific days of the week. These will work with any type of trigger event.

You can use the Gamma functions `clock` and `localtime` to specify particular days of the week. For example, these entries:



would create this Gamma code::

```
(localtime(clock()).wday > 0 && localtime(clock()).wday < 6)
```

which would cause an email to be sent only Monday through Friday. The function `localtime` returns a class whose members contain information about the date, as follows:

`.sec`	The number of seconds after the minute (`0` - `59`).
`.min`	The number of minutes after the hour (`0` - `59`).
`.hour`	The number of hours past midnight (`0` - `23`).
`.mday`	The day of the month (`1` - `31`).
`.mon`	The number of months since January (`0` - `11`)
`.year`	The number of years since 1900.
`.wday`	The number of days since Sunday (`0` - `6`).
`.yday`	The number of days since January 1 (`0` - `365`)
`.isdst`	`1` if daylight saving time is in effect, `0` if not, and a negative number if the information is not available.

The year and month are entered differently here than for **Time of Day** trigger conditions, as explained in the section called “Assigning a Trigger”.

There are two automatic variables available for working with time values:

- `lasteventtime` - the time that the last event was executed, in UNIX epoch time.
- `curtime` - the UNIX epoch time now.

Custom Conditions

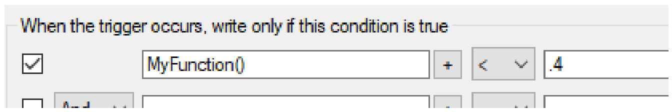
If the conditions you need to meet are beyond the scope of this interface, you can use a Gamma function to express virtually any condition you need. Then you can insert the function into one of the condition boxes, and set a condition based on the return value of the function.

To do this is you can create a DataHub script (`.g` file) that contains only the functions you will be using for conditions, without any classes or methods. For example, here is the complete contents of such a file, named `MyConditions.g`:

```
function MyFunction ()
```

```
{
    myvalue = $DataSim:Sine;
    princ("Value when the trigger fired: ", myvalue, "\n");
    myvalue;
}
```

This function prints the value of the `DataSim:Sine` point, and returns its value. We can use this function as a condition by calling it from one of the condition boxes in the interface, like this:



When the trigger fires, `MyFunction` is called, and the return value gets checked to see if it is less than .4. If so, the email is sent.

An Auto-Resetting Trigger

This script can turn any DataHub point into a trigger that automatically resets. To use it, you first need to load and run the `TriggerFunctions.g` script (shown below and included in the installation archive). Then, if you put this formula:

```
HighWithReset($default:TriggerPoint)!= nil
```

into the condition boxes, whenever the *`TriggerPoint`* changes to a non-zero number in the DataHub instance, your trigger will fire. The script waits for a millisecond, then resets the *`TriggerPoint`* back to zero. The second function works similarly, but triggers on a change to zero, instead of a change to a non-zero number.

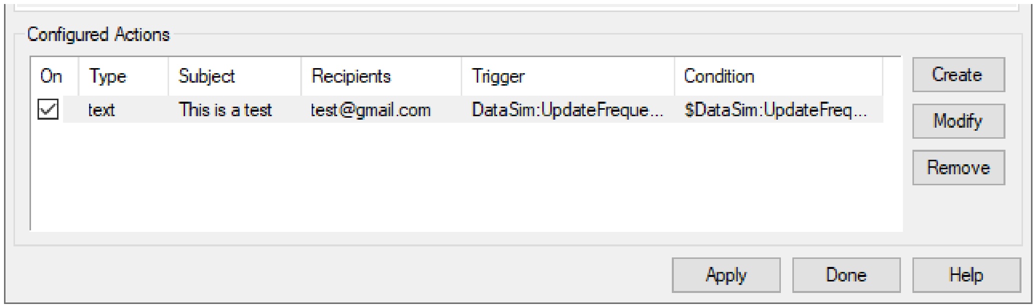
TriggerFunctions.g

```
/*
 * This file contains handy functions to perform more complex
 * condition handling in the Condition tab of the data logging
 * and email interfaces.
 */

/*
 * Test a trigger point for a non-zero value.  If the point is
 * non-zero, create a delayed event to reset the point to zero,
 * and return true, indicating that the condition has succeeded
 * and the action should proceed. If the value is 0, then simply
 * return nil indicating that the action should not proceed.  We
 * need to test for zero because when we reset the trigger point
 * to zero a second data change event will occur.
 *
```

```
 * The argument is unevaluated, so the condition should look
 * like this:
 *    HighWithReset($default:TriggerPoint) != nil
 */

function HighWithReset(!triggerpoint)
{
    local   value;
    if (!undefined_p(value = eval(triggerpoint)) && value != 0)
    {
        after(0.001, `setq(@triggerpoint, 0));
        t;
    }
    else
    {
        nil;
    }
}

/*
 * This is the inverse of HighWithReset (see above).  If the trigger
 * point is zero, perform the action and set the trigger point to 1.
 * If the trigger point is non-zero do nothing and return nil.
 */
function LowWithSet(!triggerpoint)
{
    local   value;
    if (!undefined_p(value = eval(triggerpoint)) && value == 0)
    {
        after(0.001, `setq(@triggerpoint, 1));
        t;
    }
    else
    {
        nil;
    }
}
```

Configured Actions

A *configured action* will cause a given email to be sent, based on a trigger and optional conditions. It is the end result of your configuration activities in this interface. The Configured Actions list shows the actions you have configured, and allows you to create, modify, or remove actions, as well as turn them on or off.



The list of configured actions shows the actions you have already configured. Selecting an existing action from the list automatically fills in the **Email**, **Trigger**, and **Condition** tabs with its information. Checking or unchecking the **On** box at the left lets you switch the action on or off.

The Create button creates an action for the information currently entered in the **Email**, **Trigger**, and **Condition** tabs. If you press the **Create** button while a configured action is selected, it creates a duplicate of that configured action and adds it to the list. This is a quick way to configure similar actions.

The Modify button overwrites the selected configured action with the information currently entered in the **Email**, **Trigger**, and **Condition** tabs.

The Remove button removes a configured action.

Once a configured action has been created or modified, the changes won't take effect until you click the **Apply** or **Done** button.

Sending SMS Text Messages

Sending SMS text messages from the DataHub program is the same as sending an email, but it must be a plain text email of 140 characters or less, sent to the appropriate SMS gateway email address.

Most cell phone service providers offer email and text messaging options on new subscriptions. For example, if you have a cell phone subscription with Telus in Canada, and your cell phone number is (416) 123 4567, then the SMS gateway email address for this phone would be:

```
4161234567@msg.telus.ca
```

Normally, SMS text messages are sent from one cell phone to another, which is all handled within the cell network itself. Using the SMS text message address, you can send a plain text email and it will be converted by the SMS gateway into a text message and be delivered to your phone. There may be a short delay while the conversion from email to text message occurs, but the message usually arrives in less than a minute.

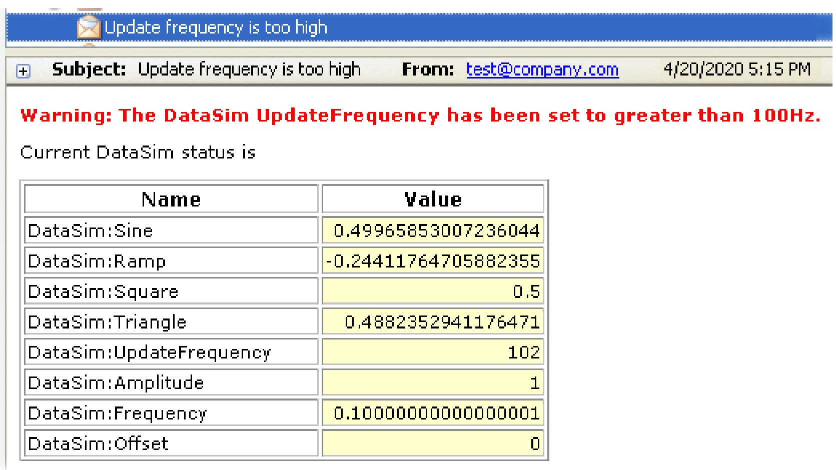
Check with your cell phone service provider for the SMS text message address for your cell phone number.If your cellphone plan does not include an Email to SMS gateway service, then an Internet search will provide a wide range of third-party companies offering inexpensive SMS gateway services.

HTML Message Examples

Sending an HTML message is as simple as clicking the **HTML Message** button in the Email tab. For the **Message Source** you can choose a file or write HTML code directly into the text-entry box. Here are two examples of how you can embed data into an HTML messages, using an ASP source file

An HTML Message with Embedded Data Points

This is an example of an ASP file that embeds the latest data from DataHub points into an HTML table. The ASP file is named `EmbedPoints.asp`, and its contents are given below. If a DataHub instance is configured to send this file as the message body, and the DataSim's UpdateFrequency is changed to, say, `102`, the DataHub instance will email a message like this:



Contents of the ASP File

```
<html>
<style>
BODY, P, TD{
background-color : White;
font-family :  Verdana, Geneva, Arial, Helvetica, sans-serif;
font-size : 8pt;
}
TH{
font-family:Verdana, Arial, Helvetica, sans-serif;
font-size: 9pt;
font-weight: bold;
background-color: #23cce6fe;
```

```
}
.highlight{background-color: #FFFFCC; text-align:right;}
.warning{color: #FF0000; font-weight: bold;}
</style>
<body>
<!--
 This is a simple example of an HTML template file which
        contains embedded point values from the DataHub.
 -->
<p></p>
<div class="warning">Warning: The DataSim UpdateFrequency has been
                     set to greater than 100Hz.</div>
<p></p>
Current DataSim status is
<p></p>
<table border="1">
  <tr>
    <th width="180">Name</th>
    <th width="80">Value</th>
  </tr>
  <tr>
    <td>DataSim:Sine</td>
    <td class="highlight"><%=$DataSim:Sine%></td>
  </tr>
  <tr>
    <td>DataSim:Ramp</td>
    <td class="highlight"><%=$DataSim:Ramp%></td>
  </tr>
  <tr>
    <td>DataSim:Square</td>
    <td class="highlight"><%=$DataSim:Square%></td>
  </tr>
  <tr>
    <td>DataSim:Triangle</td>
    <td class="highlight"><%=$DataSim:Triangle%></td>
  </tr>
  <tr>
    <td>DataSim:UpdateFrequency</td>
    <td class="highlight"><%=$DataSim:UpdateFrequency%></td>
  </tr>
  <tr>
    <td>DataSim:Amplitude</td>
    <td class="highlight"><%=$DataSim:Amplitude%></td>
  </tr>
  <tr>
    <td>DataSim:Frequency</td>
```

```
    <td class="highlight"><%=$DataSim:Frequency%></td>
  </tr>
  <tr>
    <td>DataSim:Offset</td>
    <td class="highlight"><%=$DataSim:Offset%></td>
  </tr>
</table>
</body>
</html>
```

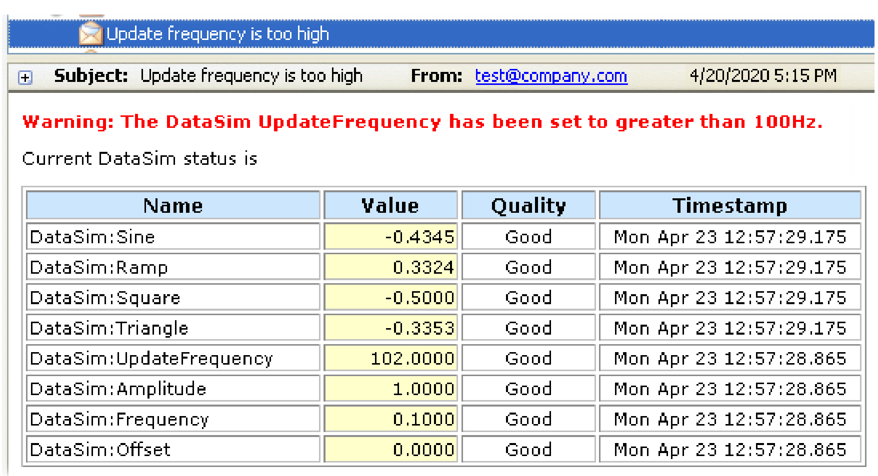
This file consists of HTML code interspersed with *Gamma* code. Gamma is the scripting language of the DataHub program. The Gamma code is often used to determine the value of a DataHub point, with the following syntax:

```
<%=$domainname:pointname%>
```

The pointed brackets and percent signs (`<% ... %>`) indicate to the DataHub ASP interpreter that this is Gamma code. The equals sign (=) tells the Gamma engine to evaluate the expression, and the dollar sign ($) tells the Gamma engine that this is a DataHub point.

An HTML Message with a Table Created in Code

This is an example of an HTML message with a table created by using code, rather than explicitly writing it out. Using code provides more flexibility in formatting the data and making changes to the table. The code is written into an ASP file named `CreateTable.asp`, and its contents are given below. If the DataHub instance is configured to send this file as the message body, and the DataSim's UpdateFrequency is changed to, say, `102`, the DataHub instance will email this message:


Update frequency is too high

Subject: Update frequency is too high From: test@company.com 4/20/2020 5:15 PM

Warning: The DataSim UpdateFrequency has been set to greater than 100Hz.

Current DataSim status is

Name	Value	Quality	Timestamp
DataSim:Sine	-0.4345	Good	Mon Apr 23 12:57:29.175
DataSim:Ramp	0.3324	Good	Mon Apr 23 12:57:29.175
DataSim:Square	-0.5000	Good	Mon Apr 23 12:57:29.175
DataSim:Triangle	-0.3353	Good	Mon Apr 23 12:57:29.175
DataSim:UpdateFrequency	102.0000	Good	Mon Apr 23 12:57:28.865
DataSim:Amplitude	1.0000	Good	Mon Apr 23 12:57:28.865
DataSim:Frequency	0.1000	Good	Mon Apr 23 12:57:28.865
DataSim:Offset	0.0000	Good	Mon Apr 23 12:57:28.865

Contents of the ASP File

```
<html>
<style>
BODY, P, TD{
    background-color : White;
    font-family :  Verdana, Geneva, Arial, Helvetica, sans-serif;
    font-size : 8pt;
}
TH{
    font-family:Verdana, Arial, Helvetica, sans-serif;
    font-size: 9pt;
    font-weight: bold;
    background-color: #cce6fe;
}
.highlight{background-color:#FFFFCC; text-align:right}
.warning{color: #FF0000; font-weight: bold;}
</style>
<body>
<p></p>
<div class="warning">Warning: The DataSim UpdateFrequency has
been set to greater than 100Hz.</div>
<p></p>
Current DataSim status is
<p></p>
<table border="1">
    <tr>
    <th width="180">Name</th><th width="80">Value</th>
    <th width="80">Quality</th><th width="160">Timestamp</th>
    </tr>
<%
require ("Time");
require ("Quality");

try
{
    local  v, q, tm, ts, info;

    with pt in [ #$DataSim:Sine, #$DataSim:Ramp, #$DataSim:Square,
                 #$DataSim:Triangle, #$DataSim:UpdateFrequency,
                 #$DataSim:Amplitude, #$DataSim:Frequency,
   #$DataSim:Offset ] do
    {
        info = PointMetadata (pt);
        v = eval (pt);
```

```
        if (!number_p(v)) v = 0;
        q = GetQualityName (info.quality);
        ts = PointGetUnixTime (pt);
        tm = format ("%19.19s.%03d", date(ts), (ts % 1.0) * 1000);
%>
        <tr><td><%= pt %></td>
            <td class="highlight"><%= format("%.4f",v) %></td>
            <td align="center"><%= q %></td>
            <td align="center"><%= tm %></td></tr>
<%
    }
}
catch
{
    princ (_last_error_, "\n");
    print_stack (nil, _error_stack_);
}
%>
</table>
</body>
</html>
```

This file consists of HTML code interspersed with *Gamma* code. Gamma is the scripting language of the DataHub program. The Gamma code is often used to determine the value of a DataHub point, with the following syntax:

```
<%=$domainname:pointname%>
```

The pointed brackets and percent signs (`<% ... %>`) indicate to the DataHub instance that this is Gamma code. The equals sign (=) tells the Gamma engine to evaluate the expression, and the dollar sign ($) tells the Gamma engine that this is a DataHub point. Other Gamma statements and functions used in this example include `require`, `try`, `local`, `with`, `if`, `format`, `catch`, `princ`, and `print_stack`. The functions `GetQualityName` and `PointGetUnixTime` are from the required files `Quality.g` and `Time.g` respectively.

Dynamically Changing Email Subjects and Recipients

The ASP processor in Gamma allows you to embed the result of any Gamma expression within the subject and recipient fields of an email. To do this on the subject field, you would use the same `<%= %>` syntax as is available for messages, for example:

```
The Sine value is now <%= $DataSim:Sine %>
```

would put the value of the `DataSim:Sine` point into the subject line of the email or message.

This syntax, explained in a the end of the section called “Defining the Email Message” can also be used to insert addresses for one or more the message recipients, by creating a point that contains the list of recipient names. The value of this point could then be changed externally based on who is on-call or is logged into an attached SCADA system. For example, a point in the `default` domain named `CurrentOperatorEmail`, would be entered in the **Recipients:** field like this:

```
<%= $default:CurrentOperatorEmail %>
```

If you need a more complex calculation to determine the recipients, you can create a Gamma script that loads when the DataHub instance starts. For example, to change the email based on the value of a point, you could do something like this:

```
function choose_mail_recipient()
{
    if ($DataSim:Sine > 0.5)
        "operator1@gmail.com";
    else
        "operator2@gmail.com";
}
```

and then put the appropriate function call into the email recipient list, like this:

```
<%= choose_mail_recipient() %>
```

Notice that the expression within `<%= %>` does not end with a semicolon. This syntax requires a Gamma *expression*, not a Gamma *statement*. Effectively, it needs to be code that would be syntactically correct in this statement:

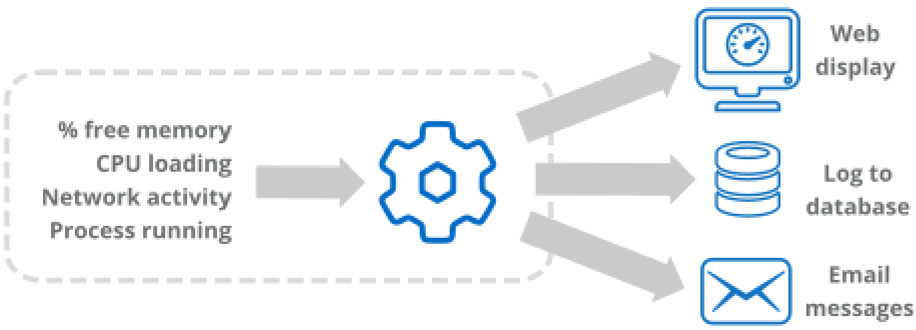
```
x = insert_expression_here;
```

You can add as many `function` statements to your script as you like. Don't use `method` statements for this, since they are just for scope of the class of that script. Once a function has been defined in a running Gamma script, it is available to all other running Gamma programs. If you have created other Gamma programs, put this one at the top of the list, so that the function becomes available before those programs start. The Email/SMS program starts after the programs in the list.

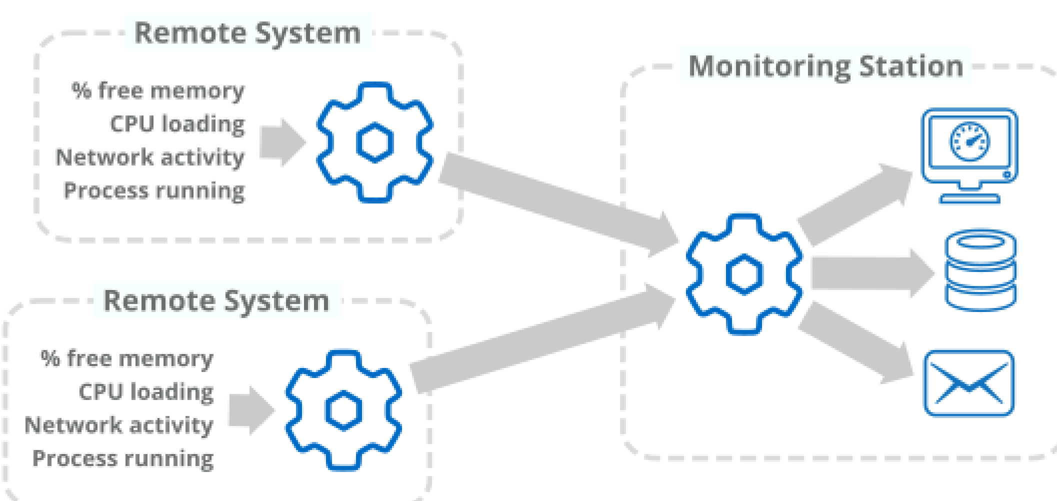
System Monitor

Introduction

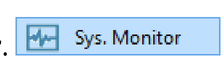
The Cogent DataHub System Monitor provides a way to access any system performance data item, such as CPU usage, memory usage, process ID, disk space, network traffic, etc. in the DataHub program.

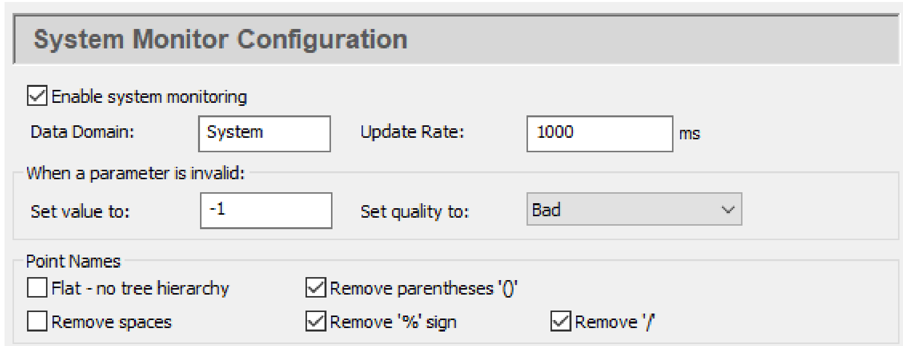


For example, by monitoring process ID you could determine whether a particular process is running or not. Any information accessed here becomes part of the DataHub data set, and can thus be tunneled across the network, used in scripts or as email triggers, viewed in a spreadsheet, or stored in a database.



Configuring the System Monitor

1. With a DataHub instance running, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **System Monitor**. 



To enable system monitoring, check the **Enable system monitoring** box and edit the configuration options as desired:

Data Domain:

The name of any DataHub data domain. The values retrieved from the system will be shown as points in this data domain.

Update Rate:

The frequency that the system is polled and all selected points are updated. The minimum polling time is 100 ms., so the value entered here cannot be less than `100`.

A high update rate (a low number here) for many data points could use a great deal of CPU.

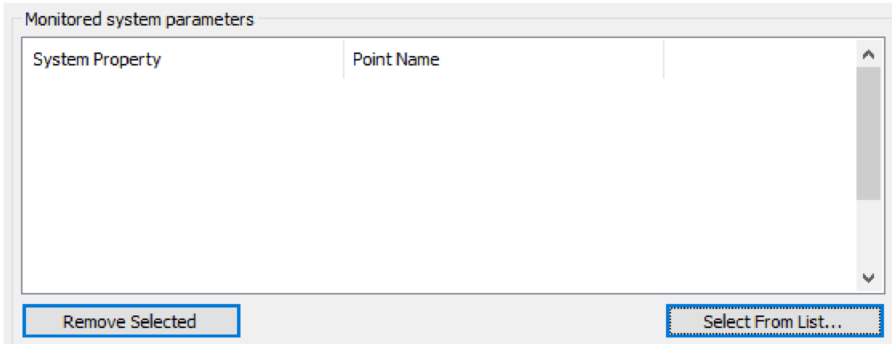
When a parameter is invalid:

A parameter will be invalid if the object being monitored is not available. For example, if a process is not running then the parameters for that process will all be invalid. This is a useful way to monitor a system process or other object. For example, you could use a script or other client to watch a process ID, and when the process ID becomes `-1` you could generate an alarm indicating that the process is no longer running.

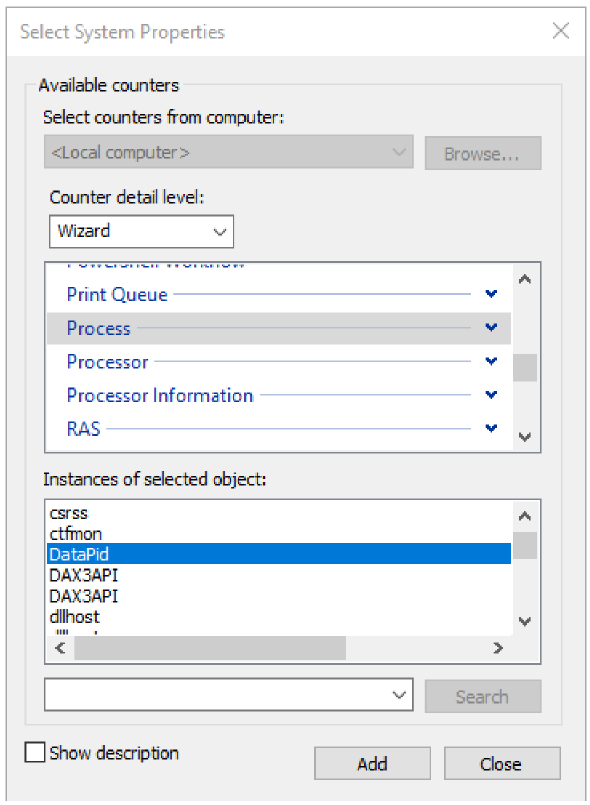
Point Names:

The System Monitor automatically creates Cogent DataHub point names based on the names of the system properties. Some client programs cannot work with point names containing special characters. This section allows you to specify which characters will be removed from the property name when constructing the point name.

Now you are ready to create the list of system parameters that you want to monitor.



3. Click the **Select From List** button. This will open the Select System Properties dialog:



Depending on your system, this dialog may take a few seconds to appear. If it does not come up, the Event Log will contain a message. Otherwise, just be patient, it will open eventually.

In the Select System Properties dialog you can specify which items to add to your list of monitored system properties, according to these criteria:

- **Performance object** A list of all available objects, such as CPU, Memory, Process, Print Queue, TCP, etc.

- **Counters** All of the available data categories related to the selected performance object. You can choose all counters, or select specific counters from the list. The **Explain** button opens a window with an explanation of the selected counter.
- **Instances** All of the instances of the chosen performance object. For example, if you chose Process for your performance, this list will show all of the processes running on your system. You can choose all processes or select specific processes from the list.

  A number in this list normally indicates a selection from multiple objects of a given type, and `_Total` means the total across all of the objects. For example, if you are looking at `Processor` in a multi-processor machine, you will see a number (`0`, `1`, etc.) for each processor and a `_Total` for the cumulative statistic over all processors.

4. Select a performance object, and counters and instances as applicable. For example, to see the process ID for DataSim, first ensure that DataSim is running, then select:
   - **Performance object** `Process`
   - **Select counters from list** `ID Process`
   - **Select instances from list** `DataSim`
5. Click the **Add** button to add the selected items to the **Monitor system parameter** list in the DataHub Properties window.
6. Click the **Apply** or **OK** button in the Properties window when you are finished making your choices and filling the list, to apply your changes. You should be able to view the results in the Data Browser.

   If you change your mind on what points to monitor, you can change the list at any time. Any points you remove from the list will continue to exist in the DataHub instance until it is shut down and restarted. Please refer to the section called “Data Points” for more information on creating and deleting points.

Monitoring Systems Across a Network

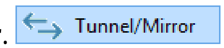
You can monitor a system across by using DataHub *mirroring*. Mirroring is how two or more DataHub instances link over a network or the Internet to maintain identical data sets.

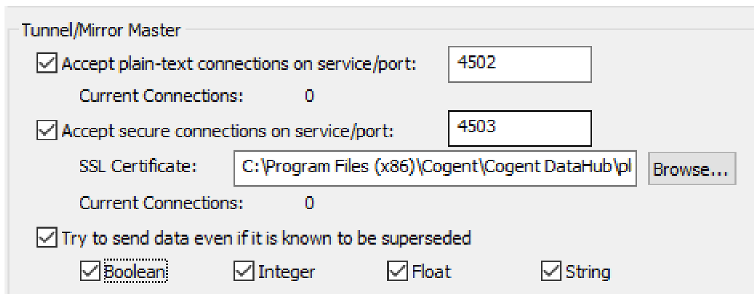
Mirroring is the same as *tunnelling*, as described in the section called “Tunnel/ Mirror”.

For every mirroring connection, you must assign one DataHub instance to be the master, and the other to be the slave. This determines which side initiates communication. Once communication is established, the data is identical. Generally it is recommended that the DataHub instance on the machine being monitored act as the master, while the machine that is collecting the monitoring data be the slave. In a hub-and-spoke arrangement, that DataHub instance could be the slave to multiple masters, to collect all the data in a single DataHub instance.

Configure the DataHub instance as a tunnel/mirror master

You must allow Remote Connections in Security for any incoming connections over the network.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 



3. In the **Tunnelling Master** section, you can configure plain-text or secure tunnelling. Ensure that at least one of these is checked. If you want to change any of the other defaults, please refer to Tunnel/Mirror in the Properties Window chapter for more information.

   To optimize throughput, un-check the **Try to send data even if it is known to be superseded** option. This will allow the DataHub instance to drop stale values for points which have already changed before the client has been notified of the original change. The latest value will always be transmitted.

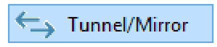
4. To support incoming WebSocket connections from DataHub tunnelling clients, you will need to configure the tunnelling master DataHub instance's Web Server. For WebSocket connections, we recommend using SSL, on port 443.
5. Click **OK** to close the Properties window.

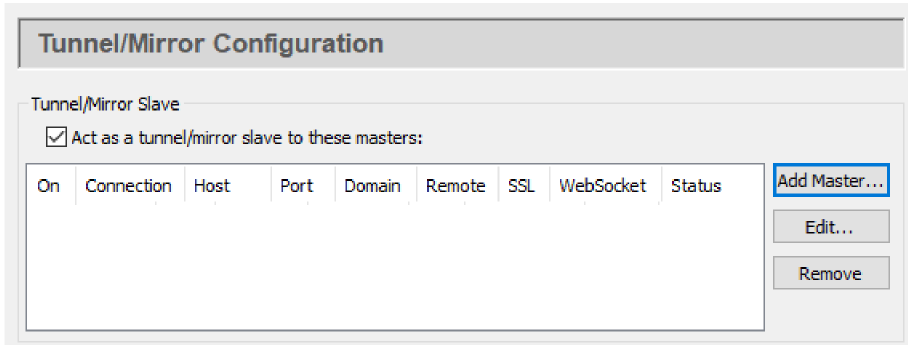
You are now ready to configure the slave DataHub instance.

Configure the DataHub instance as a tunnel/mirror slave

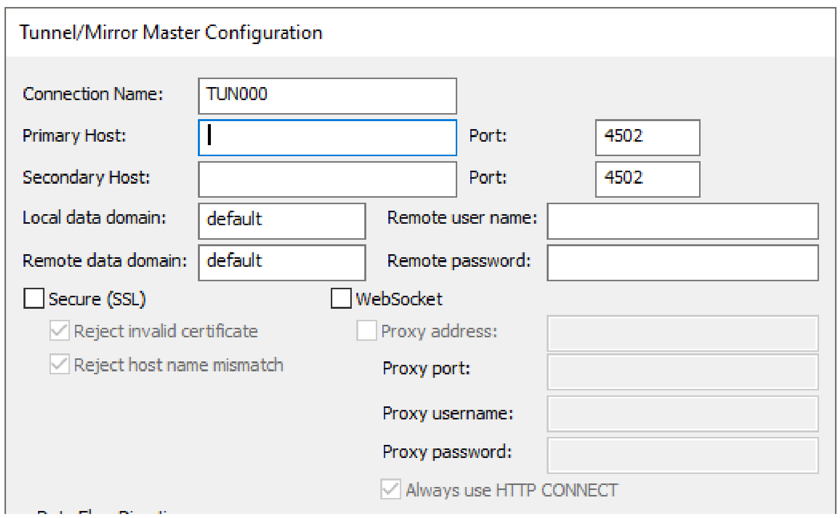
The slave DataHub instance behaves exactly like the master DataHub instance except that the slave establishes the tunnelling connection initially, and reestablishes it after a network break.

1. Right click on the DataHub system-tray icon and choose **Properties**.

2. In the Properties window, select **Tunnel/Mirror**. 



3. Check the box **Act as a tunnelling/mirror slave to these masters**.
4. Click the **Add Master...** button to assign a master to this slave. The **Tunnel/Mirror Master Configuration** window will open:



5. Type in the following information:
   - **Connection Name** a name to identify the tunnel. There should be no spaces in the name, and it doesn't matter what name is chosen, but it should be unique to other tunnel names.
   - **Primary Host** the name or IP address of the computer running the tunnelling master DataHub instance.
   - **Port** the port number or service name for this host. You should use default port number (`4502`) unless you have changed the entry in the master DataHub instance.
   - **Secondary Host** gives you the option to have an alternate host and service/port number. On startup or after a network break, the DataHub instance will search first for the primary host, then for the secondary host, alternating between primary and secondary until a connection is made. If no secondary host is specified, the connection will be attempted on the primary host only.

This feature is not recommended for implementing redundancy because it only checks for a TCP disconnect. The DataHub Redundancy feature, on the other hand, provides full-time TCP connections to both data sources, for instantaneous switchover when one source fails for any reason. There is no need to start up the OPC DA server and wait for it to configure its data set. You can also specify a preferred source, and automatically switch back to that data source whenever it becomes available. By contrast, the primary and secondary host in the tunnel can act as a primitive form of redundancy, but will only switch on a connection failure at the TCP level, which is only one sort of failure that a real redundancy pair must consider.

- **Local data domain** The data domain in which you plan to receive data.
- **Remote data domain** the master DataHub data domain from which you plan to receive data. Point names will be mapped from the remote data domain (on the master DataHub instance) into the local data domain (on this DataHub instance), and vice versa.

Unless you have a good reason for making these different, we recommend using the same data domain name on both DataHub instances for the sake of simplicity.

- **Remote user name** The user name for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.
- **Remote password** The password for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.
- **Secure (SSL)** lets you establish a secure connection using SSL tunnelling as long as the tunnelling master DataHub instance you are attempting to connect to has been configured for secure connections. The additional options allow for a connection to be made even if the security certificate is invalid, or the host name does not match. We don't recommend using these options unless absolutely necessary. For more about SSL, please refer to SSL Encryption.
- **WebSocket** lets you connect via WebSocket. This option is applied for both primary and secondary hosts, and allows you to enter a **Proxy address**, and a **Proxy port** number, **username**, and **password** as needed. When tunnelling through a proxy, HTTP uses normal HTTP proxy, and HTTPS uses HTTP CONNECT proxy. You can select the **Always use HTTP CONNECT** to use it for HTTP as well as HTTPS.

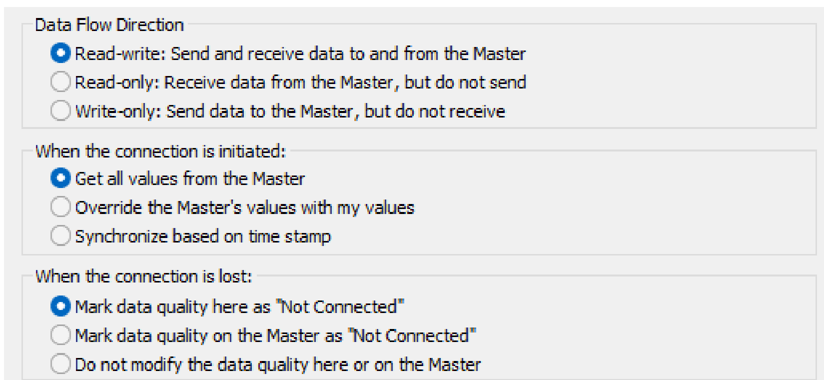
The WebSocket protocol requires a web server to act as an intermediary. So, for this option you will need to use the DataHub Web Server on the tunnelling master DataHub instance (as explained here).

There is a DataHub instance running on a Skkynet cloud server that you can connect to for testing. Here are the parameters you will need to enter for it:

- **Primary Host** `demo.skkynet.com`

- **Port** Will be set automatically by the system, `80` for **WebSocket** and `443` for **Secure (SSL)**.
- **Local data domain** `cloud`
- **Remote data domain** `DataPid`
- **Remote user name** `demo/guest`
- **Remote password** `guest`
- **WebSocket** Must be selected.
- **Secure (SSL)** Must be selected.

6. You now have several options for the mirrored connection.



a. **Data Flow Direction** lets you determine which way the data flows. The default is bi-directional data flow between slave and master, but you can effectively set up a read-only or write-only connection by choosing that respective option.

   To optimize throughput, check the **Read-only Receive data from the Master, but do not send** option. Only do this if you actually want a read-only connection. If you do not require read-write access, a read-only tunnel will be faster.

b. **When the connection is initiated** determines how the values from the points are assigned when the slave first connects to the master. There three possibilities: the slave gets all values from the master, the slave sends all its values to the master, or the master and slave synchronize their data sets, point by point, according to the most recent value of each point (the default).

c. **When the connection is lost** determines where to display the data quality as "Not Connected"—on the master, on the slave, or neither.

   If you have configured **When the connection is initiated** as **Synchronize based on time stamp** (see above), then this option must be set to **Do not modify the data quality here or on the Master** to get correct data synchronization.

d. **Connection Properties** gives you these options

- **Replace incoming timestamp...** lets you use local time on timestamps. This is useful if the source of the data either does not generate time stamps, or you do not trust the clock on the data source.
- **Transmit point changes in binary** gives users of x86 CPUs a way to speed up the data transfer rate. Selecting this option can improve maximum throughput by up to 50%.

  For more information, please refer to Binary Mode Tunnel/Mirror (TCP) Connections in Optimizing Data Throughput.

- **Run in data diode mode and discard all incoming data** This mode is used for outbound slave connections and outbound data flow. Please see Run in data diode mode... in Tunnel/Mirror Properties for more information.
- **Target is an Embedded Toolkit server** allows this slave to connect to an Embedded Toolkit server rather than to another DataHub instance.
- **Heartbeat** sends a heartbeat message to the master every number of milliseconds specified here, to verify that the connection is up.
- **Timeout** specifies the timeout period for the heartbeat. If the slave DataHub instance doesn't receive a response from the master within this timeout, it drops the connection. You must set the timeout time at least twice the heartbeat time.

  To optimize this setting, please refer to Tunnel/Mirror (TCP) Heartbeat and Timeout in Security.

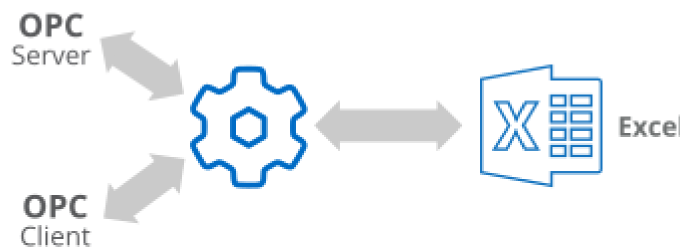
- **Retry** specifies a number of milliseconds to wait before attempting to reconnect a broken connection.

7. Click **OK** to close the **Tunnel/Mirror Master** window. The fields in the **Tunnelling Slave** table of the Properties Window should now be filled in.
8. Click the **Apply** button in the Properties Window. If the master DataHub instance is running, this DataHub instance should establish the tunnelling connection, and the **Status** should display `Connected`. You can view the data with the Data Browser, or view the connection with the Connection Viewer.

Open the Data Browser and select the data domain you requested to mirror. If the master DataHub instance has been correctly configured, you should now see all the master DataHub data for that data domain.

Excel Connections

You can use the Cogent DataHub program to put data into Excel, and to write data from Excel back to the DataHub program.



The following sections explain how to drag and drop live data into Excel, how to configure a DataHub instance to receive data, and how to use Excel macros for sending and receiving data between Excel and the DataHub instance.

Independently of the DataHub DDE feature, you can use DataHub Add-in to exchange data in real time with Excel—locally or over a network.

Getting Data into Excel

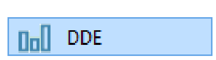
Before starting, to see any results you will have to ensure that you have some kind of data being fed into a DataHub instance. If your system isn't set up for this yet, you can create a local data feed by following the steps outlined in the section called “Test with simulated data”.

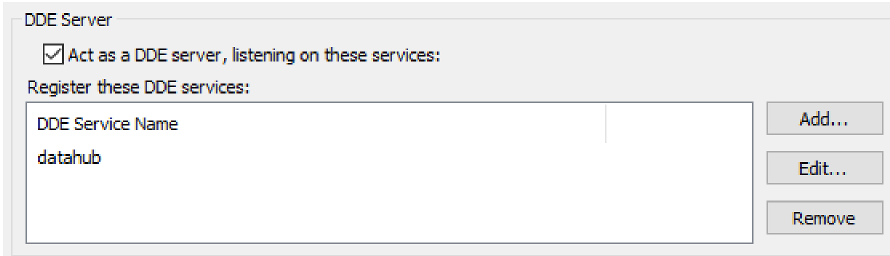
There are two ways to get data into Excel from the DataHub instance: by setting up a **DDEAdvise** loop to receive data automatically, or by using a **DDERequest** command from a macro to read data. Deciding which to use depends on your situation. We suggest you become familiar with both. For more information about DDE and these commands, please refer to the section called “DDE Protocol” and Appendix G, *DDE Overview*.

Click here to watch a video.

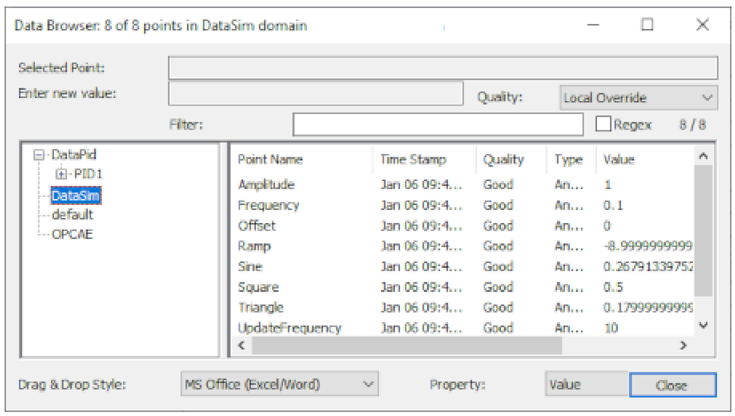
Method 1 - Drag and Drop using DDEAdvise

The easiest way to get data into Excel is to drag and drop point names from the DataHub Data Browser directly into the Excel spreadsheet. This automatically sets up a **DDEAdvise** loop between Excel and the DataHub instance. **DDEAdvise** loops update automatically so you will always see the latest data in your spreadsheet.

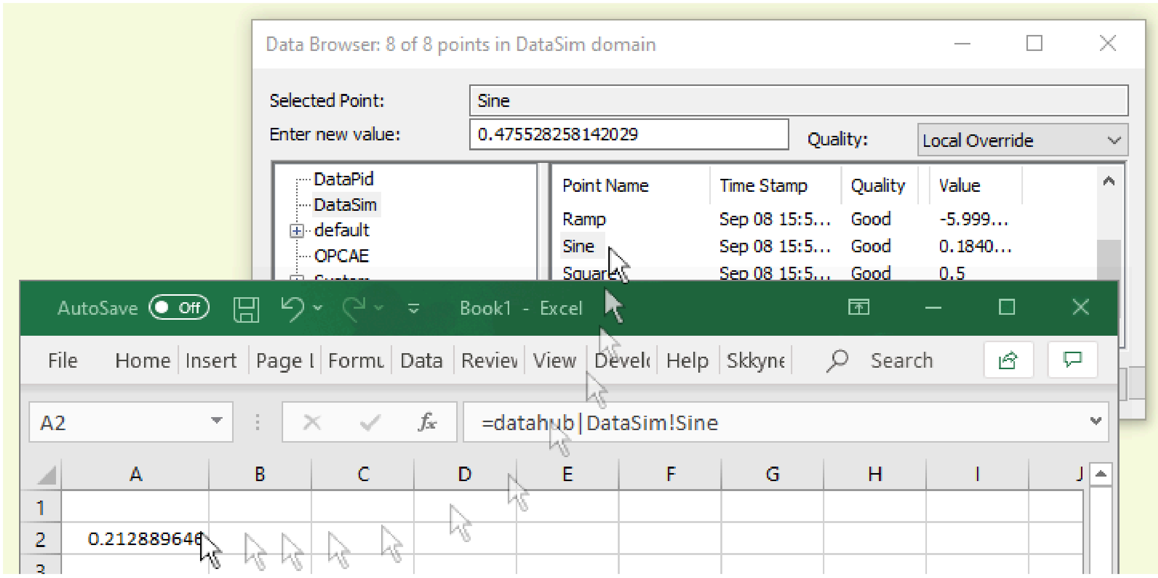
1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **DDE**. 



3. Ensure that the box **Act as a DDE server** is checked, and that the name `datahub` appears in the **DDE Service Name** area. If not, click the **Add...** button and add the name `datahub`.
4. Click **OK** to close the Properties window.
5. Right click on the DataHub system-tray icon and choose **View Data** from the pop-up menu to open the Data Browser.



6. Ensure that the **Drag & Drop Style** at the bottom of the Data Browser is set to **MS-Office (Excel/Word)**.
7. Open an Excel worksheet.
8. In the Data Browser, click on the label for a point and drag it into the Excel worksheet.



You should see the data update in the worksheet at the same rate it is updating in the DataHub instance.

You can select multiple points for drag and drop by using **Shift**-click or **Ctrl**-click.

You can drag and drop timestamps and other attributes of a point using the **Property** dropdown list. Please refer to Drag and Drop Style and Property in the Data Browser section for more details.

If your data displays but does not update, you might need to change your settings in Excel. Please refer to the section called “Basic Trouble-Shooting for Excel Connections” for more information.

When you save and close a spreadsheet connected to a DataHub instance, and then attempt to reopen it, you may get one or more messages, depending on your security settings in Excel, or other circumstances. Here's a summary of each message, and what to do:

This document contains macros. Enable them?

Click **Enable Macros**.

This workbook contains links. Update them?

Click **Update**. If a DataHub instance is already running, all the links should then update automatically. If a DataHub instance is not running, you will get a #REF! entry in each cell that has an advise loop established with the DataHub program, and the next message (see below) will probably appear.

Remote data not accessible. Start DataHub?

Click **No**. At this point the best thing to do is close the worksheet, start a DataHub instance manually, and then reopen the worksheet. When you update the spreadsheet (see above) this time you won't get any `#REF!` entries. If, instead of **No** you click **Yes** at this point, a DataHub instance will not start, but instead generate an error message, and Excel may even crash later on.

Method 2 - Excel Macros using DDERequest

Sometimes, you may prefer to manually read data into your spreadsheet, rather than use a **DDEAdvise** loop to constantly accept new values. It may be that you intend to print reports only a couple of times a day and don't need to see every point change in between. You can have Excel read specific data points from the DataHub instance; at your request by triggering the **DDERequest** command from within a macro.

Using **DDERequest** within a macro gives you complete control over when Excel reads new point values, and lets you read several data points at one time. To run the macro, it is convenient to link it to a control button. This is explained in Add a Control Button.

Create a macro

1. Open a spreadsheet.
2. From the **Tools** menu, select **Macro**, and then **Macros...**.
3. In the **Macro Name:** field of the **Macro** dialog box, type the name **`GetInput`**, and press the **Create** button.
4. In the Visual Basic text entry window that comes up, edit the macro to read as follows:

```
'
' GetInput Macro
'
Sub GetInput()
    mychannel = DDEInitiate("datahub", "default")
    Application.Worksheets("Sheet1").Activate
    newval = DDERequest(mychannel, "my_pointname")
    Sheet1.Cells(2, 3) = newval
    DDETerminate mychannel
End Sub
```

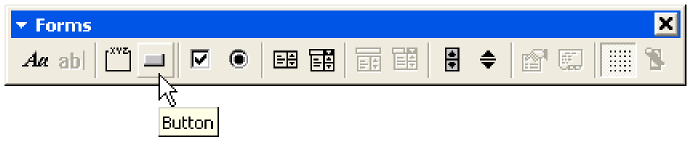
   Use the name of your data point from the DataHub instance for *`my_pointname`*.

   We use cell `C2` in this example. If you need to use another cell, you will have to replace `(2, 3)` with the row and column numbers of the cell you wish to use.

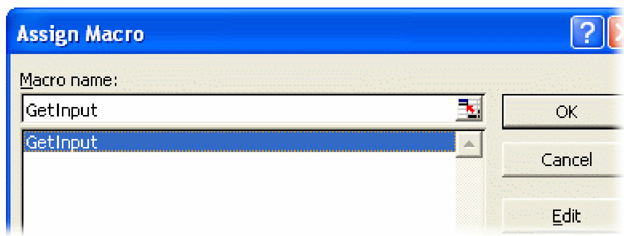
5. Save and close the Visual Basic text entry window.

Add a Control Button

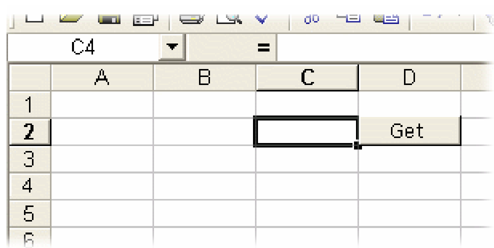
1. Activate the **Forms** toolbar by clicking on the **View** menu and selecting **Toolbars**, and then **Forms**.



2. Click on the button icon, and then click in cell **D2**. (We use this cell in our example, but you can choose another cell if you'd like.) An **Assign Macro** window should appear.
3. Select **GetInput** and click **OK**.



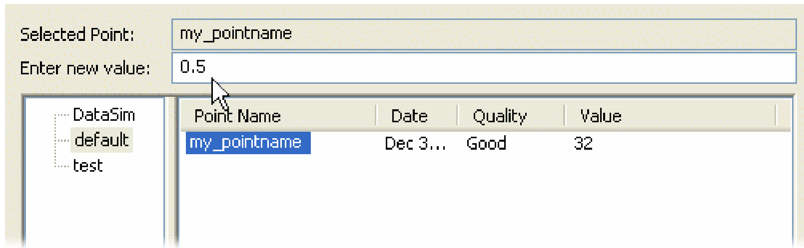
4. Change the label on the button to "**Get**".



5. For appearance, you can move the button, resize it with the handles, and change the size of the text by right-clicking on it and selecting **Format Control**.
6. Save the spreadsheet.

Receive the data

1. Now you're ready to receive the data. Open the DataHub Data Browser if it is not already open, go to the `default` data domain, and find the name of the point.
2. Click on the point to highlight it. The point name should appear in the **Selected Point:** field at the top of the Data Browser.
3. Type a new value for the point into the **Enter new value:** field and press **Enter**.



4. Go to Excel and click the **Get** button. You should see the data update each time you click the button.

Getting Data out of Excel

There are two ways to get data out of Excel and into a DataHub instance;:

1. **Configure a DDEAdvise loop** in the DataHub instance that instructs Excel to send data automatically to the DataHub instance any time a value changes.

   The data is sent immediately to the DataHub instance, every time the specified cell or range changes. This does not allow any kind of sanity check or safeguard on the data being sent, but in some cases it may be desirable to have Excel emit data automatically.

   Each time data is sent for one point (data item), it is sent for all points. This can tie up your network if you have a large number of points. If you need to send data for a large number of cells, you can reduce this effect and reduce CPU load by sending a range that contains the cells.

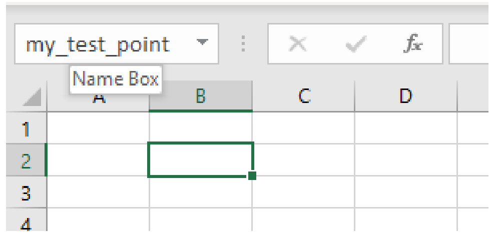
2. **Write a macro in Excel** that uses the **DDEPoke** command to 'push' data from Excel to the DataHub instance. This allows you to define exactly when the data is sent to the DataHub instance.

Click here to watch a video.

Method 1 - Configuring DDEAdvise loops in the DataHub instance

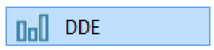
The quickest and easiest method to get data from Excel to the DataHub instance is to configure one or more **DDEAdvise** loops in the DataHub instance to automatically receive data from Excel, which is acting as a DDE server.

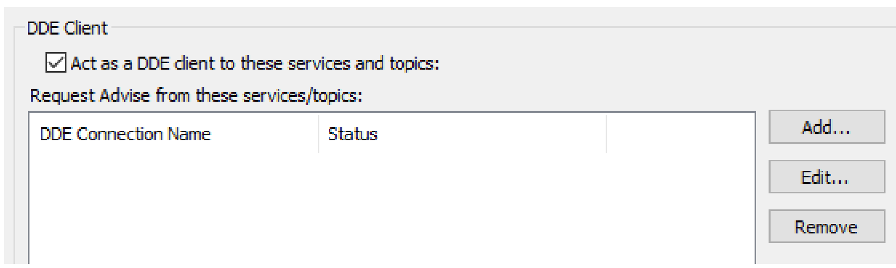
1. Open an Excel spreadsheet.
2. Choose a cell or range to hold the data you want to put into the DataHub instance. You will need to refer to your cell or range by row and column number, or by a name. For example, the cell B2 can be referred to as R2C2, or by giving it a name.



To name a cell or range, select it and enter a unique name the box just above the first column of the worksheet. Then save the worksheet.

3. Start the DataHub instance if it isn't already started, and open the Properties Window (by right-clicking on the DataHub icon in the Windows system tray and selecting **Properties**).

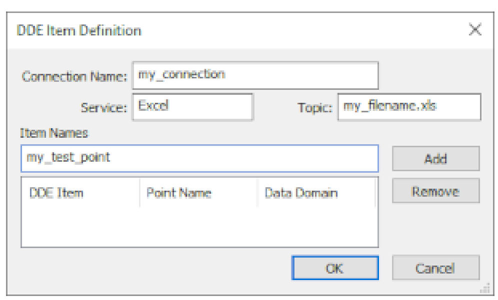
4. Click the **DDE** button. 



5. Make sure the **Act as DDE client** box is checked.

For best performance, ensure that a DDE server (in this case, Excel) is running when using the DataHub instance as a DDE client. A DDE client can consume substantial system resources trying to connect if a DDE server is not available.

6. Click the **Add** button. This opens the **DDE Item Definition** window where you can add Excel as a new DDE service.



7. Type in the following information:
   - **Connection Name** Choose a name to identify this connection. It must be unique among all DDE connections.
   - **Service** Type in `Excel`.
   - **Topic** Type the name of your worksheet file. In Windows XP, this name is the same

as what is shown after the dash in the title-bar of the Excel spreadsheet. More recent versions of Windows might not show the complete name in the title bar. In any case, you must use the complete file name, so if the worksheet is named, "`Book1`", then your Topic is simply `Book1`, but if the worksheet is named `Test.xls` then your Topic needs to be `Test.xls`.

If you want to link to a cell or range which is not on the first sheet in the workbook, you need to put the filename in square brackets, followed by the sheet name. For example, if your worksheet name is `Test.xls`:

Sheet in workbook	Service	Topic to enter
The first sheet	**`Excel`**	**`Test.xls`**
An unnamed sheet (e.g. **Sheet2**)	**`Excel`**	**`[Test.xls]Sheet2`**
A named sheet (e.g. **StockData**)	**`Excel`**	**`[Test.xls]StockData`**

- **Item Names** Type in the row and column numbers or the name you entered as the cell or range name in Excel (in step 2 above).

8. Click the **Add** button. The fields **DDE Item**, **Point Name** and **Data Domain** are then added to the list of items associated with this **DDEAdvise** loop. You can continue to add points for other cells in your spreadsheet or click **OK** to close the dialog.

   The **DDE Item** is associated with a point in the DataHub instance. You can change the **Point Name** and **Data Domain** to anything you want by double clicking on the name and typing a new name. When you click OK, the new point will be created in the DataHub instance;.

9. Click **OK** to close the DDE Item Definition window. The new **DDEAdvise** loop is added to the list.
10. Click the **Apply** button for your changes to take effect. Once you have done this, you should see the **DDEAdvise** loop connection **Status** change to **Connected**.
11. Open the Data Browser by right clicking the DataHub icon in the system tray and selecting **View Data**
12. With the **default** data domain chosen, scroll down to see the name of the point.
13. In Excel, type a number into the cell or range you named in step 2, and press **Enter**. You should see the data update in the Data Browser.

Although this is an easy way to send data from Excel, it is not the most efficient when you have a large number of points to transmit. Whenever Excel transmits a data point using **DDEAdvise**, it also transmits the current value of every other point associated with any **DDEAdvise** loop.

Where you have a large number of cells to update, we have found it to be much more efficient to transmit the data as Excel ranges. In your **DDEAdvise** loop, define a range of cells that contains the data you want to transmit. Using Excel ranges will reduce the load on the computer and make it easier to configure your application.

Another option for reducing the load on the computer when transmitting a large number of points is to write an Excel macro that uses **DDEPoke** to transmit data on a timed basis, say once a second. Information on how to write a macro in Excel to do this is given below.

When you save and close a spreadsheet connected to a DataHub instance, and then attempt to reopen it, you may get one or more messages, depending on your security settings in Excel, or other circumstances. Here's a summary of each message, and what to do:

This document contains macros. Enable them?
: Click **Enable Macros**.

This workbook contains links. Update them?
: Click **Update**. If a DataHub instance is already running, all the links should then update automatically. If a DataHub instance is not running, you will get a #REF! entry in each cell that has an advise loop established with the DataHub program, and the next message (see below) will probably appear.

Remote data not accessible. Start DataHub?
: Click **No**. At this point the best thing to do is close the worksheet, start a DataHub instance manually, and then reopen the worksheet. When you update the spreadsheet (see above) this time you won't get any #REF! entries. If, instead of **No** you click **Yes** at this point, a DataHub instance will not start, but instead generate an error message, and Excel may even crash later on.

Method 2 - Writing Excel macros that use the DDEPoke command

Writing an Excel macro is perhaps the most flexible and efficient way to send data from Excel to the DataHub instance. By using the **DDEPoke** command in an Excel macro you have complete control over exactly when the data is transmitted. We will also explain how you can write an Excel macro to transmit multiple points at the same time (see Additional Pointers for more details).

In our example, we have chosen to 'add a control button' to run the macro, but you could also run your macro on a timed interval to produce an automatic update on a cycle that you control.

Create a macro

1. Open a spreadsheet.
2. From the **Tools** menu, select **Macro**, and then **Macros...**.
3. In the **Macro Name:** field of the **Macro** dialog box, type the name **`SendOutput`**, and press the **Create** button.
4. In the Visual Basic text entry window that comes up, edit the macro to read as follows:

```
'
' SendOutput Macro
```

```
'
Sub SendOutput()
    mychannel = DDEInitiate("datahub", "default")
    Application.Worksheets("Sheet1").Activate
    Call DDEPoke(mychannel, "my_pointname", Cells(4, 3))
    DDETerminate mychannel
End Sub
```

Use the name of your data point from the DataHub instance for *`my_pointname`*.

We use cell `C4` in this example. If you need to use another cell, you will have to replace `(4, 3)` with the row and column numbers of the cell you wish to use. You can also name a range to send multiple values as an array.

5. Save and close the Visual Basic text entry window.

Add a Control Button

This explanation is illustrated in the section called “Add a Control Button”. We repeat the text briefly here.

1. Activate the **Forms** toolbar by clicking on the **View** menu and selecting **Toolbars**, and then **Forms**.
2. Click on the button icon, and then click in cell **D4**. (You can choose another cell if you'd like.) An **Assign Macro** window should appear.
3. Select **SendOutput** and click **OK**.
4. Change the label on the button to "**Send**".
5. Save the spreadsheet.

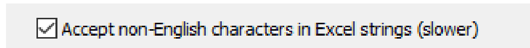
Send the data

1. Now you're ready to send the data. Open the DataHub Data Browser if it is not already open, go to the default data domain, and find the name of the point.
2. In Excel, type a number in cell **C4** (or the cell or range you assigned the macro to) and press **Enter**.
3. Click the **Send** button.
4. You should see the data update.

Additional Pointers

- To reduce CPU for large amounts of data, send arrays of data using ranges instead of sending the data for each cell as a separate point.
- If you are using Unicode characters in strings for **DDEPoke** commands, you should check the **Accept non-English characters in Excel strings (slower)** button in the DDE

option of the Properties window.



This will cause Excel to send your strings of Unicode characters correctly, although slower than numerical data.

- The **DDEInitiate** and **DDETerminate** commands that are used to open and close DDE links between applications are also very CPU expensive. When sending variables at frequent intervals it is more efficient to open a DDE channel at the beginning of the session and close it when you are finished. Here are two suggestions:

  1. Send multiple points within a single set of **DDEInitiate** and **DDETerminate** commands. For example:

```
'
' Cascade Multiple Writeback macro
'
Sub Cascade_Writeback_Many()
      mychannel = DDEInitiate("datahub", "default")
      Application.Worksheets("variables").Activate
      DDEPoke(mychannel, "pointname1", Cells(1,2))
      DDEPoke(mychannel, "pointname2", Cells(2,2))
      DDEPoke(mychannel, "pointname3", Cells(3,2))
      DDEPoke(mychannel, "pointname4", Cells(4,2))
      DDEPoke(mychannel, "pointname5", Cells(5,2))
      DDEPoke(mychannel, "pointname6", Cells(6,2))
      DDETerminate mychannel
End Sub
```

     In this example the worksheet named `variables` contains six variables (`pointname1` through `pointname6`) that we wish to send to the DataHub instance. The **DDEInitiate** command opens the channel, then all six variables are sent to the DataHub instance before the link is closed.

  2. Create a separate 'open' and 'close' macro for the worksheet, and place the **DDEInitiate** and **DDETerminate** commands in those macros. This will keep communication to the DataHub instance open for the whole time the worksheet is open. The only drawback is that your data transmission could get interrupted (see below).

- If you need to send data continually from Excel to the DataHub instance you may run into problems using **DDEInitiate** and **DDEPoke**. When you open a DDE channel using the **DDEInitiate** statement, and follow it with several **DDEPoke** statements, there is a chance that the DDE channel may fail after some time. For this reason, if you need to keep a DDE channel open for an extended period of time, we suggest that you attempt to deal with DDE errors within the macro.

Networking Excel

You can use the DataHub program to network Excel in real time, by using DataHub *mirroring*. Mirroring is how two or more DataHub instances link over a network or the Internet via DHTP to maintain identical data sets.

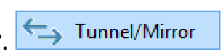
Mirroring is the same as *tunnelling*, as described in the section called “Tunnel/Mirror”.

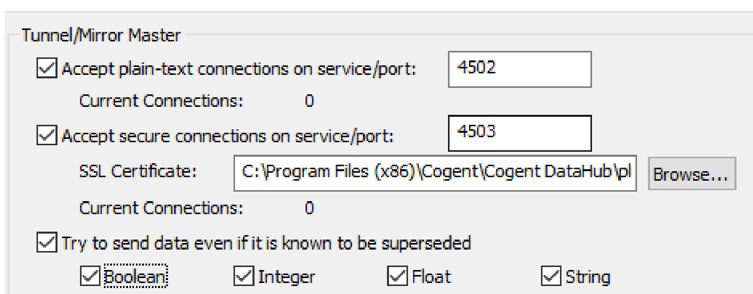
Independently of the DataHub DDE feature, you can use DataHub Add-in to exchange data in real time with Excel—locally or over a network.

To network Excel, on each node you need to connect Excel to a DataHub instance. Then a mirroring connection is configured between each DataHub instance. For every mirroring connection, you must assign one DataHub instance to be the master, and the other to be the slave. This determines which side initiates communication. Once communication is established, the data is identical. Generally it is recommended that the DataHub instance on the server or the machine least likely to shut down act as the master, while the slave be on the client machine. In a hub-and-spoke arrangement, that DataHub instance; could be the slave to multiple masters, to collect all the data in a single DataHub instance.

Configure the DataHub instance as a tunnel/mirror master

You must allow Remote Connections in Security for any incoming connections over the network.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 



3. In the **Tunnelling Master** section, you can configure plain-text or secure tunnelling. Ensure that at least one of these is checked. If you want to change any of the other defaults, please refer to Tunnel/Mirror in the Properties Window chapter for more information.

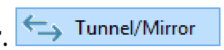
   To optimize throughput, un-check the **Try to send data even if it is known to be superseded** option. This will allow the DataHub instance to drop stale values for points which have already changed before the client has been notified of the original change. The latest value will always be transmitted.

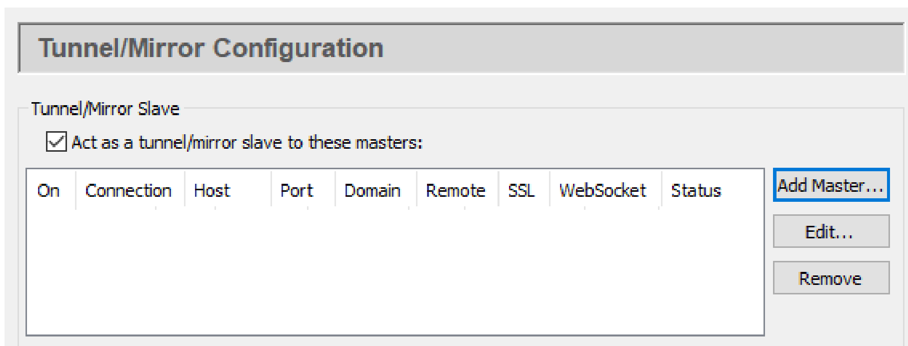
4. To support incoming WebSocket connections from DataHub tunnelling clients, you will need to configure the tunnelling master DataHub instance's Web Server. For WebSocket connections, we recommend using SSL, on port 443.
5. Click **OK** to close the Properties window.

You are now ready to configure the slave DataHub instance.

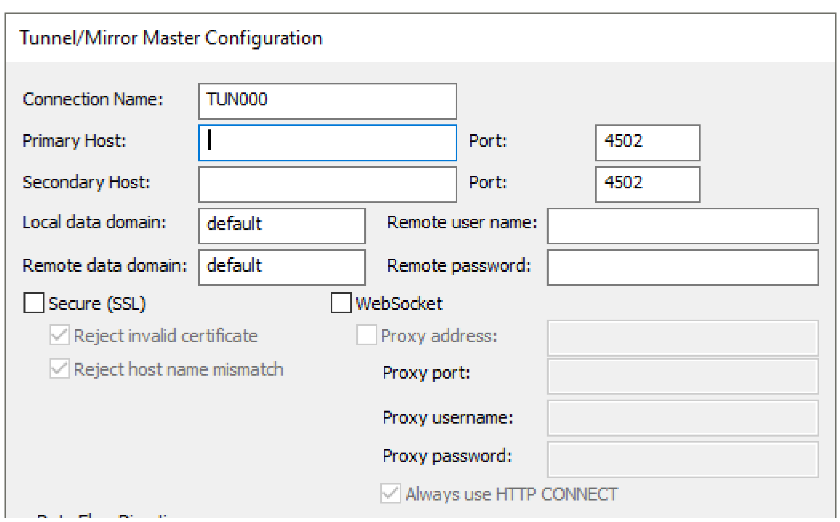
Configure the DataHub instance as a tunnel/mirror slave

The slave DataHub instance behaves exactly like the master DataHub instance except that the slave establishes the tunnelling connection initially, and reestablishes it after a network break.

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 



3. Check the box **Act as a tunnelling/mirror slave to these masters**.
4. Click the **Add Master...** button to assign a master to this slave. The **Tunnel/Mirror Master Configuration** window will open:



5. Type in the following information:

   - **Connection Name** a name to identify the tunnel. There should be no spaces in the name, and it doesn't matter what name is chosen, but it should be unique to other tunnel names.
   - **Primary Host** the name or IP address of the computer running the tunnelling master DataHub instance.
   - **Port** the port number or service name for this host. You should use default port number (`4502`) unless you have changed the entry in the master DataHub instance.
   - **Secondary Host** gives you the option to have an alternate host and service/port number. On startup or after a network break, the DataHub instance will search first for the primary host, then for the secondary host, alternating between primary and secondary until a connection is made. If no secondary host is specified, the connection will be attempted on the primary host only.

     This feature is not recommended for implementing redundancy because it only checks for a TCP disconnect. The DataHub Redundancy feature, on the other hand, provides full-time TCP connections to both data sources, for instantaneous switchover when one source fails for any reason. There is no need to start up the OPC DA server and wait for it to configure its data set. You can also specify a preferred source, and automatically switch back to that data source whenever it becomes available. By contrast, the primary and secondary host in the tunnel can act as a primitive form of redundancy, but will only switch on a connection failure at the TCP level, which is only one sort of failure that a real redundancy pair must consider.
   - **Local data domain** The data domain in which you plan to receive data.
   - **Remote data domain** the master DataHub data domain from which you plan to receive data. Point names will be mapped from the remote data domain (on the master DataHub instance) into the local data domain (on this DataHub instance), and vice versa.

     Unless you have a good reason for making these different, we recommend using the same data domain name on both DataHub instances for the sake of simplicity.
   - **Remote user name** The user name for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.
   - **Remote password** The password for TCP security, established on the tunnelling master, using the DataHub Security option in the Properties window.
   - **Secure (SSL)** lets you establish a secure connection using SSL tunnelling as long as the tunnelling master DataHub instance you are attempting to connect to has been configured for secure connections. The additional options allow for a connection to be made even if the security certificate is invalid, or the host name does not match. We don't recommend using these options unless absolutely necessary. For more

about SSL, please refer to SSL Encryption.

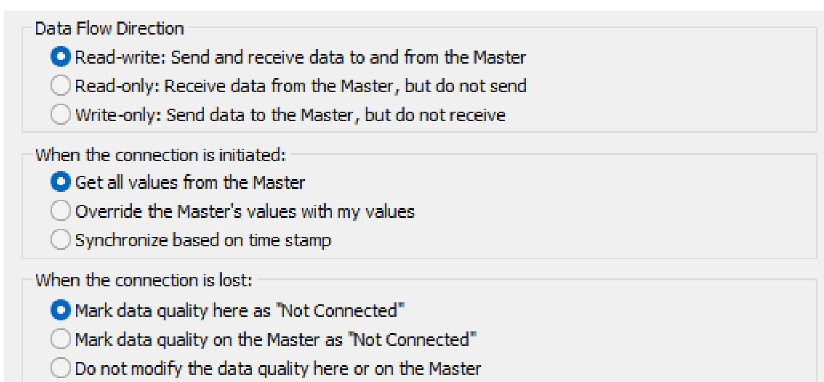
- **WebSocket** lets you connect via WebSocket. This option is applied for both primary and secondary hosts, and allows you to enter a **Proxy address**, and a **Proxy port** number, **username**, and **password** as needed. When tunnelling through a proxy, HTTP uses normal HTTP proxy, and HTTPS uses HTTP CONNECT proxy. You can select the **Always use HTTP CONNECT** to use it for HTTP as well as HTTPS.

  The WebSocket protocol requires a web server to act as an intermediary. So, for this option you will need to use the DataHub Web Server on the tunnelling master DataHub instance (as explained here).

There is a DataHub instance running on a Skkynet cloud server that you can connect to for testing. Here are the parameters you will need to enter for it:

- **Primary Host** `demo.skkynet.com`
- **Port** Will be set automatically by the system, `80` for **WebSocket** and `443` for **Secure (SSL)**.
- **Local data domain** `cloud`
- **Remote data domain** `DataPid`
- **Remote user name** `demo/guest`
- **Remote password** `guest`
- **WebSocket** Must be selected.
- **Secure (SSL)** Must be selected.

6. You now have several options for the mirrored connection.



   a. **Data Flow Direction** lets you determine which way the data flows. The default is bi-directional data flow between slave and master, but you can effectively set up a read-only or write-only connection by choosing that respective option.

      To optimize throughput, check the **Read-only Receive data from the Master, but do not send** option. Only do this if you actually want a read-only connection. If you do not require read-write access, a read-only tunnel will be faster.

b. **When the connection is initiated** determines how the values from the points are assigned when the slave first connects to the master. There three possibilities: the slave gets all values from the master, the slave sends all its values to the master, or the master and slave synchronize their data sets, point by point, according to the most recent value of each point (the default).

c. **When the connection is lost** determines where to display the data quality as "Not Connected"—on the master, on the slave, or neither.

> If you have configured **When the connection is initiated** as **Synchronize based on time stamp** (see above), then this option must be set to **Do not modify the data quality here or on the Master** to get correct data synchronization.

d. **Connection Properties** gives you these options

- **Replace incoming timestamp...** lets you use local time on timestamps. This is useful if the source of the data either does not generate time stamps, or you do not trust the clock on the data source.
- **Transmit point changes in binary** gives users of x86 CPUs a way to speed up the data transfer rate. Selecting this option can improve maximum throughput by up to 50%.

> For more information, please refer to Binary Mode Tunnel/Mirror (TCP) Connections in Optimizing Data Throughput.

- **Run in data diode mode and discard all incoming data** This mode is used for outbound slave connections and outbound data flow. Please see Run in data diode mode... in Tunnel/Mirror Properties for more information.
- **Target is an Embedded Toolkit server** allows this slave to connect to an Embedded Toolkit server rather than to another DataHub instance.
- **Heartbeat** sends a heartbeat message to the master every number of milliseconds specified here, to verify that the connection is up.
- **Timeout** specifies the timeout period for the heartbeat. If the slave DataHub instance doesn't receive a response from the master within this timeout, it drops the connection. You must set the timeout time at least twice the heartbeat time.

> To optimize this setting, please refer to Tunnel/Mirror (TCP) Heartbeat and Timeout in Security.

- **Retry** specifies a number of milliseconds to wait before attempting to reconnect a broken connection.

7. Click **OK** to close the **Tunnel/Mirror Master** window. The fields in the **Tunnelling Slave** table of the Properties Window should now be filled in.

8. Click the **Apply** button in the Properties Window. If the master DataHub instance is running, this DataHub instance should establish the tunnelling connection, and the **Status** should display `Connected`. You can view the data with the Data Browser, or view the connection with the Connection Viewer.

Open the Data Browser and select the data domain you requested to mirror. If the master DataHub instance has been correctly configured, you should now see all the master DataHub data for that data domain.

Working with Ranges

The Cogent DataHub program can send and receive the data contained in an entire range of an Excel spreadsheet. This data is treated as an *array*, a two-dimensional range of cells as rows and columns. The array can be as big as necessary (within point size limits), or as small as a single cell—at least one row and one column.

Data Format

Excel transmits array data as a tab-and-newline delimited text string of values. Each value in a row is separated by a tab, and each row is separated by a newline character. The string does not contain any information concerning the source range of the array within the spreadsheet.

Getting a Range out of Excel

There are two methods of transmitting a range, or array data, from Excel to the DataHub instance. These exactly match the mechanisms used for individual point data: DDEPoke and DDEAdvise.

Using DDEPoke with a Macro

A DDEPoke command can be issued by Excel to send data to the DataHub instance based on a trigger within Excel. For this to work, the DataHub instance needs to be configured to act as a DDE server and have registered at least one service name. An Excel macro can then issue a DDEPoke to that service, along with a DataHub data domain name (the DDE topic), a point name (the DDE item) and a value. If the value is of type `Range` then Excel will automatically format the value as a tab-and-newline separated string.

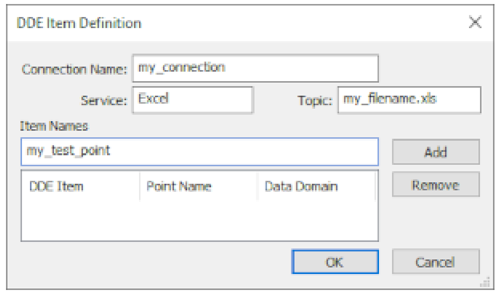
Example: See the definition of the `PutData` function in the Excel macro coding examples below.

Using a DDE Advise Loop

When sending data from Excel to the DataHub instance using a DDE advise loop, Excel acts as the DDE server and DataHub instance acts as the client. To create the advise loop:

1. Open the Cogent DataHub Properties Window (by right-clicking on the DataHub icon in the Windows system tray and selecting **Properties**).

2. Click the **DDE** button.
3. Make sure the **Act as DDE client** box is checked.
4. Click the **Add** button. This opens the **DDE Item Definition** window.



5. Type in the following information:
   - **Connection Name** Choose a name to identify this connection. It must be unique among all DDE connections.
   - **Service** Type in `Excel` (case is not important).
   - **Topic** Type the name of your worksheet file, including the `.xls` extension, like this: *`my_filename`*`.xls`.
   - **Item Names** These create a mapping between Excel cells and ranges, and DataHub point names. You may specify a single cell in `r`*`1`*`c`*`1`* format, a range of cells in `r`*`1`*`c`*`1`*`:r`*`2`*`c`*`2`* format, a cell name, or a range name as the DDE Item name. For example:

`r2c5`	- accesses the cell `E2` (second row, fifth column)
`r3c3:r5c9`	- accesses the range `C3:I5`
`MyRange`	- accesses the cell or range that is named `MyRange`

6. Click the **Add** button. The fields **DDE Item**, **Point Name** and **Data Domain** should automatically fill in with some values.

   Check the names in the **Point Name** and **Data Domain** columns. If either of them is not what you need, double-click it to select it, and change it.

7. Click **OK** to close the **DDE Item Definition** window. The fields **DDE Connection Name** and **Status** in the Properties Window should now be filled in as well.
8. Click **OK** to close the Properties Window.
9. Enter some values in the range of the spreadsheet you have defined. You should see the array in the Data Browser change accordingly.

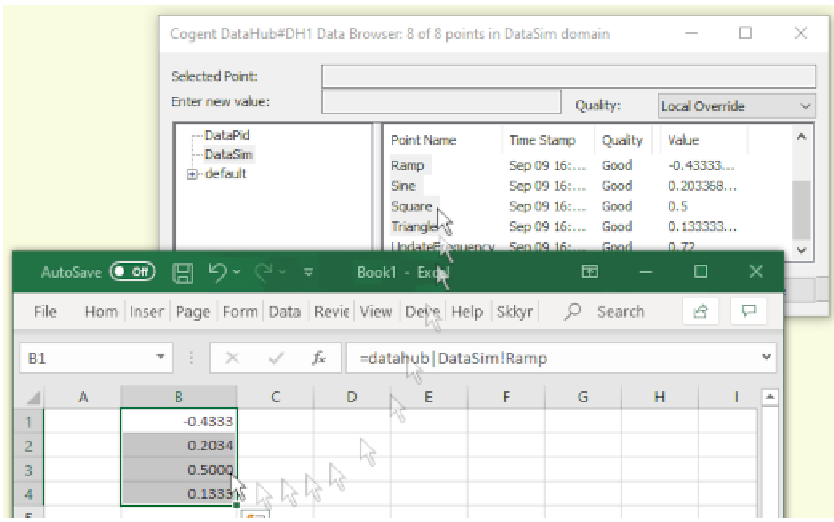
Getting a Range into Excel

There are two ways to drag and drop data into Excel to create a range, using DDE advise loops. Or you can use DDE Request and macros.

Drag and drop a group of points into Excel

Here is how you can collect a group of points in the DataHub instance and drag them all into Excel, where the data for each point occupies a unique cell.

1. With the DataHub instance and DataSim running, open the Data Browser.
2. Select a group of points in the Data Browser.
3. Drag the point names into Excel.



You should see the data updating in the cells.

You can drag and drop point names, timestamps, and other attributes of a point using the **Property** dropdown list. Please refer to Drag and Drop Style and Property in the Data Browser section for more details.

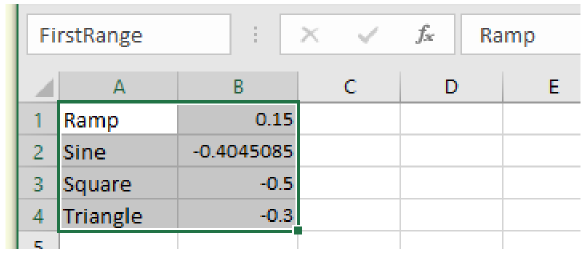
Drag and drop an array into Excel

Here is how you can take a single point in the DataHub instance whose value is an array, and have each value in the array occupy a unique cell in Excel.

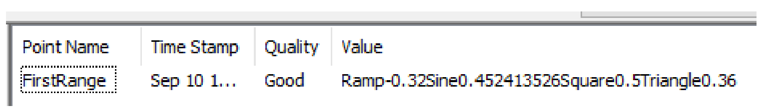
To demonstrate this, we are going to first combine the two procedures shown above to create an array in the DataHub instance.

Make an array

1. Select a range in Excel, such as created in Drag and drop a group of points into Excel above, and in the name box at the top left corner, enter the name **`FirstRange`**.



2. In the DataHub Properties Window, select the **DDE** option and make sure the **Act as DDE client** box is checked. Then click the **Add** button.
3. In the **DDE Item Definition** window type in the following information:
   - **Connection Name** Type in **Ranges**.
   - **Service** Type in **`Excel`**.
   - **Topic** Type in **Book1**, or the name of your worksheet file including the `.xls` extension.
   - **Item Names** Type in **`FirstRange`**.
4. Click the **Add** button. The fields **DDE Item** and **Point Name** should be `FirstRange`, and the **Data Domain** should be `default`.
5. Click **OK** to close the **DDE Item Definition** window, and in the Properties Window click **OK** to close it as well.
6. Open the Data Browser and go to the `default` data domain. You should see the point `FirstRange`, with a value like this:

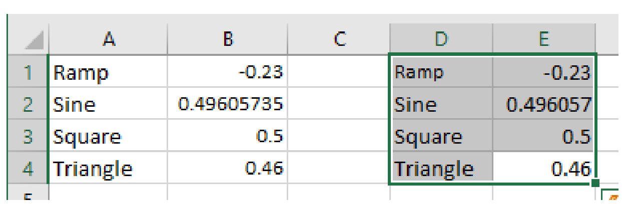


   The array is now ready to put into Excel.

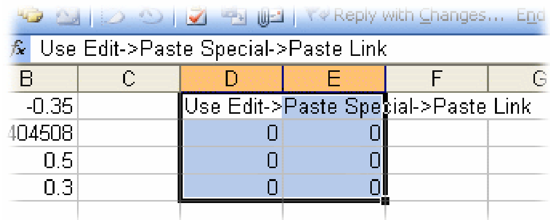
Drag and drop the array

For simplicity's sake we are going to just put the same array back into Excel.

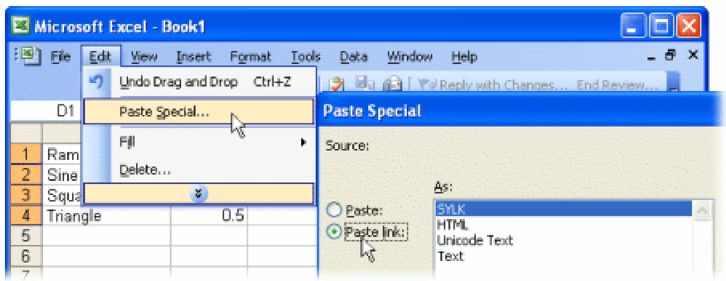
1. Click on the `FirstRange` point name, and drag it into Excel, dropping it in cell D1.



2. For older versions of Excel, the values don't start updating right away because you have to tell Excel how to paste in the link.



Go to the **Edit** menu and select **Paste Special**.



3. Select **Paste link** and click **OK**. The cells should fill with the correct, updating data.

Using DDE Request in Excel

If you are creating macros in Excel to read data from a DataHub instance, you can use the DDERequest function call. This will return an array type value that can be written directly into any range in the spreadsheet. If the array data is larger in any dimension than the range into which it is written, then extra data in the array is discarded. If the array data is smaller than the target range then extra cells in the range are filled by repeating the data in the array. See below for an Excel macro that dynamically determines the target range to ensure that all array data is entered into the spreadsheet with no duplication.

Sample Excel Macros for Arrays

The following macros represent the entire macro set for a simple test spreadsheet that reads and writes a single array point in the DataHub instance. The two functions `GetData` and `PutData` can be attached to buttons on a spreadsheet for easy testing. The `PutData` subroutine contains two alternative representations of the source range, one of which is commented out in the macro.

```
Sub GetDataArray(Channel As Integer, SheetName As String, DataPoint _
    As String, StartRow As Integer, StartCol As Integer)
    Dim NRows As Integer, NCols As Integer

    ' This sub performs a DDERequest for DataPoint in the DDE Channel
    ' and reads in a tab delimited array with carriage returns at the
    ' end of each line. It then fills a range of cells with the data.
    ' The native format for Excel data is tab delimited text with a
    ' carriage return at the end of each row of data. If we assign
    ' this type of data to a range of cells using the FormulaArray
```

```
    ' function, Excel automatically parses the data and fills it into
    ' the specified range.  The real trick here is to ensure that the
    ' range is the same size as the incoming data, so we do not have
    ' to know the size a priori.

    ' request DataPoint from Channel

    DataArray = DDERequest(chan, DataPoint)

    ' find the upper row and column bounds for the variant array

    If StartCol = 0 Then StartCol = 1   ' Starting column where
                                        ' data will go in our sheet
    If StartRow = 0 Then StartRow = 1   ' set the starting row
    NCols = 1                           ' set default number or
                                        ' columns to 1
    On Error Resume Next                ' ignore errors (error occurs
                                        ' if array has one dimension)

    ' get upper bound of the array columns
    ' the following line will generate an error if the array is only
    ' a one dimensional array
    ' We just skip this, and use the default 1
    NCols = UBound(DataArray, 2)

    On Error GoTo 0                     ' allow errors
    NRows = UBound(DataArray, 1)        ' get upper bound of
                                        ' array y dimension

    NRows = NRows + StartRow - 1        ' add offset from StartRow
                                        ' - this is the ending row
    NCols = NCols + StartCol - 1        ' add offset from StartCol
                                        ' - this is the ending col

    ' the following line fills up the cells in the range starting
    ' in "StartCol:StartRow" to "Nrows:Ncols" with the data from
    ' the variant array
    Sheets(SheetName).Range(Cells(StartRow, StartCol), _
          Cells(NRows, NCols)) = DataArray
End Sub

Sub PutDataArray(Channel As Integer, SheetName As String, DataPoint _
    As String, StartRow As Integer, StartCol As Integer, _
    NRows As Integer, NCols As Integer)
    DDEPoke Channel, DataPoint, _
      Sheets(SheetName).Range(Cells(StartRow, StartCol), _
```

```
            Cells(StartRow + NRows - 1, StartCol + NCols - 1))
End Sub
```

```
Sub PutDataRange(Channel As Integer, DataPoint As String, _
     DataRange As Range)
    DDEPoke Channel, DataPoint, DataRange
End Sub

Sub GetData()
'
'   This is a test function assigned to a button.  It reads a test
'   point into an arbitrarily sized matrix starting at A10
'
    Dim chan As Integer
    chan = DDEInitiate("datahub", "default")
    GetDataArray chan, "Sheet1", "TestArray", 10, 1
    DDETerminate (chan)
End Sub

Sub PutData()
'
'   This is a test function assigned to a button.  It writes
'   a 3 row x 5 column area of Sheet1 into a single data point
'   in a DataHub instance.  You can use either PutDataArray or
'   PutDataRange, depending on how you wish to specify the range.
'
    Dim chan As Integer
    chan = DDEInitiate("datahub", "default")
    'PutDataArray chan, "Sheet1", "TestArray", 1, 1, 3, 5
    PutDataRange chan, "TestArray", Sheets("Sheet1").Range("A1:E3")
    DDETerminate (chan)
End Sub
```

Basic Trouble-Shooting for Excel Connections

If you cannot get a connection working in Excel, there are a couple of things you can check:

- Is the workbook automatic calculation turned on? It may need to be in order for the links to update.
- Is **Update links to other documents** turned off? It may need to be turned on for the links to update.
- Is **Ignore other applications that use Dynamic Data Exchange (DDE)** turned off?
- In the worksheet, select **DATA—>Edit Links** and ensure that the links are automatically updated. Also select **Startup Prompt** in the **Edit Links** dialog and ensure that the links are set to automatically update.

- In the **Edit Links** dialog, try pressing **Update Values**. Do the values change in the spreadsheet? If they do, it seems to confirm that there is an Excel setting interfering with normal operation.

Also be sure these initial points are covered:

- Make sure the **Act as a DDE Server** checkbox is checked in the DataHub DDE properties window.
- Make sure you have at least one DDE Service name listed in the list just below that checkbox.
- Make sure Excel is set to do **Automatic Calculations**, (See **Tools**, **Options**, **Calculation** tab for details). When set to **Manual Calculations**, Excel will not process incoming DDE events.

Messages from Excel

When you save and close a spreadsheet connected to the DataHub instance and then attempt to reopen it, you may get one or more messages, depending on your security settings in Excel, or other circumstances. Here's a summary of each message, and what to do:

This document contains macros. Enable them?

Click **Enable Macros**.

This workbook contains links. Update them?

Click **Update**. If the DataHub instance is already running, all the links should then update automatically. If not, you may get a `#REF!` entry in some cells, and the next message (see below) will probably appear.

Remote data not accessible. Start a DataHub instance?

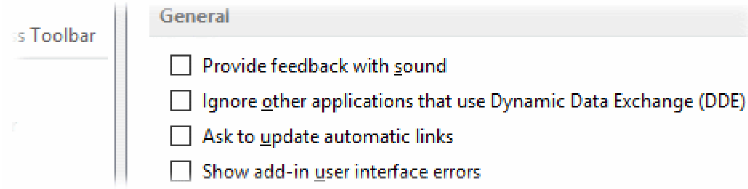
Click **No**. At this point the best thing to do is close the worksheet, start the requested program, and then reopen the worksheet. When you update the spreadsheet (see above) this time you won't get any `#REF!` entries.

Excel not accepting DDE client connection

When using a DataHub instance with Excel for the first time, you may encounter this message:

```
Outgoing DDE Client connection failed...
```

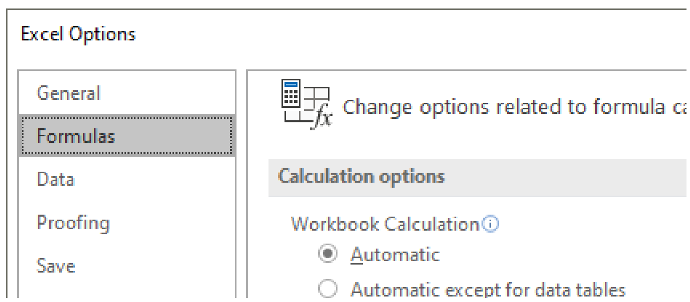
This is likely due to Excel configuration. In Excel, go to the **Options** menu, and select **Advanced**. There, under the **General** heading, ensure that the box **Ask to update automatic links** is *not* checked.



Excel not updating

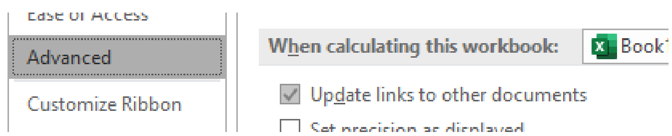
The default settings in Excel allow you to drag and drop from a DataHub instance into your spreadsheet and see the data updating automatically. Sometimes however the Excel configuration may have been changed so that you do not see this. For example, if you drag a data point into Excel and you get the first value, but then nothing after that, you may want to check the following settings.

1. For newer versions of Excel, in the **File** menu go to **Options** > **Formulas** > **Calculation options**.



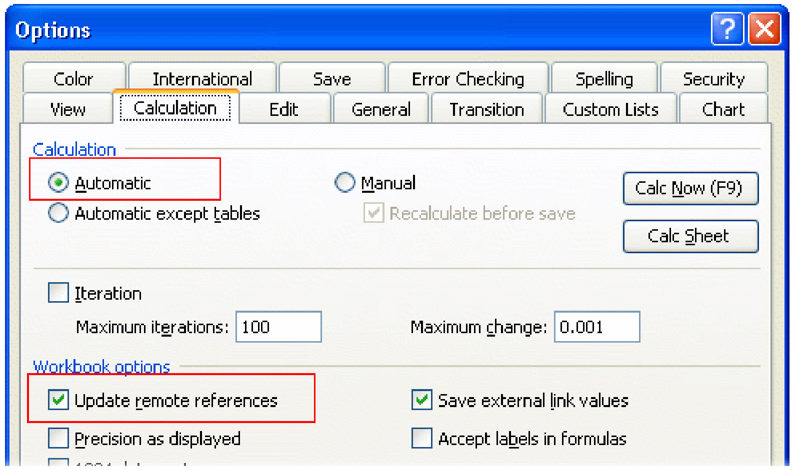
   a. Ensure that the **Automatic** option in **Workbook Calculation** is selected.

   b. Go to **Advanced** > **When calculating this workbook**



   c. Ensure that the **Updata links to other documents** option is selected.

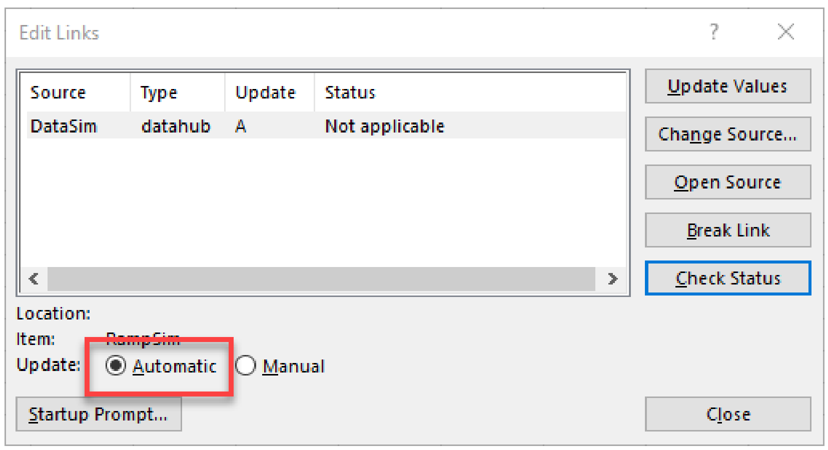
2. In older versions of Excel, from the **Tools** menu, choose **Options** to open the Options window.



a. Ensure that the **Automatic** option in **Calculation** is selected.

b. Ensure that the **Update remote references** option in **Workbook options** is selected. Then close the **Options** window.

3. From the **Edit** menu, choose **Links** to open the Edit Links window.



4. Ensure that the **Automatic** option for **Update** is selected. Then close the Edit Links window.

DataHub Scripting

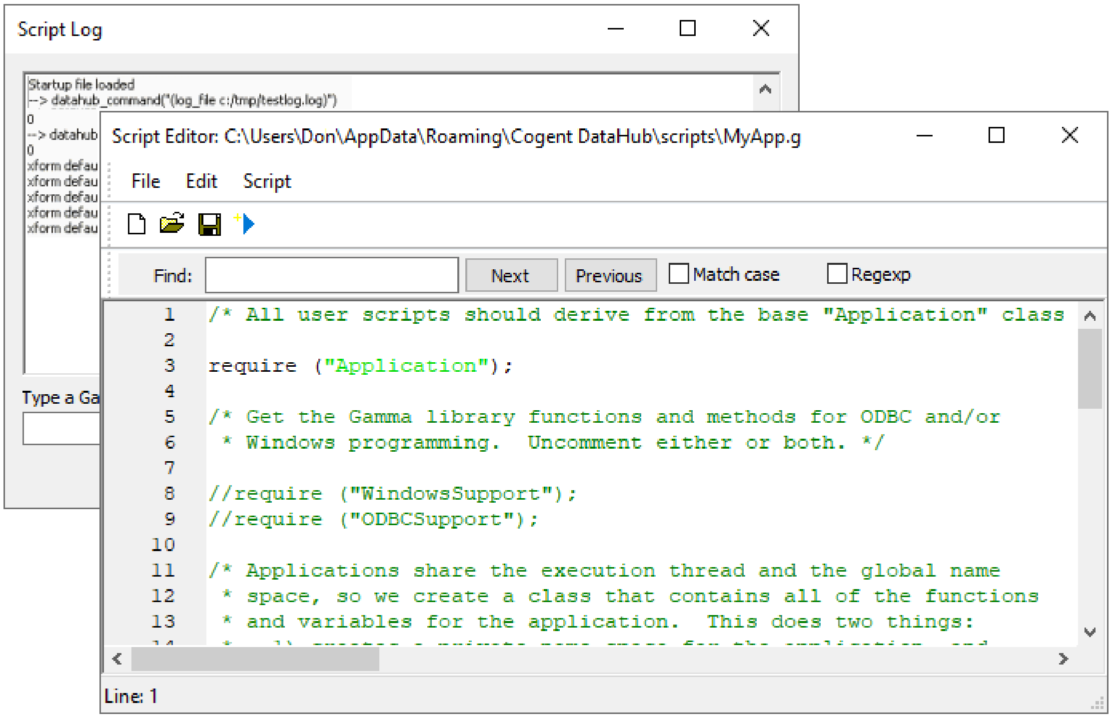
The Cogent DataHub program has a powerful, built-in scripting language called *Gamma*. Using the Gamma language, you can write scripts to interact with the DataHub program and its data in various ways, such as:

- Attach scripts to specific data points so the scripts are run whenever the point value changes.
- Build custom dashboards and summary displays directly in Gamma scripts to create self-contained DataHub applications.
- Create alarm condition scripts and have them display warning messages to the user.
- Create Excel readable log files from your live data by running logging code on a timed interval, or whenever a point change occurs.
- Connect to ODBC compliant relational databases to extract data as well as create records from live data.
- Apply linear transforms on data as it passes through the DataHub program (for example change a temperature reading from Celsius to Fahrenheit).
- Create full simulation programs to test production systems before you 'go live'.

Please refer to the DataHub Scripting manual for more information about scripting.

Tools

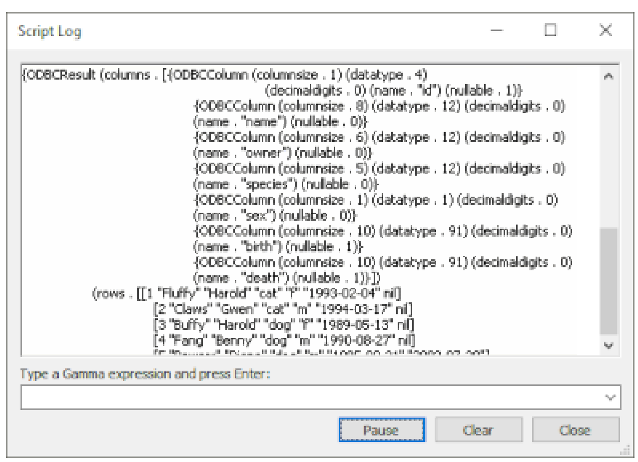
The DataHub program comes with a built-in Script Editor for writing and editing scripts, as well as a Script Log for viewing script outputs.



Please refer to the DataHub Scripting manual for more information about how to use these tools.

DataHub ODBC (Open Database Connectivity) Scripting

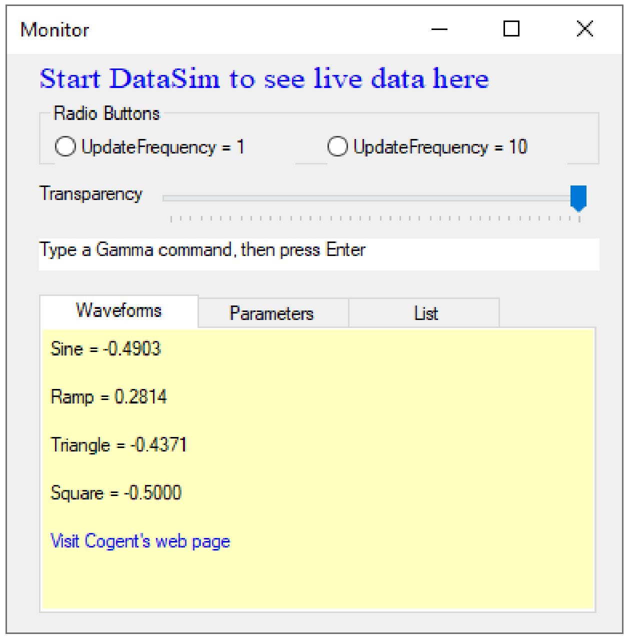
The ODBC support in the DataHub program provides an interface to any ODBC-compliant database. It lets you create a class for any database table, and assign each column of the table as an instance variable of the class, giving you complete access to any point of data in the database.



Please refer to the DataHub ODBC Support manual for more information.

DataHub Windows Scripting

The DataHub program offers Windows scripting support, with the classes necessary to create windows, buttons, frames, tabs, entry fields, and so on—all animated with live data. Here is a screenshot of a test program:



Please refer to the DataHub Windows Scripting manual for more information. The code for this example is in the `WindowsExample.g` file included in your distribution.

Working With Data

This chapter gives an overview of how the DataHub program handles data and the various protocols it works with.

Data Points

Each value stored in the DataHub program is called a *point*. A point has the following attributes:

- **Name** A character string. Currently the only limit on length is internal buffer size, about 1000 bytes by default.
- **Value** An integer, floating-point number, or character string.
- **Time** The date and time of the last significant change to the point's value, confidence, quality or other status information. In general, all timestamps in the DataHub program are in UTC time, and only converted to local time for the purpose of display.
- **Quality** The quality of the connection, assigned by the DataHub program for this point, such as `Good`, `Bad`, `Last known`, `Local override`, etc. Please refer to the **quality** command documentation for a complete list.
- **Type** A character string representing the Windows variant type of the point value. Please see below for a complete list.
- **Confidence** A value from `0` to `100` that indicates as a percentage the probability that the value shown for the point is actually its true value. This feature can be accessed and changed only by using the API. The DataHub program never uses confidence itself, but carries it for use by client applications.

Creating New Points

A DataHub instance automatically creates a point whenever a connecting program tries to read, write, or create a point that doesn't exist. When the point is created, the DataHub instance assigns its value, time, quality, and confidence.

The OPC UA protocol does not support the ability for a client to create OPC tags on a server. However, you can use the **Automatically create unknown items requested by the client** option in the DataHub OPC UA server Advanced configuration to enable it.

It is possible to have the DataHub instance create points and assign values to them at startup. Sometimes referred to as *seeding*, this is done with supplemental configuration files. Please refer to the section called “Configuration Files” for more details. It is also possible to create a point in a DataHub script, using the `datahub_write` function. In a similar way, sending a DataHub command like `cset` will create a point, if it does not already exist. Another option is to use the Bridging feature to create new points.

Deleting Points

You can delete data points from the Data Browser. Please see Deleting Points in the Data Browser chapter for details

However, it is not possible to completely delete points from a DataHub instance. This is because a connecting process may be using that point. Performance does not suffer if there are unused points in the system, but some users prefer to remove them to just keep things tidy. Should a point no longer be in use or requested by any participating program, when the DataHub instance is shut down and restarted, the point will no longer appear. For multiple DataHub instances connected via a tunnel/mirror connection, all of them must be shut down together to ensure that a point is deleted.

Viewing Data Points

You can view the values of all data points with the Data Browser. You can also create a dump of a DataHub instance's current point list by issuing this command in the Script Log entry field:

```
datahub_command("(dump \"c:/temp/datahub.dump\")", 1)
```

Point Size Limits

The DataHub program limits the size of a message to 128 MB. The size of a point message is the length of the value plus the length of the point name plus ~60 bytes. A string value may include escaped characters or non-ASCII UTF-8 characters, such that it takes more than one byte to represent a single character. The result is that the maximum length of the character-encoded value of a point could be substantially less than the 128 MB limit, depending on the characters being transmitted.

If you intend to share data with Linux computers through a custom connection, there is a limit of 128,000 bytes per message.

In any case, bear in mind that very large values will take some time to be transmitted over a network, and can impose a large CPU and memory burden on a DataHub instance.

Data Types

The DataHub program supports the following Windows variant data types:

Windows variant type	DataHub string	Description
VT_BOOL	bool	Boolean (1 = TRUE, 0 = FALSE)
VT_BSTR	bstr	Text string
VT_BSTR	string	Text string
VT_CY	cy	Currency
VT_DATE	date	Date
VT_DECIMAL	decimal	Decimal number

Windows variant type	DataHub string	Description
VT_EMPTY	any	No type specified, or unknown
VT_I1	i1	1-byte signed character
VT_I2	i2	2-byte signed integer
VT_I4	i4	4-byte signed integer
VT_I8	i8	8-byte signed integer
VT_INT	int	Integer
VT_R4	r4	4-byte real number
VT_R8	r8	8-byte real number
VT_UI1	ui1	1-byte unsigned character
VT_UI2	ui2	2-byte unsigned integer
VT_UI4	ui4	4-byte unsigned integer
VT_UI8	ui8	8-byte unsigned integer
VT_UINT	uint	Unsigned integer
VT_VARIANT	variant	Variant
VT_BOOL | VT_ARRAY	bool array	Boolean array
VT_BSTR | VT_ARRAY	bstr array	Text string array
VT_BSTR | VT_ARRAY	string array	Text string array
VT_CY | VT_ARRAY	cy array	Currency array
VT_DATE | VT_ARRAY	date array	Date array
VT_DECIMAL | VT_ARRAY	decimal array	Decimal array
VT_I1 | VT_ARRAY	i1 array	1-byte signed character array
VT_I2 | VT_ARRAY	i2 array	2-byte signed integer array
VT_I4 | VT_ARRAY	i4 array	4-byte signed integer array
VT_I8 | VT_ARRAY	i8 array	8-byte signed integer array
VT_INT | VT_ARRAY	int array	Integer array
VT_R4 | VT_ARRAY	r4 array	4-byte real number array
VT_R8 | VT_ARRAY	r8 array	8-byte real number array
VT_UI1 | VT_ARRAY	ui1 array	1-byte unsigned character array
VT_UI2 | VT_ARRAY	ui2 array	2-byte unsigned integer array
VT_UI4 | VT_ARRAY	ui4 array	4-byte unsigned integer array
VT_UI8 | VT_ARRAY	ui8 array	8-byte unsigned integer array
VT_UINT | VT_ARRAY	uint array	Unsigned integer array
VT_VARIANT | VT_ARRAY	variant array	Variant array

Coercing a Number to a DATE Type

Any number value sent to a `DATE` type is checked for type. If the value is not a `DATE` type, the DataHub engine coerces it to a `DATE` type as follows:

- A value of `0` appears as Jan 1, 1970 (UNIX epoch start)
- A value greater than `0` and less than or equal to `1,000,000` is treated as an OADate (days since midnight, December 30, 1899).
- A value greater than `1,000,000` and less than or equal to `10,000,000,000` is treated as UNIX seconds.
- All other values are treated as UNIX milliseconds (JSON timestamp)

Data Communication Concepts

These basic concepts of data communications will help you understand how the DataHub program works.

Send and Receive Data

- **Send/write data:** A program *sends* a value for a data point, and the DataHub instance records, or *writes*, the value for that point. This type of communication is synchronous. The send and the write are essentially two parts of a single process, so we use the terms pretty much interchangeably. You can write a value to a DataHub instance manually using the Data Browser.

  A typical write command from a program using DDE protocol is **DDEPoke**.
- **Receive/read data:** A program requests to *receive* the value of a data point. The DataHub instance then responds by sending the current value of the point. We call this *reading* the value from the DataHub instance. Again, we sometimes use the two terms interchangeably, and again, this type of communication is synchronous.

  A typical read command from a program using DDE protocol is **DDERequest**.
- **'Automatic' Receive:** It is possible to set up live data channels, where a program receives updates on data points sent from a DataHub instance. How it works is the program sends an initial request to the DataHub instance to register for all changes to a data point. The DataHub instance immediately sends the current value of the point, and then again whenever it changes. A DataHub instance can receive data automatically in a similar way. This asynchronous type of communication is sometimes referred to as *publish-subscribe*.

  A **DDEAdvise** command sets up this type of connection, which is called an *advise loop*.

Client - Server

Exchanging data with the DataHub program is done through a client-server mechanism, where the *client* requests a service, and the *server* provides the service. Depending on the programs it interacts with, a DataHub instance is capable of acting as a client, as a server, or as both simultaneously.

The client-server relationship itself does not determine the direction of data flow. For example, a client may read data from the server, or it might write data to the server. The data can flow either way; the client might initiate a read or a write, and the server would respond.

Synchronous and Asynchronous Communication

Every type of communication, natural or man made, comes in two basic forms: *synchronous* or *asynchronous*.

- Synchronous communication means that for each message, the sender expects to get a reply from the receiver, like a telephone call. There is a back-and-forth exchange, so that each party knows that the other is receiving the message. If there is no response, you can be pretty sure that communication didn't occur.
- Asynchronous communication means that a message gets sent but the receiver is not expected to reply, like a radio broadcast or a newspaper.

Each of these communication types has its own value and purpose in data communications, and the DataHub program is capable of both. The specific circumstances and application will determine which form of communication you end up using.

Data Exchange Protocols

The DataHub program relays data between programs using OPC, TCP or DDE. It also tunnels data over a network or the Internet using TCP. This section gives an overview of these protocols.

OPC Protocol

OPC is an interface specification for data communications that is popular in industrial environments. Please refer to for general information about OPC.

OPC connections are always client-server. Setting up the DataHub program to use OPC is simply a matter of configuring it to act as a client or as a server, or both. When acting as a client, it will automatically attempt to find or start the OPC server that has been configured, and then start receiving data. When acting as a server, it will automatically respond to requests from any OPC client on the system.

OPC Items and Properties

There are two implementation of OPC for real-time data access: OPC DA (Classic) and OPC UA. Both use the concept of an *item* as a way to structure data. In OPC DA, every item has 6 required *properties*: Value, Timestamp, Quality, Access Rights, Scan Rate, and Canonical Type. The OPC UA spec includes this kind of item, as well as many others.

DataHub software implements only the part of the OPC UA spec that is similar to OPC DA. Furthermore, as users of the data, we are mostly interested in Value, Timestamp, and Quality. OPC items can also have up to 30 optional properties, such as Description, Engineering Units, High, Low, Alarm Level, and so on. For example, an item might represent a temperature reading on a tank like this:

Property	Current value
Value	47.2
Timestamp	Apr 27 16:27:24.300
Quality	Good
High	60.0
Low	38.5
Alarm Level	54.0
Engineering Units	Celsius
Description	Temperature of Tank A

The DataHub program maintains an item and all of its optional properties as separate data points. The item's 6 required properties are maintained internally, but the DataHub program displays the information corresponding to the Value, Timestamp, and Quality in the Data Browser under the columns **Value**, **Date** and **Quality**.

This relatively simple picture becomes more complex when we learn that the OPC specification allows a property to be an item in its own right. This implies, in turn, that properties can have properties. Some OPC servers implement properties as items, and some do not. Normally when an OPC server does treat properties as items, those items have only the 6 required properties and you don't get an infinite recursion.

This has implications for configuring a DataHub instance and working with data sets. If an OPC server implements properties as items, the DataHub instance could potentially have access to many more data points than for an OPC server whose items are not properties. For this reason, the DataHub program makes it optional to pick up all items that are properties.

It also affects the results of a filtered connection to an OPC server. Filters set up in the DataHub program are based on items. If your OPC server implements properties as items, and if you choose to pick up all items that are properties, then any filter you run apply to those items as well.

DDE Protocol

DDE (Dynamic Data Exchange) is a well-established mechanism for exchanging data among processes in MS-Windows. There are three DDE commands for establishing communication with Windows programs such as Excel. Which of these commands you use depends on how you plan to control the flow of data between the spreadsheet and the DataHub instance.

1. **DDEPoke** writes a data value to the DataHub program. For example, to send a value from an Excel spreadsheet to a DataHub instance, the **DDEPoke** command is run from within an Excel macro. For more details, please refer to the section called “Method 2 - Writing Excel macros that use the **DDEPoke** command”.
2. **DDERequest** reads a data value from the DataHub program. To get that value into Excel, for example, the **DDERequest** command is run from within an Excel macro. For more details, please refer to the section called “Method 2 - Excel Macros using **DDERequest**”.
3. **DDEAdvise** creates a connection, called an *advise loop*, that updates a new data value automatically. The advise loop is a unidirectional link, established by a client program that wants to receive data from a server program. The client continues to receive new point values as long as the two programs are running, or until the advise loop is terminated.

   You can use **DDEAdvise** to read data from a DataHub instance by configuring it to act as a DDE Server. For an example using Excel, please refer to the section called “Method 1 - Drag and Drop using **DDEAdvise**”.

   Likewise, you can use **DDEAdvise** to write data to a DataHub instance, by configuring it to act as a DDE Client. For an example using Excel, please refer to the section called “Method 1 - Configuring **DDEAdvise** loops in the DataHub instance”.

For more information on DDE, please refer to Appendix G, *DDE Overview*.

Tunnelling/Mirroring

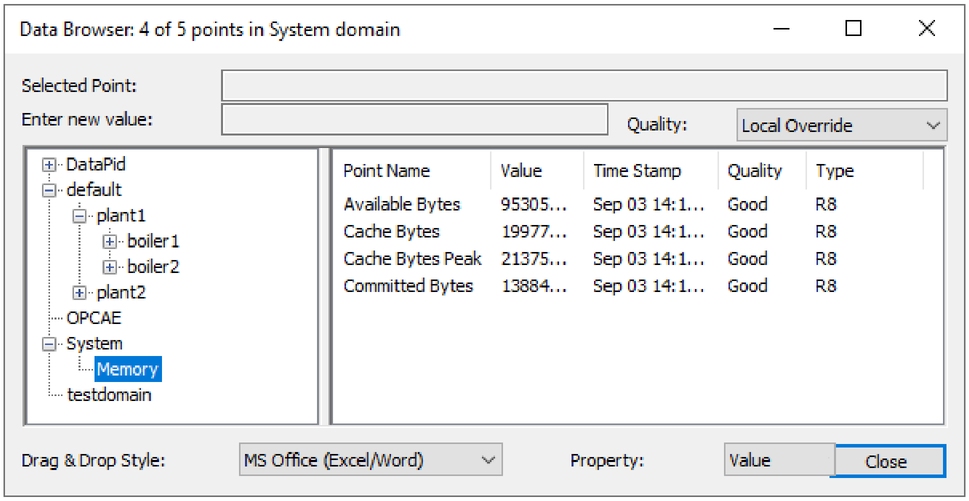
The Cogent DataHub program uses DHTP to communicate over a LAN, WAN, or the Internet. You can join two or more DataHub instances together and share exact copies of the data through data *tunnelling/mirroring*. Tunnelling/Mirroring means that the data and any updates to that data on one DataHub instance are exactly tunneled/mirrored across the network onto any other DataHub instance that is connected. Once a tunnelling/mirroring connection is established each participant maintains and updates an identical data set, as simultaneously as the TCP connection will permit. For more information on tunnelling/mirroring, please refer to the section called “Tunnel/Mirror”.

The DataHub APIs

The DataHub APIs for C++, Java, and .NET lets any TCP-enabled program interface with the DataHub program.

Data Organization

The DataHub program offers a hierarchical system to organize your data. The hierarchy is separate from the actual data. It contains points, but is not made up of data, per se. You specify the data model, similar to specifying a class in a programming language, and then you create zero or more instances of that data model. The data hierarchy can be viewed in the left-hand pane of the Data Browser window.



Data Domains

The highest level of the data hierarchy is the data domain. You can create as many data domains as you need, and use them to separate data by user, function, or any other criteria. Points in different data domains can have the same name because each data domain creates a separate namespace. Two data domains you are probably familiar with are `default`, the default data domain, and `DataSim` which holds data from DataSim. All the data domains in a DataHub instance are listed in the **General** option of the Properties window.

The written syntax used by the DataHub program to denote data domains and points is:

```
domain:point
```

In many cases, this is the only level of data organization you will ever need. However, should you desire a more sophisticated way to structure your data, the DataHub program provides a way.

Assemblies, Subassemblies, Attributes, and Properties

Within a data domain, data can be arranged hierarchically as assemblies, subassemblies, attributes, and properties. Each assembly can have zero or more attributes and zero or more subassemblies, and each attribute can have zero or more properties. Subassemblies can have subassemblies. You can think of assemblies and subassemblies as branches in a tree, and attributes as the leaves. Here is an example of what a tree might look like:

```
Data Domain
    Assembly
        Subassembly (zero or more)
            Attribute  (zero or more)
                Property  (zero or more)
        Attribute...
        Attribute...
```

```
        Attribute...
            Property...
            Property...
            Property...
        Subassembly
            Subassembly
                Attribute...
                  Property...
                  Property...
            Attribute...
            Attribute...
                Property...
    Assembly...
```

and so on.

The written syntax for all of these levels uses a dot (`.`) to divide the names, rather than a colon that was used for the data domain name. Hence, the syntax of point in a property in an attribute in a subassembly in an assembly in a data domain would be:

```
domain:assembly.subassembly.attribute.property
```

Properties describe the attributes in more detail. An attribute can have a *default property* such that if you interact with the attribute point directly you will in fact be interacting with its default property. For example, an item might be `plant.temperature`, with properties `value`, `highlimit`, `units`. This would create 4 tags:

```
plant.temperature
plant.temperature.highlimit
plant.temperature.units
plant.temperature.value
```

The tags:

```
plant.temperature
plant.temperature.value
```

are aliases of one another. Both refer to the default property of `plant.temperature`. If you specify no property at all for an item, the item takes on the default property.

Attributes and Types

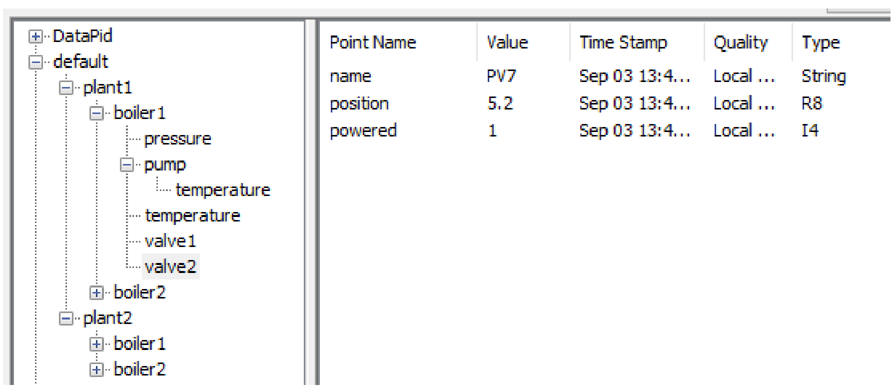
It is common for attributes to contain the same type of information. For example, all temperatures in a system are likely to share units, high alarm level, and value. To avoid repeating this information for each and every temperature in the system, we use a *type*. A type is the prototype, or class, of an attribute. You define a type and its properties first, and then define attributes of that type on assemblies. When the assembly is instantiated, its attributes are instantiated by creating an attribute and then assigning the properties to it that are associated with the attribute's type.

There is an alternative to using types and attributes as described here, a *private attribute*. A private attribute provides a one-command (**private_attribute**) means of creating an attribute on an assembly without having to define a type. This prevents the attribute properties from being shared across more than one attribute in the assembly or in other assemblies, but is easier to use when defining simple hierarchies. (See Example 2.)

Example 1: Attributes and Types

Suppose we want to create a hierarchical data model like this: We have a control system consisting of process areas, that we will call "Plants". Each plant contains 2 boilers, and each boiler has a pump and 2 valves. Each boiler measures temperature, pressure and level. Each pump measures speed, on/off state and operating temperature. There are two types of valves - a normal one that only measures position, and another that also verifies that it has power applied to it. Temperatures have a value and a high alarm limit.

The sample file `plant.cfg` shown below included in the DataHub distribution will create a point hierarchy in the `default` data domain that looks like this:



You can have a DataHub instance load this `plant.cfg` configuration file on startup (see the section called “Configuration Files”).

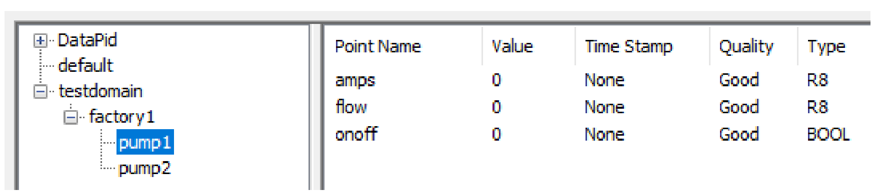
```
;;; Create a generic object to share all of the common properties and
;;; attributes in the model.  Give it a common property, called "name"

(assembly default Object)
(property default Object AUTO name string rw "unnamed" 100)

;;; Create a temperature attribute to be shared by boilers and pumps.
;;; It has three properties: value,highlimit,units

(type default Temperature)
(property default Temperature AUTO value R8 rw 0 100)
(property default Temperature AUTO highlimit R8 rw 120 100)
(property default Temperature AUTO units STRING rw "C" 100)
(defaultprop default Temperature value)
```

```
;;; Create a pressure attribute for boilers.

(type default Pressure)
(property default Pressure AUTO value R8 rw 0 100)
(property default Pressure AUTO units STRING rw "kPa" 100)
(defaultprop default Pressure value)

;;; Create a plant model, sharing the properties and attributes
;;; of "object"

(assembly default Plant Object)

;;; Create a boiler model, as an "object"

(assembly default Boiler Object)
(attribute default Boiler temperature Temperature)
(attribute default Boiler pressure Pressure)

;;; Create a pump model, as an "object"

(assembly default Pump Object)
(attribute default Pump temperature Temperature)
(property default Pump AUTO speed R8 rw 0 100)
(property default Pump AUTO state I4 rw 0 100)

;;; Create a valve object.  It has a property, position, directly
;;; attached to the assembly.  We do not need an attribute unless
;;; there is more than one property to be associated with it.  In
;;; this example position has only a value, without limits or
;;; units.

(assembly default Valve Object)
(property default Valve AUTO position R8 rw 0 100)

;;; Create a specialization of a Valve that also measures whether
;;; the valve is powered.

(assembly default Powervalve Valve)
(property default Powervalve AUTO powered I4 rw 0 100)

;;; Create the hierarchy in the model

;;; Plants have two boilers, named boiler1 and boiler2
(subassembly default Plant Boiler boiler1)
(subassembly default Plant Boiler boiler2)
```

```
;;; Boilers have one Pump, named pump
(subassembly default Boiler Pump pump)

;;; Boilers have a normal valve and a powered valve, named valve1
;;; and valve2 respectively.
(subassembly default Boiler Valve valve1)
(subassembly default Boiler Powervalve valve2)

;;; Create two plants named plant1 and plant2.  These actually
;;; create the data points in the DataHub instance and arrange them
;;; in the hierarchy specified above.  Up to this point, the commands
;;; have just been building a model.  These calls instantiate the
;;; model.

(instance default plant1 Plant)
(instance default plant2 Plant)
```

Example 2: Private Attributes

Here is a simpler example for creating a hierarchical data model using private attributes. This models a control system in a factory with 2 pumps. The sample file shown below will create a point hierarchy in the `default` data domain that looks like this:




```
; Create two assemblies.
(assembly testdomain factory)
(assembly testdomain pump)

; Create two subassemblies.
(subassembly testdomain factory pump pump1)
(subassembly testdomain factory pump pump2)

; Assign private attributes.
(private_attribute testdomain pump flow R8 rw 0 100)
(private_attribute testdomain pump amps R8 rw 0 100)
(private_attribute testdomain pump onoff BOOL rw 0 100)
```

```
; Instantiate the model.
(instance testdomain factory1 factory)
```

Optimizing Data Throughput

The Cogent DataHub program has a wide range of configuration options. Among these there are several settings that will optimize data throughput, which are explained in this chapter.

Binary Mode Tunnel/Mirror (TCP) Connections

TCP/IP connections to a DataHub instance can be either ASCII or binary mode. A large part of the CPU cost of transmission is marshalling messages (constructing messages at the source and parsing them at the destination). The binary mode is more efficient in both network bandwidth and CPU usage for both the sender and the receiver. Binary mode requires that the CPU architecture of the sender and the receiver agree, so you can only use this mode if you are running both the sender and the receiver on an Intel x86 CPU. The CPU gain could be as much as 50% when using binary mode. Numeric data benefits most from this option.

How to Optimize

- For tunnelling connections, always use binary mode if possible. Please refer to How to Optimize, Binary mode transmission for details.
- For TCP/IP connections using the C++ API, always use binary mode if possible. Please refer to How to Optimize, the section called “DataHub C++ API” for details.

Tunnel/Mirror (TCP) Heartbeat and Timeout

The DataHub program uses a heartbeat to determine the status of the network connection. The tunnel/mirror slave sends a special heartbeat message to the master at specified time intervals, to detect network failures. If the master does not respond within a certain timeout period, the slave changes the status of its connection to **Disconnected** and attempts to reconnect.

The overall principle for optimizing the heartbeat and timeout is choosing settings based on the dynamics of the system and how quickly you need to know about a lost connection. With that in mind, we recommend choosing the longest reasonable timeout that fits your needs, and then set the heartbeat to half of that.

Specific Guidelines

1. The timeout should be at least twice the heartbeat.
2. The default heartbeat is set to 1 second and the timeout to 5 seconds. That is reasonable LAN timing. If the network or CPU situation could produce temporary timeouts longer than 5 seconds then this timing could cause unnecessary disconnect/reconnect cycles.
3. When connecting to a DataHub instance over the Internet we recommend setting the heartbeat to 10 seconds and the timeout to 30 seconds. That generally produces a very stable connection.

4. When connecting to a remote system via a metered connection (usually cellular) we recommend setting the heartbeat to 30 seconds and the timeout to 60 seconds.
5. A short timeout will notify the DataHub instance quickly when a connection is lost. If you need to know quickly about a lost connection, set the timeout low.
6. A long timeout makes it less likely that the connection will time out during a temporary event, like a burst of heavy network traffic or a high CPU load on one of the computers. A short timeout under these conditions will cause extra traffic to reconnect the tunnel, and will cause data to temporarily become **Not Connected**.
7. A short heartbeat will cause more traffic when the connection is idle. This traffic is not significant on a LAN, but could be important on a metered connection like a cellular modem. If traffic is an issue, set the heartbeat high.

Additional Considerations

Normal ping times on a LAN are less than a millisecond, so you could technically set the heartbeat very low on a LAN. However, Windows O/S time slices are 33 ms, which means that a busy CPU could easily hold off the DataHub instance for tens of milliseconds. We generally do not recommend sub-second heartbeats without a really good reason.

VPNs, proxies and encryption can all have an impact on latency, which can result in transmission delays.

Old Value Queuing

The DataHub program maintains a queue of old values for all registered points for each client. The depth of this queue is variable. The purpose of queuing old values is to reduce the chance that a data change will be missed during bursts of abnormally high data flow.

For example, if a switch is turned on, then off, then on again very rapidly, the data might arrive at a DataHub instance so quickly that it has no opportunity to send it where it needs to go before the next value arrives. If this happens, the DataHub instance may only transmit the final "on" value and the client will not notice that there was in fact an on-off-on transition.

The DataHub program can maintain a short queue to reduce the probability of this happening. If the queue is at least three values deep, the DataHub instance will send the on-off-on transition even if it knows that the first two values are already stale.

Old value queuing is harmless so long as periods of abnormally high data flow are short. If the data flow rate is high enough that a DataHub instance can never keep up, the effect is that the old value queue will always be full, no matter how long or short it is. The CPU cost of maintaining even a short queue in a sustained overload situation is very high, and depends on the queue depth. See also the section called “CPU Saturation”.

How to Optimize

- If your system runs at CPU saturation, eliminate the old value queue if at all possible for TCP/IP connections. Please refer to How to Optimize, Old value queueing and unbuffered delivery for details.

- If your system runs at CPU saturation, eliminate the old value queue if at all possible for the Gamma scripting engine. Please refer to How to Optimize, the section called “Gamma scripts” for details.

Un-Buffered Delivery

The DataHub program buffers data that will be transmitted to a client such that if it knows that more incoming data is available, it will hold off outgoing transmissions until it has a complete data set to send onward to the client. This does not introduce extra latency because a DataHub instance will only accumulate data destined for a client that arrives together in an incoming message.

This buffering greatly increases efficiency by reducing thread context switching and by giving its protocol-specific data transmitters an opportunity to collect more than one data change into a single outgoing message.

One of the side-effects of buffering is that the old value queue will be more likely to fill. If your application is very sensitive to every change of value, then it may be necessary to turn off the buffering. The CPU penalty for turning off buffering is very high, perhaps as much as 200% in heavy load conditions.

How to Optimize

Do not use un-buffered data delivery in high load conditions unless you absolutely must. Please refer to How to Optimize, Old value queueing and un-buffered delivery for details.

Screen Output

Output to the screen can use a huge amount of processing time. The worst offenders are multi-line text boxes where text is constantly being added and scrolled. If you think that the CPU usage for a DataHub instance is too high, close all Event Log and Script Log windows.

You may also find that the Data Viewer window uses too much CPU if the data is changing very rapidly or if the number of data points visible in the right-hand pane of the Data Viewer is very large. Try closing the Data Viewer to reduce CPU load. If you need to monitor some data in the Data Viewer, consider using bridging to collect the subset of data points that you need into separate data domain. Viewing that subset of the data will consume less CPU and may have the added benefit of being more convenient.

How to Optimize

- Close the Event Log windows when not in use.
- Close the Script Log window when not in use.
- Close the Data Viewer when not in use, or use bridging to create a smaller subset of data in a separate data domain.

CPU Saturation

When your system is running with maximum CPU utilization, the transmitting and receiving threads within a DataHub instance must all share the CPU available. This will cause data to be queued more frequently, and will cause the DataHub instance to take measures to cope with the lack of CPU. The DataHub program treats a high-CPU condition as if the various connections cannot consume data as quickly as it is available. It will begin tracking and ultimately discarding old data values, and will more aggressively accumulate data changes into larger messages wherever possible. The DataHub program's goal is to ensure that latency remains low, that all clients continue to receive data, and that the clients always receive the most recent data that is available.

This effort to cope with reduced resource availability also uses more CPU, somewhat further increasing the system load. If old value queues are deep, the system can reach a "tipping point" from which it is difficult to recover without severely reducing the input data rate.

How to Optimize

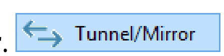
Avoid running your system at maximum CPU capacity.

How to Optimize

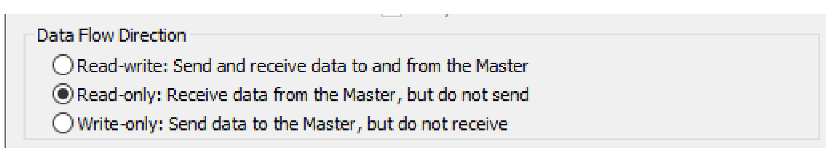
Tunnel/Mirror (TCP) connections

Read-only connections

On the **slave** side of the connection, you can determine the data flow direction for the connection. If the data flow is to be one-way, from the master to the slave (i.e. the slave will only read from the master, not write), you will get the fastest performance by configuring the connection "read-only", as follows:

1. On the DataHub instance; that is making the *slave* side connection, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 

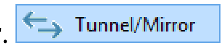
3. In the **Data Flow Direction** section, select **Read-only: Receive data from the Master, but do not send**.



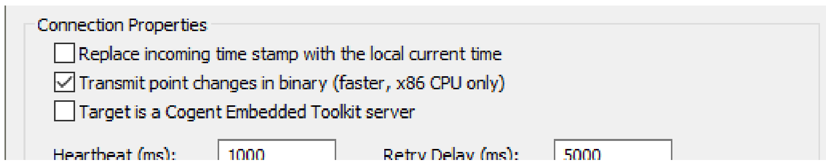
4. Click **Apply**.

Binary mode transmission

Ensure that the **slave** side of the tunnel/mirror connection is set to use binary mode transmission:

1. On the DataHub instance that is making the *slave* side connection, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 

3. In the **Tunnel/Mirror Slave** section, highlight the host name of the tunnelling master, and click the **Edit** button to open the Tunnel/Mirror Master Configuration window.
4. Check the **Transmit point changes in binary** box.



5. Click **Apply**.

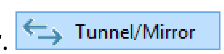
For more information, please refer to the section called “Binary Mode Tunnel/Mirror (TCP) Connections”.

Timeout and Heartbeat

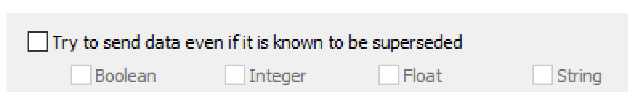
To optimize performance for the network heartbeat and timeout, please refer to the section called “Tunnel/Mirror (TCP) Heartbeat and Timeout”.

Old value queueing and un-buffered delivery

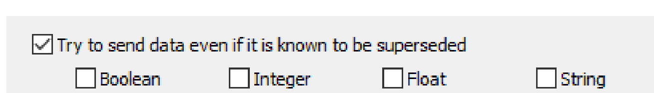
Configure the **master** side of the tunnel/mirror connection:

1. On the DataHub instance that is the *master* for the tunnel/mirror connection, right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror**. 

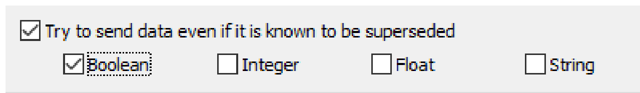
3. In the **Tunnel/Mirror Master** section, you can choose between one of three states:
   - **No queuing with buffered delivery** This is the fastest state. To do this, un-check the option **Try to send data even if it is known to be superseded** in the Tunnel/Mirror configuration tab:

   - **Queuing with buffered delivery** This is a reasonable compromise that will keep up to three old values for each data point if there is a short burst of heavy data traffic. If there are more than three values for a point outstanding, the oldest will be discarded. To do this, check the option **Try to send data even if it is known to be superseded**, but do not select any of the data types below it:

- **Queuing with un-buffered delivery** This is the slowest mode, but also the one least likely to discard old values during short periods of heavy data traffic. In this mode there is a queue of up to 3 old values for each data point. In addition, you may choose to force the data transmission when a point with any of the specified types changes. The goal here is to possibly allow buffering (and hence, possible discarding of old values) for some types, while attempting to preserve all changes for other types. For example, here we have chosen to force an outbound transmission if any boolean or string value changes, but to buffer any changes in floating point and integer types:



4. Click **Apply**.

For more information, please refer to the section called “Old Value Queuing” and the section called “Un-Buffered Delivery”.

DataHub C++ API

Binary mode connections

- In your program, call the method `CDataHubConnector::sendBinaryPointMessage(bool enable)` to enable or disable binary messages.

For more information, please refer to the section called “Binary Mode Tunnel/Mirror (TCP) Connections”.

Gamma scripts

The Gamma engine services all DataHub scripts through a single queue, for the sake of efficiency. This means that any changes you make to the default behaviour will apply to all running scripts. By default, the Gamma engine runs with a 3-deep queue and buffered transmission. This is equivalent to the queuing with buffered delivery option (above) for TCP/IP connections. As of Cogent DataHub version 6.4.2, you can modify the behaviour of the queuing and the buffering via Gamma function calls:

- **`set_point_queue_depth`** lets you specify the depth of the per-point queue. It is wise to keep this value small. Please see set_point_queue_depth in the DataHub Scripting manual for details about this function.
- **`get_point_queue_depth`** determines the current point queue depth for the Gamma engine. Please see get_point_queue_depth in the DataHub Scripting manual for details about this function.
- **`set_point_flush_flags`** sets which data types will cause the point buffer to immediately be transmitted to the Gamma engine. Please see set_point_flush_flags in the DataHub Scripting manual for details about this function.

Using DataHub Commands

The Cogent DataHub program has an internal command set, documented in the Cogent DataHub Command Set reference. When you change the configuration of a DataHub instance in the Properties window, one or more of these commands is written in the configuration file, and the DataHub instance receives that command every time it starts up. You can use these commands to create custom configuration files. (Please see the section called “Configuration Files”.)

It is also possible to issue these commands to the DataHub instance during run-time in any of the following ways:

- With a DataHub script, using the special `datahub_command` function.
- Using the DataHub APIs for C++, Java, and .NET.
- Over a direct TCP connection.

This is how custom applications can interact directly with a DataHub instance. For example, DataSim connects to a DataHub instance by using the DataHub APIs for C++, Java, and .NET.

Command Syntax

DataHub commands have the following syntax:

```
(command arg1 arg2 ...)
```

The whole command must be surrounded by parentheses. The command name and its arguments are each separated by white space—single spaces, tabs, or carriage returns are allowed. For example, the following line of a custom configuration file tells the DataHub instance to create a new data domain, named `TestDomain`.

```
(create_domain TestDomain)
```

Multiple-word strings must be in quotes. Numbers take their own values. Booleans are `0` for false and `1` for true.

Return Syntax

When a DataHub instance executes a command, it may return a success message or an error message. The returned message contains the original command, and some or all of the arguments for the command. These messages will be received by programs connected to the DataHub instance, but they will not be received by DataHub scripts. The two types of success messages are:

- **No arguments** `(success command)`
- **One or more arguments** `(success command arg1)`

Success messages are returned if the DataHub command **acksuccess** has been previously issued with a value of `1`. A value of `0` means no success messages will be returned. Error messages are returned any time there is an error. There are four types of error messages:

- **No arguments** `(error "-2: (`*command*`): `*error message*`")`
- **One argument** `(error "-2: (`*command* arg_1`): `*error message*`")`
- **Two arguments** `(error "-2: (`*command* arg_1 arg_2`): `*error message*`")`
- **More than two arguments** `(error "-2: (`*command* arg_1 `...): `*error message*`")`

The error messages are the negation of these error codes:

ST_OK	The function executed without error.
ST_ERROR	An error occurred.
ST_NO_TASK	A required task does not exist.
ST_NO_MSG	There is no message available.
ST_WOULDBLOCK	This action would block, and is not permitted.
ST_INTR	An interrupt occurred.
ST_FULL	The queue is full.
ST_LOCKED	A DataHub point is locked.
ST_SECURITY	The security level is insufficient.
ST_NO_POINT	A required DataHub point does not exist.
ST_INSIG	A change in a DataHub point value is insignificant. This is not really an error, but a notification that no exception will be generated by the DataHub instance.
ST_UNKNOWN	There is an unknown error.
ST_NO_QUEUE	A target task has no queue, or **qserve** is absent.
ST_CMD_SYNTAX_ERROR	The command was not found, or there was a syntax error.
ST_REPLIED	The reply was complete.
ST_WRONG_TYPE	The type of a point or variable was wrong.
ST_TOO_LARGE	A value to be written to memory is larger than the available buffer.
ST_NO_MEMORY	There is insufficient memory available.
ST_OLD_DATA	Time-significant data is out of date.
ST_TIMEOUT	A timeout occurred in poll mode.

Sending Commands by TCP

It is possible to send DataHub commands directly to a DataHub instance over TCP, by using a tunnelling/mirroring connection. The communication between a client and the DataHub instance over TCP follows the guidelines below.

You must allow Remote Connections in Security for any incoming connections over the network.

- The connection is a single bi-directional socket.
- All communication from the DataHub instance to the client is non-blocking and asynchronous. It is possible to use blocking I/O in the client, and to wait for a response from the DataHub instance as well, but we don't advise doing either.
- Since TCP is streamed, there are no packets as such. Each message starts with an open parenthesis and ends with a matching closing parenthesis. Messages should be terminated with a newline (`\n`) character. If they are not, then the DataHub instance will hold off on processing the incoming messages until it receives a newline character, and then it processes all messages in order, in a batch. There is a maximum character length allowed (around 1 MB) for a batch of messages, after which the DataHub instance will discard data until it sees a newline.
- Parameters within a message can themselves be parenthesized expressions. For example, the following message contains a command and five parameters:

  ```
  (OPCAddItem server1 item1 0 default:server1.item1
   (default server1 item1))
  ```

  The fifth parameter is itself a command: `(default server1 item1)`.
- All strings in a message are surrounded by double quotes. Inside the double quotes, the sequence `\"` embeds a double quote, `\\` embeds a `\` character, `\n` embeds a newline, `\t` embeds a tab, `\f` embeds a form feed, `\r` embeds a carriage return. `\` followed by any other character produces that character with the `\` removed. Parentheses inside double quotes do not match parentheses outside double quotes.
- You can embed any character inside a non-quoted string by putting a `\` in front of that character, so the string `abc\ def` would be the same as `"abc def"`.
- Example of using a TCP socket directly:

  ```
  SOCKET s;
  char buf[256];
  int len;
  char *pointname = "testpoint";
  double value = 1.0;

  len = sprintf(buf, "(cset \"default:%s\" %g)\n", pointname, value);
  send(s, buf, len, 0);
  ```

There is a function in the C++ header file of the C++ API that parses this kind of stream, called `UT_LispParse`, and another function called `UT_LispString` that can help a little with writing Lisp expressions. They automatically add double-quotes around `%s` formatted strings, and escape characters within the string.

Cogent DataHub Command Set

This is the internal command set for the DataHub program and related software. For general information on how to use these commands, please refer to *Using DataHub Commands*.

acksuccess

acksuccess — tells the DataHub instance to return success messages.

Synopsis

```
(acksuccess 0|1)
```

Arguments

`0|1`
: Use `1` to have messages returned, or `0` to not have messages returned.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command tells the DataHub instance to return a message for successfully executed command. Error messages are always sent for unsuccessful attempts to execute a command. Please refer to Return Syntax for details about the message format.

add

add — adds a value to a point.

Synopsis

```
(add name number [secs] [nano])
```

Arguments

name
: The name of a point, which must be a number type.

number
: A value to add to the value of the point.

secs
: The time in seconds. If this is not specified, the current date and time in seconds is used.

nano
: A fraction of a second, in nanoseconds. If this is not specified, the number of nanoseconds past the current date and time is used.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used to add to the value of a point.

alias

alias — creates an alias point for an existing point.

Synopsis

```
(alias point alias)
```

Arguments

point
: The name of a DataHub point, as a string.

alias
: A name for the new point, as a string.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a new point that will alias, or tunnel/mirror its value with, an existing point. The first point must exist, and the second point will be created if it does not exist. They do not need to be in separate domains.

alive

alive — tells a DataHub instance that the client is running.

Synopsis

```
(alive)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command provides a means for the client to tell a DataHub instance that it is still up and running.

append

append — appends a string to the value of a point.

Synopsis

```
(append name string [secs] [nano])
```

Arguments

name
: The name of a point, which must be a string type.

string
: A string to add to the current string value of the point.

secs
: The time in seconds. If this is not specified, the current date and time in seconds is used.

nano
: A fraction of a second, in nanoseconds. If this is not specified, the number of nanoseconds past the current date and time is used.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used to add a string to the value of a point.

assembly

assembly — creates an assembly.

Synopsis

```
(assembly domain name [supername])
```

Arguments

domain
: The name of the domain in which this assembly will be created.

name
: A name for this assembly.

supername
: The name of an assembly.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates an assembly level of a data organization. The *supername* denotes a special assembly that can be created to hold properties and attributes that may be used by several assemblies, in much the way that a parent class has instance variables that are used by child classes. For more information about assemblies and an example, please refer to the section called “Assemblies, Subassemblies, Attributes, and Properties”.

attribute

attribute — creates an attribute.

Synopsis

```
(attribute domain assemblyname attrname typename)
```

Arguments

domain
: The domain in which this attribute applies.

assemblyname
: The assembly or subassembly in which this attribute applies.

attrname
: The name of this attribute.

typename
: The type of this attribute.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates an attribute. For more information and an example, please refer to the section called "Assemblies, Subassemblies, Attributes, and Properties".

auth

auth — requests authentication for a client.

Synopsis

```
(auth username password)
```

Arguments

username

A user name in plain text. Any non-alphanumeric characters must be in double quotes.

password

A password in plain text. Any non-alphanumeric characters must be in double quotes.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is sent to a DataHub instance by a client to request authentication.

authreload

authreload — is new, not yet documented.

Synopsis

```
(authreload)
```

Description

This command has not yet been documented.

auto_create_domains

auto_create_domains — automatically adds domains requested by clients.

Synopsis

```
(auto_create_domains 0|1)
```

Arguments

`0|1`
: Use `1` to have domains added, or `0` to not have domains added automatically.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command instructs a DataHub instance to create a domain automatically if a client requests a domain that doesn't already exist. This corresponds to the **Automatically add domains requested by clients** checkbox in the General option of the Properties window.

auto_timestamp

auto_timestamp — adds timestamps to unstamped changes.

Synopsis

```
(auto_timestamp 0|1)
```

Arguments

`0|1`
: Use `1` to add timestamps, or `0` to not add timestamps automatically.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command instructs a DataHub instance to timestamp points automatically to changes that don't already have a timestamp. This corresponds to the **Automatically add a timestamp to unstamped changes** checkbox in the General option of the Properties window.

bridge

bridge — creates a bridge between two points.

Synopsis

```
(bridge source destination
 [flags [multiply add [srcmin srcmax dstmin dstmax]]])
```

Arguments

source

The fully qualified point name of the source, or starting point of the bridge.

destination

The fully qualified point name of the destination, or ending point of the bridge.

flags

A bitwise combination of:

`1`	Forward bridge: bridge from source to destination
`2`	Inverse bridge: bridge from destination to source
`16`	Clamp output to the minimum. (Range mapping only.)
`32`	Clamp output to the maximum. (Range mapping only.)
`256`	The bridge is a direct copy
`512`	The bridge uses a linear transformation
`1024`	The bridge uses range mapping
`4096`	The bridge is disabled

Bits `256`, `512` and `1024` are mutually exclusive.

multiply

The multiplier value for a linear transformation. This is ignored if `(flags & 512) == 0`.

add

The adder value for a linear transformation. This is ignored if `(flags & 512) == 0`.

srcmin

The minimum range map value for the source point. This is ignored if `(flags & 1024) == 0`.

srcmax

The maximum range map value for the source point. This is ignored if `(flags &`

`1024) == 0`.

`dstmin`

The minimum range map value for the destination point. This is ignored if `(flags & 1024) == 0`.

`dstmax`

The maximum range map value for the destination point. This is ignored if `(flags & 1024) == 0`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a bridge between two data points so that a change to the value of one point automatically propagates to the other point. The scaling and the limits on source and destination points used for linear transformations are stored with the bridge so that if you decide to change from a direct bridge to one that uses linear transformations your previous entries are preserved. The values themselves are only applied when the flag set indicates the corresponding transfer function.

bridge_remove

bridge_remove — deletes a bridge.

Synopsis

```
(bridge_remove source destination)
```

Arguments

`source`
: A string containing the fully qualified point name of the source, or starting point of the bridge.

`destination`
: A string containing the fully qualified point name of the destination, or ending point of the bridge.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command permanently deletes a bridge. The *`source`* and *`destination`* names must be fully qualified, specifying the domain and point name, as in "*`domain`*`:`*`pointname`*".

bridge_remove_pattern

bridge_remove_pattern — deletes all bridges that match a pattern.

Synopsis

```
(bridge_remove_pattern source_pattern destination_pattern)
```

Arguments

source_pattern
: A string containing a pattern for the name of the source points of the bridge, such as `"domain1:*"`.

destination_pattern
: A string containing a pattern for the name of the destination points of the bridge, such as `"*:*"`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command permanently deletes all bridges that match a specified pattern. The available patterns are as follows:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

bridge_transform

bridge_transform — modifies an existing bridge.

Synopsis

```
(bridge_transform name
 flags [multiply add [srcmin srcmax dstmin dstmax]])
```

Arguments

name

The name of the bridge.

flags

A bitwise combination of:

`1`	Forward bridge: bridge from source to destination
`2`	Inverse bridge: bridge from destination to source
`16`	Clamp output to the minimum. (Range mapping only.)
`32`	Clamp output to the maximum. (Range mapping only.)
`256`	The bridge is a direct copy
`512`	The bridge uses a linear transformation
`1024`	The bridge uses range mapping
`4096`	The bridge is disabled

Bits `256`, `512` and `1024` are mutually exclusive.

multiply

The multiplier value for a linear transformation. This is ignored if `(flags & 512) == 0`.

add

The adder value for a linear transformation. This is ignored if `(flags & 512) == 0`.

srcmin

The minimum range map value for the source point. This is ignored if `(flags & 1024) == 0`.

srcmax

The maximum range map value for the source point. This is ignored if `(flags & 1024) == 0`.

dstmin

The minimum range map value for the destination point. This is ignored if `(flags & 1024) == 0`.

dstmax

The maximum range map value for the destination point. This is ignored if `(flags & 1024) == 0`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command modifies an existing bridge between two data points. The scaling and the limits on source and destination points used for linear transformations are stored with the bridge so that if you decide to change from a direct bridge to one that uses linear transformations your previous entries are preserved. The values themselves are only applied when the flag set indicates the corresponding transfer function.

cforce

cforce — creates a point and forces a value to be written to it.

Synopsis

```
(cforce name value [confidence])
```

Arguments

name
: The name of the point. This is a string.

value
: A string representation of the value for the point. It will be interpreted into the type specified by the type parameter.

value
: A string representation of the value for the point. The point value will be interpreted as integer, float or string based on the contents of the value string. This function tries each type in order, and uses the first type for which the value parameter is a valid representation. Double quotes around the value parameter are ignored. For example:

- `123` is an integer.
- `123.4` is a float.
- `1.234e2` is a float.
- `"123"` is an integer.
- `123abc` is a string.

All strings can be surrounded by double-quotes if the string contains spaces or special characters. The backslash character (\) escapes double quotes and backslashes within the string. Newline, carriage return, form feed and tab are represented with `\n`, `\r`, `\f`, `\t` respectively. Strings must not contain newline characters.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is the same as **cset**, except that it forces a write even if the DataHub instance would otherwise refuse it, for example if the point is old, the value is insignificant or hasn't changed, or the point is marked as read-only. When this value is set, the following attributes of the point are set as follows:

- `seconds` and `nanoseconds` are set to the current time on the machine running the

DataHub instance.

- `locked`, `sec`, and `quality` are all maintained at their previous values for this point.
- `flags` is set to `0`.

Please refer to the **write** command for more information about these parameters. See also **set** and **force**.

cread

cread — creates and reads a point.

Synopsis

```
(cread name)
```

Arguments

name
The name of the point.

Returns

The complete point definition in a message, with this syntax:

```
(point name type value
 [conf security locked seconds nanoseconds flags quality])
```

where:

name
The name of the point.

type
The data type of the point, one of integer, floating point, or character string.

value
The value of the point.

conf
The confidence level of the point, `0` - `100` percent, unused by most applications.

security
The security level of the point, `0` to `32768`, where higher numbers represent higher security.

locked
`0` for locked, or `1` for unlocked.

seconds
The operating system time in seconds when the point was read.

nanoseconds
The number of nanoseconds after *seconds* when the point was read.

flags
User-defined flags.

quality

A constant representing a quality of the connection, assigned by the DataHub instance for this point, such as `Good`, `Bad`, `Last known`, `Local override`, etc. The possible values are those supported by OPC in Microsoft Windows.

Description

This command creates a point and then reads the information it contains. See also **read**.

create

create — creates a new point.

Synopsis

```
(create name [0|1])
```

Arguments

name

The name of the point, as a string.

`0|1`

Tells **create** what to do if a point already exists with that name. Use `1` to ignore an existing point and do nothing. Use `0` to have **create** throw an error. If nothing is entered, the default is `0`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a new point in a DataHub instance. Normally it is not necessary to create points manually—the DataHub instance creates a new point any time a program sends one. However, this command is useful for creating points programmatically from within the DataHub instance. See also cset.

Example

Using the Gamma datahub_command function, you could pass a `create` command to a DataHub instance as follows to create `MyNewPoint` in the `default` domain, and assign it a value of `1`.

```
datahub_command ("(create default:MyNewPoint)", 1);
```

create_domain

create_domain — creates a new domain.

Synopsis

```
(create_domain name)
```

Arguments

name
The name of the domain, as a string.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a new domain in a DataHub instance. This corresponds to using the **Add** button in the Domains section in the General option of the Properties window.

creport

creport — creates a point and requests notification of changes.

Synopsis

```
(creport name)
```

Arguments

The name of the data point to be created.

Returns

A message with the complete definition of the point.

Description

This command creates a data point and then requests a DataHub instance to report changes (also called exceptions) to the value or any other information about the point, as soon as any change takes place. See **report** for more details.

cset

cset — creates a point and assigns it a value.

Synopsis

```
(cset name value [confidence])
```

Arguments

name

The name of the point. This is a string.

value

A string representation of the value for the point. The point value will be interpreted as integer, float or string based on the contents of the value string. This function tries each type in order, and uses the first type for which the value parameter is a valid representation. Double quotes around the value parameter are ignored. For example:

- `123` is an integer.
- `123.4` is a float.
- `1.234e2` is a float.
- `"123"` is an integer.
- `123abc` is a string.

confidence

A confidence factor in the range of `0` to `100` (optional). This is not used by the DataHub program, so is available to programs that produce graduated confidence, such as expert systems. If this value is not specified, it is set to `100`.

All strings can be surrounded by double-quotes if the string contains spaces or special characters. The backslash character (\) escapes double quotes and backslashes within the string. Newline, carriage return, form feed and tab are represented with `\n`, `\r`, `\f`, `\t` respectively. Strings must not contain newline characters.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This is a convenience command that combines **create** and **set**, allowing you to create a point and set its value in a single command. If the point already exists, **cset** will simply set the value. When this value is set, the following attributes of the point are set as follows:

- `seconds` and `nanoseconds` are set to the current time on the machine running the

DataHub instance.

- `locked`, `sec`, and `quality` are all maintained at their previous values for this point.
- `flags` is set to `0`.

Please refer to the **write** command for more information about these parameters. See also **set**, **force**, and **cforce**.

cwrite

cwrite — creates a point and writes information to it.

Synopsis

```
(cwrite name type value conf sec locked seconds nanoseconds
 [flags quality])
```

Arguments

name
: The name of the point. This is a string.

type
: The type of point. One of

- `0` = string
- `1` = float (8-byte double)
- `2` = integer (32-bit integer)

value
: A string representation of the value for the point. It will be interpreted into the type specified by the *type* parameter.

conf
: A confidence factor in the range of `0` to `100`. This is not used by the DataHub program, so is available to programs that produce graduated confidence, such as expert systems.

sec
: A security level for this point. This is rarely used. If a point's security level is set to a non-zero value then attempts to write to that point must claim a security level equal to or greater than the security level of the point. This uses a "good citizen" model - the writer can claim any security it wants, and is assumed to be honest - so there is no strong security here. It is intended for systems that want to avoid accidental changes to values. Security level can be from `0` to `32767`.

locked
: An indication that the point is locked, and cannot be changed. Can be `0` or `1`. Attempts to write to a locked point will fail.

seconds
: The UNIX epoch - seconds since Jan. 1, 1970, as produced by the `time()` function.

nanoseconds
: The number of nanoseconds inside this second. Cannot exceed `1,000,000,000`.

flags

User level code should always send a `0` for this value.

quality

A quality indicator consistent with the OPC DA specification. This is not a bit field. It can be one of:

PT_QUALITY_BAD	0
PT_QUALITY_UNCERTAIN	0x40
PT_QUALITY_GOOD	0xc0
PT_QUALITY_CONFIG_ERROR	0x04
PT_QUALITY_NOT_CONNECTED	0x08
PT_QUALITY_DEVICE_FAILURE	0x0c
PT_QUALITY_SENSOR_FAILURE	0x10
PT_QUALITY_LAST_KNOWN	0x14
PT_QUALITY_COMM_FAILURE	0x18
PT_QUALITY_OUT_OF_SERVICE	0x1c
PT_QUALITY_WAITING_FOR_INITIAL_DATA	0x20
PT_QUALITY_LAST_USABLE	0x44
PT_QUALITY_SENSOR_CAL	0x50
PT_QUALITY_EGU_EXCEEDED	0x54
PT_QUALITY_SUB_NORMAL	0x58
PT_QUALITY_LOCAL_OVERRIDE	0xd8

All strings can be surrounded by double-quotes if the string contains spaces or special characters. The backslash character (`\`) escapes double quotes and backslashes within the string. Newline, carriage return, form feed and tab are represented with `\n`, `\r`, `\f`, `\t` respectively. Strings must not contain newline characters.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you manually write information to a point. If the point does not exist, the point is automatically created and the value is written. This command is identical to the **write** command, except that **write** will produce an error if the point does not exist.

DDEAdvise

DDEAdvise — sets up the item for a DDEAdvise connection.

Synopsis

```
(DDEAdvise label item pointname [domain])
```

Arguments

label
: A string that identifies the connection for this item.

item
: The item name, as a string

pointname
: The name of the point with which the *item* is associated, as a string.

domain
: The domain of the point. If unspecified, it defaults to the `default` domain.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command supports a DDEAdvise connection. It associates a DDE item with a point and domain, as well as the label used by the item's service and topic (see **DDEConnect**). This command is used when you add or edit connections in the DDE option of the Properties window. For more information on DDE connections, please see Appendix G, *DDE Overview*.

DDEConnect

DDEConnect — makes a connection to a DDE service and topic.

Synopsis

```
(DDEConnect label service topic [retry_sec])
```

Arguments

label
: A string that identifies this connection.

service
: The DDE service name, as a string

topic
: The DDE topic, as a string.

retry_sec
: The time interval, in seconds, that the connection should be retried in case of a disconnect or network failure.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command establishes a connection to a DDE service and topic, and names the connection. The point or points that use this connection are defined by the **DDEAdvise** command. Both of these commands are used when you add or edit connections in the DDE option of the Properties window. For more information on DDE connections, please see Appendix G, *DDE Overview*.

DDEDisconnect

DDEDisconnect — disconnects and discards a DDE connection.

Synopsis

```
(DDEDisconnect label)
```

Arguments

label

A label identifying a connection, as assigned by the **DDEConnect** command.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command disconnects and discards a DDE connection that had been previously established by the **DDEConnect** command.

DDEExcelUnicode

DDEExcelUnicode — accepts Unicode characters in strings in Excel.

Synopsis

```
(DDEExcelUnicode 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of the a DataHub instance to function properly with Unicode characters in strings in Excel. This corresponds to the **Accept non-English characters in Excel strings (slower)** checkbox in the DDE option of the Properties window.

DDEInit

DDEInit — initializes the a DataHub instance to act as a DDE server.

Synopsis

```
(DDEInit)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command instructs a DataHub instance to act as a DDE server. Service names are assigned using the **DDEService** command.

DDEService

DDEService — assigns a DDE service name.

Synopsis

```
(DDEService service)
```

Arguments

service
A DDE service name for the DataHub instance, as a string.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command assigns a DDE service name to a DataHub instance. It is possible to use several names simultaneously. This command is used when adding service names to the DataHub instance in the DDE option of the Properties window. Also see **DDEInit**.

DDEUnadvise

DDEUnadvise — removes an item from a DDE connection.

Synopsis

```
(DDEUnadvise label item)
```

Arguments

label
: A label identifying a connection, as assigned by the **DDEConnect** command.

item
: The DDE item name of the point you wish to stop advising on.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command essentially undoes the **DDEAdvise** command, removing an item from a DDE connection.

DDEUnadvisePattern

DDEUnadvisePattern — removes multiple items from a DDE connection.

Synopsis

```
(DDEUnadvisePattern label pattern)
```

Arguments

label

A label identifying a connection, as assigned by the **DDEConnect** command.

pattern

A pattern that matches the DDE item names of the points you wish to stop advising on.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command undoes the **DDEAdvise** command for a group of points that match the *pattern*, removing those items from a DDE connection. The available patterns are as follows:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

DDEUnadvisePoint

DDEUnadvisePoint — removes an item from a DDE connection, by its point name.

Synopsis

```
(DDEUnadvisePoint label pointname)
```

Arguments

label
: A label identifying a connection, as assigned by the**DDEConnect**.

point
: The point name corresponding to the DDE item you wish to stop advising on.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command essentially undoes the **DDEAdvise** command, removing an item from a DDE connection.

debug

debug — sets the debug level.

Synopsis

```
(debug debug_level)
```

Arguments

debug_level
An integer from 0 to 4 specifying the debug level.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you specify the level of detail of debugging, from the least (0) to the most (4).

defaultprop

defaultprop — sets a default type for a property.

Synopsis

```
(defaultprop domain type propname)
```

Arguments

domain
: The domain name of the property whose default type will be set.

type
: The default type for this property, as a string.

propname
: The name of the property, as a string.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets a default type for a property on a given domain. For more information and an example, please refer to the section called “Assemblies, Subassemblies, Attributes, and Properties”.

delete

delete — deletes a point—use with caution.

Synopsis

```
(delete pointname [domain])
```

Arguments

pointname

The name of the point to delete, as a string.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

Deleting points with this command could cause unexpected behavior for other users of the point.

This command allows you to delete points from a DataHub instance. You should exercise caution when using it, however, because any program connected to the DataHub instance now or in the future might be relying on the existence of that point. We suggest you use this command only after ensuring that no connecting program uses that point.

div

div — does division on the value of a point.

Synopsis

```
(append name number [secs] [nano])
```

Arguments

name
: The name of a point, which must be a number type.

number
: A value to divide the value of the point by.

secs
: The time in seconds. If this is not specified, the current date and time in seconds is used.

nano
: A fraction of a second, in nanoseconds. If this is not specified, the number of nanoseconds past the current date and time is used.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used to divide to the value of a point.

domain

domain — identifies the client domain name.

Synopsis

```
(domain domain_name)
```

Arguments

domain_name
The name of the domain.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command identifies to a DataHub instance the domain that the client is using.

domain_bridge

domain_bridge — configures a redundancy set.

Synopsis

```
(domain_bridge label src1 src2 dst flags switchflags point quality
 value  statepoint controlpoint statuspoint1 statuspoint2
 [fill_delay_ms])
```

Arguments

Many of these parameters correspond to a similarly named entry field or checkbox in the Configure Redundancy dialog options in the Redundancy option of the Properties window. The names that appear in that dialog are shown here in parentheses.

label
: A label for this redundancy set, as a string. (**Label:**)

src1
: The domain for the first data source, as a string. (**Source Domain 1:**)

src2
: The domain for the second data source, as a string. (**Source Domain 2:**)

dst
: The name of the domain that will contain the output. (**Output Domain**)

flags
: are not yet documented.

switchflags
: are not yet documented.

point
: The name of a point which will be used in comparisons. (**For this point**)

quality
: The quality of the data which will be used in comparisons, as a number. The valid numbers and corresponding qualities can be found in **quality** . (**Data quality is:**)

value
: The value of the data which will be used in comparisons, as a number. (**Data value is:**)

statepoint
: The name of a point that will be used to indicate which data source is currently being used. (**Point for current source number:**)

controlpoint
: The name of a point that will be used to indicate which data source is preferred.

(**Point for preferred source number:**)

statuspoint1

The name of a point that will be used to indicate the current status of the first data domain. (**Point for the current state of domain 1:**)

statuspoint2

The name of a point that will be used to indicate the current status of the second data domain. (**Point for the current state of domain 2:**)

`fill_delay_ms`

The number of seconds to wait before switching domains if the data flow detection is activated.**(Switch sources if data stops for:**)

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command configures a DataHub redundancy set. It corresponds to the **Configure Redundancy** dialog options in the Redundancy option of the Properties window.

domain_bridge_enable

domain_bridge_enable — enables or disables the Redundancy feature.

Synopsis

```
(domain_bridge_enable label [enabled])
```

Arguments

label
: The label of the redundant connection, as seen in the in the Redundancy option of the Properties window.

enabled
: A value of `1` enables the capability, `0` disables it. The default value is `1`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the DataHub Redundancy feature. It corresponds to the **Redundancy** checkbox in the Redundancy option of the Properties window.

domain_bridge_prefer

domain_bridge_prefer — specifies a preferred source for a Redundancy connection.

Synopsis

```
(domain_bridge_prefer label [index])
```

Arguments

label
: The label of the redundant connection, as seen in the in the Redundancy option of the Properties window.

index
: a value of 1 specifies **Source Domain 1**, while a value of 2 specifies **Source Domain 2**. The default value is 1.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command specifies a preferred source for a Redundancy connection. It corresponds to the **Preferred source** checkboxes in the Configure Redundancy option of the Properties window.

domain_bridge_refresh

domain_bridge_refresh — refreshes a Redundancy connection.

Synopsis

```
(domain_bridge_refresh label)
```

Arguments

label
: The label of the redundant connection, as seen in the in the Redundancy option of the Properties window.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command refreshes a Redundancy connection, typically after reconfiguration.

domain_bridge_remove

domain_bridge_remove — removes a Redundancy connection.

Synopsis

```
(domain_bridge_remove label)
```

Arguments

label

The label of the redundant connection to remove, as seen in the in the Redundancy option of the Properties window.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command removes a configured Redundancy connection. It corresponds to clicking the **Remove** button for the selected label in the Redundancy option of the Properties window.

domains

domains — lists all domains in a DataHub instance.

Synopsis

```
(domains)
```

Arguments

none

Returns

On success, a message with the following syntax:

```
(domains "default" "domain1" "domain2" "domain3" ...)
```

the following syntax. On error, an error message as described inReturn Syntax.

Description

This command generates a response message listing all of the domains currently in a DataHub instance. The response message is different from the usual DataHub command return syntax, in that it doesn't contain the string `success` on success.

dump

dump — writes the entire content of a DataHub instance to a file.

Synopsis

```
(dump filename)
```

Arguments

filename
The name of the file to write to.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command dumps the contents of a DataHub instance to a file. The results are listed by domain, data types, and assemblies.

Example

You can create a dump of the DataHub instance's current point list by issuing this command in the Script Log entry field:

```
datahub_command("(dump \"c:/temp/datahub.dump\")", 1)
```

enable_bridging

enable_bridging — enables or disables bridging capabilities.

Synopsis

```
(enable_bridging 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of a DataHub instance to support bridging.

See Also

bridge

enable_dde_client

enable_dde_client — enables or disables DDE client capabilities.

Synopsis

```
(enable_dde_client 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of a DataHub instance to act as a DDE client. This corresponds to the **Act as a DDE client...** checkbox in the DDE option of the Properties window.

enable_dde_server

enable_dde_server — enables or disables DDE server capabilities.

Synopsis

```
(enable_dde_server 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of a DataHub instance to act as a DDE server. This corresponds to the **Act as a DDE server...** checkbox in the DDE option of the Properties window.

enable_domain_bridging

enable_domain_bridging — enables or disables domain bridging capabilities.

Synopsis

```
(enable_domain_bridging 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command has not yet been documented.

enable_opc_client

enable_opc_client — enables or disables OPC client capabilities.

Synopsis

```
(enable_opc_client 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of a DataHub instance to act as an OPC client. This corresponds to the **Act as an OPC Client...** checkbox in the OPC option of the Properties window.

enable_opc_server

enable_opc_server — enables or disables OPC server capabilities.

Synopsis

```
(enable_opc_server 0|1)
```

Arguments

`0|1`

`1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of a DataHub instance to act as an OPC server. This corresponds to the **Act as an OPC Server.** checkbox in the OPC option of the Properties window.

enable_scripting

enable_scripting — enables or disables scripting capabilities

Synopsis

```
(enable_scripting 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables the capability of a DataHub instance to support scripting.

error

error — sends an error with an error string.

Synopsis

```
(error errstring)
```

Arguments

`errstring`
: a string containing an error message.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sends an error to a DataHub instance, which it displays in the Event Log, along with the message from the *`errstring`*.

execute_plugin

execute_plugin — executes a plugin. (*experimental*)

Synopsis

```
(execute_plugin plugin_name)
```

Arguments

plugin_name
The name of a plugin.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you instruct a DataHub instance to execute a plugin.

The commands related to plugins are currently experimental.

exit

exit — shuts down a DataHub instance.

Synopsis

```
(exit [exit_status])
```

Arguments

exit_status
An optional string to describe the circumstances of the shut-down.

Returns

A message containing the *exit_status* message.

Description

This command closes a DataHub instance and all associated windows.

ExternalHistorianAddPoint

ExternalHistorianAddPoint — adds a data point for this historian connection.

Synopsis

```
(ExternalHistorianAddPoint label pointname)
```

Arguments

label

The label for this historian connection.

pointname

The full name of the point to add, as a string, including the *domain*: prefix.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command adds a data point to the list of points being stored by this historian connection. The point name must be fully qualified, including the *domain*: prefix.

ExternalHistorianApplyEdit

ExternalHistorianApplyEdit — applies edits made to the temporary copy of the configuration.

Synopsis

```
(ExternalHistorianApplyEdit)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command applies the edits made to the temporary copy of the configuration created by **ExternalHistorianBeginEdit** to the currently active configuration. This command deletes the temporary configuration copy, and all subsequent **ExternalHistorian*** commands will fail until **ExternalHistorianBeginEdit** is called again.

ExternalHistorianBeginEdit

ExternalHistorianBeginEdit — creates a temporary copy of the configuration for editing.

Synopsis

```
(ExternalHistorianBeginEdit)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a temporary copy of the current configuration. Subsequent **ExternalHistorian*** commands will be executed on this temporary copy.

ExternalHistorianCancelEdit

ExternalHistorianCancelEdit — deletes the temporary configuration and all edits made to it.

Synopsis

```
(ExternalHistorianCancelEdit)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command abandons any edits made to the temporary copy of the configuration. This command deletes the temporary configuration copy and all subsequent **ExternalHistorian*** commands will fail until **ExternalHistorianBeginEdit** is called again.

ExternalHistorianEnable

ExternalHistorianEnable — enables or disables external historian connections.

Synopsis

```
(ExternalHistorianEnable labelPattern 0|1)
```

Arguments

labelPattern
: A globbing pattern that matches all connections to be enabled or disabled, according to the matching rules in `shell_match`.

0|1
: `0` disables the connections, `1` enables them.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables zero or more external historian connections. The *labelPattern* is compared to each configured historian connection label, and all connections matching the pattern are modified. The *labelPattern* is a globbing pattern, not a regular expression. The pattern of asterisk character (*) matches all connections. See the matching rules in `shell_match` for the globbing pattern rules. If the second argument is `0`, all matching connections are disabled, otherwise the connections are enabled.

ExternalHistorianGet

ExternalHistorianGet — gets the value of a historian configuration option.

Synopsis

```
(ExternalHistorianGet label settingName)
```

Arguments

label
: The label for this historian connection.

settingName
: The name of the configuration option whose value is to be retrieved.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command retrieves the value of a setting for this historian connection option. These settings are dependent on the historian connection type, and can be identified in the `plugin_GeneralHistorian.cfg` file, typically located here:

`C:\Users\Username\AppData\Roaming\Cogent DataHub\plugin_GeneralHistorian.cfg`

Each setting is represented by a `<Properties>` entry, where the `<Name>` tag identifies the specific setting, and is used as the *settingName* for this command. Non-numeric values will be represented as strings.

ExternalHistorianRemovePoint

ExternalHistorianRemovePoint — removes a data point from a historian connection.

Synopsis

```
(ExternalHistorianRemovePoint label pointname)
```

Arguments

label
: The label for this historian connection.

pointname
: The full name of the point to remove, as a string, including the *domain*: prefix.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command removes a data point from the list of points stored by this historian connection. The point name must be fully qualified, including the *domain*: prefix.

ExternalHistorianSet

ExternalHistorianSet — sets the value of a historian configuration option.

Synopsis

```
(ExternalHistorianSet label settingName value)
```

Arguments

label
The label for this historian connection.

settingName
The name of the configuration setting whose value is to be retrieved.

value
The new value for this setting.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets the value of a option setting for this historian connection. See **ExternalHistorianGet** for more information.

force

force — forces a write to a point.

Synopsis

```
(force name value [confidence])
```

Arguments

name

The name of the point. This is a string.

value

A string representation of the value for the point. The point value will be interpreted as integer, float or string based on the contents of the value string. This function tries each type in order, and uses the first type for which the value parameter is a valid representation. Double quotes around the value parameter are ignored. For example:

- `123` is an integer.
- `123.4` is a float.
- `1.234e2` is a float.
- `"123"` is an integer.
- `123abc` is a string.

confidence

A confidence factor in the range of `0` to `100` (optional). This is not used by the DataHub instance, so is available to programs that produce graduated confidence, such as expert systems. If this value is not specified, it is set to `100`.

All strings can be surrounded by double-quotes if the string contains spaces or special characters. The backslash character (\) escapes double quotes and backslashes within the string. Newline, carriage return, form feed and tab are represented with `\n`, `\r`, `\f`, `\t` respectively. Strings must not contain newline characters.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is the same as **set**, except that it forces a write even if the DataHub instance; would otherwise refuse it, for example if the point is old, the value is insignificant or hasn't changed, or the point is marked as read-only. When this value is set, the following attributes of the point are set as follows:

- `seconds` and `nanoseconds` are set to the current time on the machine running the DataHub instance.
- `locked`, `sec`, and `quality` are all maintained at their previous values for this point.
- `flags` is set to `0`.

Please refer to the **write** command for more information about these parameters. See also **set** and **cforce**.

format

format — is an efficiency enhancement for Linux.

Synopsis

```
(format flag)
```

Arguments

flag

One of the following flags:

- `1` turns on the behavior.
- `0` turns off the behavior.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is an efficiency enhancement for Linux, for SRR Module connections only. It tells a DataHub instance that this client would like to get point exceptions in binary instead of ASCII encoding. It is more CPU efficient but does not work well in a heterogeneous network.

get_client_stats

get_client_stats — provides statistics for all clients.

Synopsis

```
(get_client_stats [label_pattern])
```

Arguments

label_pattern

Not yet documented.

Returns

A list containing each client of a DataHub instance, and its associated statistics.

Description

This command generates a list of DataHub clients, along with their statistics in Lisp format. The statistics in the list correspond to the statistics displayed in the Connection Viewer.

Example

```
--> pretty_princ(datahub_command ("(get_client_stats)", 1));
("get_client_stats" (
   ("" "Gamma Scripting Engine" "Gamma Scripting Engine" "" "" ""
     ((PointsIn 0)(PointsOut 4)(ConnectOk 0)(ConnectFail 0)
      (Disconnect 0)(Block 0)(Unblock 0)(PointsCreate 0)
      (PointsRead 0)(PointsRegister 2)(PointsUnregister 0)
      (CmdInvalid 0)(CmdFailed 0)(PointsDropped 0)(QueueSize 0)))
   ("" "TCP Outgoing" "Outgoing plain text to
     developers.cogentrts.com:4502 into domain test" "Running" "" ""
     ((PointsIn 88495)(PointsOut 0)(ConnectOk 0)(ConnectFail 0)
      (Disconnect 0)(Block 0)(Unblock 0)(PointsCreate 11)
      (PointsRead 0)(PointsRegister 0)(PointsUnregister 0)
      (CmdInvalid 0)(CmdFailed 0)(PointsDropped 0)(QueueSize 0)))
   ("" "Mainline" "Mainline" "" "" ""
     ((PointsIn 0)(PointsOut 0)(ConnectOk 0)(ConnectFail 0)
      (Disconnect 0)(Block 0)(Unblock 0)(PointsCreate 4)
      (PointsRead 0)(PointsRegister 0)(PointsUnregister 0)
      (CmdInvalid 0)(CmdFailed 0)(PointsDropped 0)(QueueSize 0)))
   ("" "OPCAE" "OPC A&E Server: 0 client connections" "" "" ""
     ((PointsIn 0)(PointsOut 9)(ConnectOk 0)(ConnectFail 0)
```

```
      (Disconnect 0)(Block 0)(Unblock 0)(PointsCreate 0)
      (PointsRead 0)(PointsRegister 16)(PointsUnregister 0)
      (CmdInvalid 0)(CmdFailed 0)(PointsDropped 0)(QueueSize 0)))
 ))
t
```

heartbeat

heartbeat — establishes a heartbeat message.

Synopsis

```
(heartbeat ms)
```

Arguments

ms

The number of milliseconds between each pulse.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command establishes a heartbeat message that verifies the connection every *ms* milliseconds. The heartbeat is sent from the DataHub instance to the client.

HistorianAdd

HistorianAdd — adds a point to a Historian group.

Synopsis

```
(HistorianAdd point [grouplabel])
```

Arguments

point
: The name of the point to be added.

grouplabel
: The name of the Historian group to which the point will be added, such as `HIST000`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command adds a point to the specified Historian group, which corresponds to adding a point using the **Configure Historical Data Capture** interface in the Historian option of the Properties window.

HistorianFlags

HistorianFlags — is new, not yet documented.

Synopsis

```
(HistorianFlags flags)
```

Description

This command has not yet been documented.

HistorianRemove

HistorianRemove — removes points.

Synopsis

```
(HistorianRemove point_pattern [group_pattern])
```

Arguments

point_pattern
: A pattern that matches one or more names of the points to be removed.

group_pattern
: A pattern that matches names of Historian groups, to select the groups from which points will be removed, such as `HIST0`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command deletes histories for selected points in selected groups. It corresponds to unchecking the box associated with the *point_pattern* in the Historian option of the Properties window.

HistorianSaveConfig

HistorianSaveConfig — saves the configuration of the Historian.

Synopsis

```
(HistorianSaveConfig)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command saves the configuration of the Historian.

HistorianSetConfiguring

HistorianSetConfiguring — sets the Historian status to "Configuring".

Synopsis

```
(HistorianSetConfiguring 0|1)
```

Arguments

`0|1`
: `1` sets the Historian status to "Configuring", `0` releases it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets the Historian status to "Configuring", or releases it. There is no corresponding item in the Historian option of the Properties window for this.

HistoryGroupAdd

HistoryGroupAdd — adds a new history group.

Synopsis

```
(HistoryGroupAdd group_label basedir extension cachesize flags)
```

Arguments

group_label
: The label for the group, such as `HIST000`.

basedir
: The name of the base directory for the group, where history files will be stored.

extension
: A filename extension for the history files.

cachesize
: The size of the in-memory cache, which can have an impact on the speed of data recall.

flags
: Not yet documented.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command adds a new history group. Its parameters correspond to the **Group Configuration** options in the Configure Historical Data Capture dialog of the Historian option of the Properties window.

HistoryGroupAddPoint

HistoryGroupAddPoint — adds a point to a Historian group.

Synopsis

```
(HistoryGroupAddPoint group_label pointname)
```

Arguments

group_label
The label for the group, such as `HIST000`.

pointname
The name of the point to be added.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command adds a point to a Historian group. This corresponds to adding points in the Configure Historical Data Capture dialog of the Historian option of the Properties window.

HistoryGroupDeadband

HistoryGroupDeadband — sets a deadband for a Historian group.

Synopsis

```
(HistoryGroupDeadband group_pattern
 flags absolute percent maxsecs maxcount)
```

Arguments

group_pattern
: A pattern to match one or more groups, such as `HIST`.

flags
: Not yet documented.

absolute
: Sets the deadband range to a single value.

percent
: Sets the deadband range to be a percent of the last logged data value.

maxsecs
: Sets the maximum time period (in seconds, a real number) to deadband.

maxcount
: Sets a maximum number of values to skip for the deadband.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets a deadband for a Historian group. This corresponds to the **Deadband** options in the Historian option of the Properties window. Please refer to that section of the documentation for more details about the deadband options.

HistoryGroupDefault

HistoryGroupDefault — sets a default group.

Synopsis

```
(HistoryGroupDefault label)
```

Arguments

label
The label for the group, such as HIST000.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets a default group, to which all new requests are automatically assigned, if not specified otherwise. This corresponds to checking the **Automatically assign new requests to this group** checkbox in the Historian option of the Properties window.

HistoryGroupFileTimes

HistoryGroupFileTimes — sets a frequency for changing history files.

Synopsis

```
(HistoryGroupFileTimes group_pattern days hours minutes)
```

Arguments

group_pattern
: A pattern to match one or more groups, such as `HIST`.

days
: The number of days between file changes. Enter `0` to ignore this parameter.

hours
: The number of hours between file changes. Enter `0` to ignore this parameter.

minutes
: The number of minutes between file changes. Enter `0` to ignore this parameter.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets a frequency for changing history files. This corresponds to the **Change file every** option in the Configure Historical Data Capture dialog of the Historian option of the Properties window.

HistoryGroupFlushTimes

HistoryGroupFlushTimes — specifies how frequently to flush history data to disk.

Synopsis

```
(HistoryGroupFlushTimes group_pattern days hours minutes)
```

Arguments

group_pattern
: A pattern to match one or more groups, such as `HIST`.

days
: The number of days between disk writes. Enter `0` to ignore this parameter.

hours
: The number of hours between disk writes. Enter `0` to ignore this parameter.

minutes
: The number of minutes between disk writes. Enter `0` to ignore this parameter.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command specifies how frequently to flush history data to disk. This corresponds to the **Flush to disk every** option in the Configure Historical Data Capture dialog of the Historian option of the Properties window.

HistoryGroupRemove

HistoryGroupRemove — removes a group and all of its histories.

Synopsis

```
(HistoryGroupRemove group_pattern)
```

Arguments

group_pattern
A pattern to match one or more groups, such as `HIST`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command removes a group and all of its histories. This corresponds to the **Remove** button in the Historian option of the Properties window.

HistoryGroupStorageTimes

HistoryGroupStorageTimes — specifies how long to keep data in a history.

Synopsis

```
(HistoryGroupStorageTimes group_pattern days hours minutes)
```

Arguments

group_pattern
: A pattern to match one or more groups, such as `HIST`.

days
: The number of days to store data. Enter `0` to ignore this parameter.

hours
: The number of hours to store data. Enter `0` to ignore this parameter.

minutes
: The number of minutes to store data. Enter `0` to ignore this parameter.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command specifies how long to keep data in a history. This corresponds to the **Keep data for** option in the Configure Historical Data Capture dialog of the Historian option of the Properties window.

ignore

ignore — ignores a given point.

Synopsis

```
(ignore pointname)
```

Arguments

pointname
The name of the point to be ignored.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command tells a DataHub instance to ignore changes in value to the point *pointname*.

ignore_old_data

ignore_old_data — ignores changes with an old timestamp.

Synopsis

```
(ignore_old_data 0|1)
```

Arguments

`0|1`

Use `1` to ignore old data, or `0` to not ignore old data.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command instructs a DataHub instance to ignore any changes to data that arrive with an old timestamp. This corresponds to the **Do not transmit changes with an old timestamp** checkbox in the General option of the Properties window.

include

include — includes a file in with configuration files.

Synopsis

```
(include filename [enabled] [as-sender-0|1])
```

Arguments

filename
: The name of the configuration file to include.

enabled
: One of the following flags indicating the enabled state.

- `1` means enabled; it will be used immediately after loading.
- `0` means disabled; it will be loaded but not used.

`as-sender-0|1`
: Not yet documented.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command includes a file with configuration files. It can be used in a configuration file itself, causing the included file to be inserted into the configuration file at the point of this command. Or it can be sent to the DataHub instance by another program. The *enabled* parameter puts the file into the enabled state, meaning that it is loaded and then immediately used. With that parameter turned off, the file is simply added to the DataHub instance's list of configuration files.

instance

instance — creates an instance of a data organization model.

Synopsis

```
(instance domain pointname assemblyname)
```

Arguments

domain
: The domain of the model.

pointname
: A name for the instance.

assemblyname
: The assembly associated with the model.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates an instance of a data organization model, based on a given domain and assembly. For more information and an example, please refer to the section called “Data Organization”.

load_config_files

load_config_files — loads configuration files.

Synopsis

```
(load_config_files 0|1)
```

Arguments

`0|1`

Use `1` to have configuration files loaded, or `0` to not have them loaded.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you instruct a DataHub instance to load or not load its configuration files.

load_plugin

load_plugin — loads a specified plugin. (*experimental*)

Synopsis

```
(load_plugin plugin_name run_now)
```

Arguments

plugin_name
The name of a plugin.

run_now
One of the following flags:

- `1` means the plugin will run immediately after it is loaded.
- `0` means disabled; the plugin will be loaded but not run.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you instruct a DataHub instance to load a plugin.

The commands related to plugins are currently experimental.

load_scripts

load_scripts — loads scripts.

Synopsis

```
(load_scripts filename enabled)
```

Arguments

filename

The name of a script.

enabled

One of the following flags indicating the enabled state.

- `1` means enabled; the script will be run immediately after it is loaded.
- `0` means disabled; the script will be loaded but not run.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you instruct a DataHub instance to load or not load scripts.

lock

lock — locks and unlocks points.

Synopsis

```
(lock name secur 0|1)
```

Arguments

name
: The point name.

secur
: The security level of the point.

`0|1`
: Use `1` to lock the point, or `0` to unlock the point.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command locks and unlocks points. When a point is locked, it cannot be changed until it is unlocked.

log_file

log_file — sets up a log file.

Synopsis

```
(log_file filename)
```

Arguments

logfile
The name of the log file.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets up a log file for messages that appear in the Event Log. If a log file already exists, this command changes that file's name. Starting and stopping logging is done with the **log_to_file** command. If logging to a file is enabled, the log messages will also continue to appear in the Event Log.

log_file_max

log_file_max — sets a size limit for log files.

Synopsis

```
(log_file_max kbytes)
```

Arguments

kbytes
The maximum file size, in kilobytes.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets a size limit for log files, and corresponds to the **Limit** entry field in the Event Log window.

log_to_file

log_to_file — starts or stops logging to a file.

Synopsis

```
(log_to_file 0|1)
```

Arguments

Use `1` to start logging to a file, or `0` to stop.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command starts or stops logging error messages to the log file set up by **log_file**.

mirror_master

mirror_master — sets up a mirroring master.

Synopsis

```
(mirror_master host service localdomain [masterdomain])
```

Arguments

host
: The master host's name or IP address.

service
: The service name or port number of the mirroring master.

localdomain
: The domain of the slave (i.e. local) computer

masterdomain
: The domain of the mirroring master.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is to be sent to the slave DataHub instance in a mirroring relationship. It tells the slave all the information it needs about its connection to the master DataHub instance. This command corresponds to all the entries in the Mirror Master dialog that opens when you click the **Add** button in the Tunnel/Mirror option of the Properties window.

mirror_master_2

mirror_master_2 — sets up a secure mirroring master.

Synopsis

```
(mirror_master_2 host port flags localdomain remotedomain
 heartbeat timeout [username password])
```

Arguments

host
The master host's name or IP address.

port
The port number or service name of the mirroring master.

flags
Any combination of:

Hex	Flag	Notes
0x00000001	USE_SSL	Use an SSL connection.
0x00000002	USE_WEBSOCKET	Use a WebSocket connection.
0x00000004	VALIDATE_SSL	Validate the SSL certificate when making a connection.
0x00000008	VALIDATE_HOST	Validate the SSL certificate against the host name when making a connection.
0x00000010	USE_PROXY	Use a forward proxy when connecting via WebSocket.
0x00000020	USE_HTTP_CONNECT	Use HTTP CONNECT when connecting to a forward proxy.
0x00008000	DISABLED	Client is disabled (and not connected).
0x00010000	USE_BINARY	Send point messages in binary rather than ASCII.
0x00020000	EMBEDDED	Target is an Embedded Toolkit server (ETK).
0x00100000	READABLE	Data is readable from the master. Always set this.
0x00200000	WRITABLE	Data is writable to the master.
0x01000000	SYNC_SEND	On initial connection, send all data to the master
0x02000000	SYNC_RECV	On initial connection, receive all data from

Hex	Flag	Notes
		the master
`0x04000000`	`SYNC_TIME`	On initial connection, synchronize by comparing time stamps.
`0x10000000`	`AUTHORITATIVE`	Master is authoritative. Data here is marked Not Connected when the connection drops.
`0x20000000`	`NON_AUTHORITATIVE`	I am authoritative. Data in the master is marked Not Connected when the connection drops.
`0x40000000`	`OVERRIDE_TIME`	Override the time stamp on incoming data with the system clock time.

Some combinations of flags will generate strange results:

- Combining `WRITABLE` with `OVERRIDE_TIME` will result in pollution of the master's time stamps.
- Only one of `SYNC_SEND`, `SYNC_RECV` and `SYNC_TIME` should be specified.
- Only one of `AUTHORITATIVE` and `NON_AUTHORITATIVE` should be specified.
- If `WRITABLE` is not set, then `SYNC_SEND`, `SYNC_TIME` and `NON_AUTHORITATIVE` make no sense.

`localdomain`

The domain of the slave (i.e. local) computer

`remotedomain`

The domain of the mirroring master.

`heartbeat`

The number of milliseconds for the heartbeat on this connection. `0` means disabled.

`timeout`

The number of milliseconds for the timeout on this connection. `0` means disabled. The timeout should be significantly longer than the heartbeat.

`username`

(optional) The user name to use if authenticating this connection.

`password`

(optional) The password to use if authenticating this connection. This password is stored in obfuscated text to stop somebody from casually copying it. However, since this obfuscation must be reversible to give access to the original password, it does not represent strong security. Do not allow untrusted people access to your configuration file.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is the same as **mirror_master**, but includes the necessary parameters for security. This command is sent to the slave DataHub instance in a mirroring relationship. It tells the slave all the information it needs about its connection to the master DataHub instance. This command corresponds to all the entries in the Mirror Master dialog that opens when you click the **Add** button in the Tunnel/Mirror option of the Properties window.

The **mirror_master_2** command was originally used for setting up tunnel connections in the `Cogent DataHub.cfg` file. When the tunnel code was moved to a separate plug-in (`plugin_TCP.cfg`), the command format was changed, and renamed **master**. Now when the DataHub instance receives a **mirror_master_2** command, it converts it into a **master** command and forwards it to `plugin_TCP.cfg`.

The **master** command is not accessible outside of `plugin_TCP.cfg`. Its syntax is:

```
(master primaryhost primaryport secondaryhost secondaryport
 localdomain remotedomain remoteusername remotepassword flags timeout
 heartbeat retrydelay proxyaddress proxyport proxyusername
 proxypassword)
```

Optional entries that get left blank during configuration are designated by empty quotes (`""`).

ModbusApplySettings

ModbusApplySettings — applies all scripted changes.

Synopsis

```
(ModbusApplySettings)
```

Arguments

None.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used in a script to apply all changes made to Modbus connections. When reconfiguring, you might need to add or remove points, deadbands, etc. These changes don't take effect immediately, they reside temporarily, in memory only. Using the **ModbusApplySettings** command applies your changes. This command affects all edits since the last time you used it, and is roughly equivalent to clicking the **Apply** button in the Modbus option of the Properties window.

ModbusCancelSettings

ModbusCancelSettings — cancels all scripted changes.

Synopsis

```
(ModbusCancelSettings)
```

Arguments

None.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used in a script to cancel all changes made to Modbus connections. When reconfiguring, you might need to add or remove points, deadbands, etc. These changes don't take effect immediately, they reside temporarily, in memory only. Using the **ModbusApplySettings** command cancels your changes. This command affects all edits since the last time you used the **ModbusApplySettings**, and is roughly equivalent to clicking the **Cancel** button in the Modbus option of the Properties window.

ModbusCreateSlave

ModbusCreateSlave — creates a slave connection.

Synopsis

```
(ModbusCreateSlave slaveName hostSpec dataDomain pollMs retryMs
 maxMsgLength slaveId supportedFunctions addressFlags)
```

Arguments

`slaveName`
: Any alphanumeric string identifying this connection.

`hostSpec`
: A list of (`hostType`, `hostName`, `port`) where `hostType` should be `"tcp"`

`dataDomain`
: The data domain into which to write data points.

`pollMs`
: The number of milliseconds in the polling cycle, with a minimum of `10`.

`retryMs`
: The number of milliseconds to wait before retrying after a disconnection, with a minimum of `10`.

`maxMsgLength`
: The maximum length of a message, in bytes, between `20` and `260`.

`slaveId`
: The ID for the slave device. This should match the configuration in the slave.

`supportedFunctions`
: A list of zero or more of `(5, 6, 15, 16, 22).`

`addressFlags`
: A list of zero or more of `("BitOrderReversed", "OneBasedAddressing", "OneBasedBitAddressing").`

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a slave connection, as specified by the parameters.

ModbusDeleteSlave

ModbusDeleteSlave — deletes a slave connection.

Synopsis

```
(ModbusDeleteSlave slaveNamePattern)
```

Arguments

slaveNamePattern
: An alphanumeric string that matches the name(s) of one or more slave connections.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command deletes one or more slave connections whose names match the pattern specified. This is equivalent to clicking the **Remove Slave** button for items the list of slave connections in the Modbus option of the Properties window.

ModbusEnableMaster

ModbusEnableMaster — enables and disables Modbus master functionality.

Synopsis

```
(ModbusEnableMaster 0|1)
```

Arguments

`0|1`
: If `1`, the DataHub Modbus master functionality is enabled; if `0`, it is disabled.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

If the argument is `1`, the DataHub Modbus master functionality is enabled. This is equivalent to checking the **Enable Modbus master** check-box in the Modbus option of the Properties window.

ModbusEnableSlave

ModbusEnableSlave — enables and disables Modbus slave connections.

Synopsis

```
(ModbusEnableSlave slaveNamePattern 0|1)
```

Arguments

slaveNamePattern
: An alphanumeric string that matches the name(s) of one or more slave connections.

0|1
: If 1, the specified Modbus slave connection or connections are enabled; if 0, they are disabled.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables slave connections, the equivalent to the check-boxes in the list of Modbus slave connections in the Modbus option of the Properties window.

ModbusQuerySlave

ModbusQuerySlave — checks for the existence of a slave connection.

Synopsis

```
(ModbusQuerySlave name)
```

Arguments

name
The name of a Modbus slave connection, as a string.

Returns

`t` on success, `nil` on failure, otherwise an error.

Description

This command checks to see if a given Modbus slave connection exists.

ModbusReloadSettings

ModbusReloadSettings — loads all Modbus configuration.

Synopsis

```
(ModbusReloadSettings)
```

Arguments

None.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command loads all Modbus configuration, including from outside sources, such as from a spreadsheet or a DataHub script. This command is roughly equivalent to clicking the **Load Modbus Configuration...** button in the Modbus option of the Properties window.

ModbusSlaveAddPoint

ModbusSlaveAddPoint — configures a Modbus point.

Synopsis

```
(ModbusSlaveAddPoint slaveName pointName blockType pointType address
 allowWrite xformType xformArgs conversion)
```

Arguments

slaveName
: The name of the Modbus slave, as a string.

pointName
: The point name, as a string, not including the data domain name.

blockType
: A string, one of

- `MB_DI` for digital input
- `MB_DO` for digital output
- `MB_AI` for analog input
- `MB_AO` for analog output

pointType
: The type of point, as a string, consisting of *typesize.flags*, where:

- *type* is one of:
  - `i` for integer
  - `r` for real (floating point)
  - s for string
  - b for bit
- *size* is one of
  - `1` for one bit (b) or one byte (s)
  - 2 for two bytes (i or s)
  - 4 for four bytes (i or r)
  - 8 for eight bytes (i or r)
- *flags* is any combination of
  - `-` (a minus sign) to indicate a signed integer (i)
  - b to swap bytes within words for 2, 4, or 8 byte sizes
  - `w` to swap words within dwords for 4 or 8 byte sizes

- d to swap dwords within quadwords for 8 byte sizes
- u to indicate UTF-8 for string (s) types of size 1, otherwise ASCII. s2 strings are always UTF-16.

For example, `"i4.-b"` would be a signed, 4-bit integer with bytes swapped within words.

`address`

The Modbus address, as a string, consisting of one of the following:

- *`number`* - the Modbus address offset, starting from `0` or `1` depending on the slave definition
- *`number.bit`* - a single bit within the integer starting at address number
- *`number.bit-bit`* - a bit field consisting of all bits between the first and last, inclusive
- *`number`*`[`*`length`*`]` - an array, starting at address *`number`*

`allowWrite`

`0` for not writable, `1` for writable

`xformType`

The type of transformation to make, one of: `direct`, `linear` or `range`

For more information about transformations, please refer to the Transform section of the Modbus option of the Properties window.

`xformArgs`

One of the following, that corresponds to the transformation you specified above for *`xformType`*.

- `direct`: an empty list (a list with zero elements).
- `linear`: a list containing two elements: (*`multiply`*, *add*) where *`multiply`* is the amount to multiply the original value, and *add* is the amount to add to the original value.
- `range`: a list containing these six elements: (*`modbusMin`*, *`modbusMax`*, *`pointMin`*, *`pointMax`*, *`clampMin`*, *`clampMax`*) where:
  - *`modbusMin`* is the minium value for the Modbus value.
  - *`modbusMax`* is the maximum value for the Modbus value.
  - *`pointMin`* is the minium value for the point value.
  - *`pointMax`* is the maximum value for the point value.
  - *`clampMin`* is the minium clamp value.
  - *`clampMax`* is the maximum clamp value.

`conversion`

A list of (*`enabled`*, *`targetType`*), where:

- *`enabled`* is `0` or `1`
- *`targetType`* is a type name, as a string, such as `"i4"` or `"r8"`

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command configures a Modbus point. For more information about Modbus data points, please refer to the Data Points section of the Modbus option of the Properties window.

ModbusSlaveAddRange

ModbusSlaveAddRange — configures a range of Modbus points.

Synopsis

```
(ModbusSlaveAddRange slaveName pointName blockType pointType address
 allowWrite xformType xformArgs conversion itemCount, nameStart)
```

Arguments

slaveName

The name of the Modbus slave, as a string.

pointName

A pattern that contains the sequence `{0}` in at least once place. This sequence will be replaced by an incrementing number for each point in the range. The pattern may optionally include `:D`*n* after the `0`, to indicate the number of digits. For example, for sequence number `7`, `{0}` will produce `7` and `{0:D3}` will produce `007`. For example, a point name could be `myPoint{0:D3}_Sp`.

blockType

A string, one of

- `MB_DI` for digital input
- `MB_DO` for digital output
- `MB_AI` for analog input
- `MB_AO` for analog output

pointType

The type of point, as a string, consisting of *typesize.flags*, where:

- *type* is one of:
  - `i` for integer
  - `r` for real (floating point)
  - s for string
  - b for bit
- *size* is one of
  - `1` for one bit (b) or one byte (s)
  - `2` for two bytes (i or s)
  - `4` for four bytes (i or r)
  - `8` for eight bytes (i or r)

- `flags` is any combination of
  - `-` (a minus sign) to indicate a signed integer (i)
  - b to swap bytes within words for 2, 4, or 8 byte sizes
  - `w` to swap words within dwords for 4 or 8 byte sizes
  - d to swap dwords within quadwords for 8 byte sizes
  - u to indicate UTF-8 for string (s) types of size 1, otherwise ASCII. s2 strings are always UTF-16.

  For example, `"i4.-b"` would be a signed, 4-bit integer with bytes swapped within words.

`address`

The Modbus address, as a string, consisting of one of the following:

- *`number`* - the Modbus address offset, starting from `0` or `1` depending on the slave definition
- *`number.bit`* - a single bit within the integer starting at address number
- *`number.bit-bit`* - a bit field consisting of all bits between the first and last, inclusive
- *`number`*`[`*`length`*`]` - an array, starting at address *`number`*

`allowWrite`

`0` for not writable, `1` for writable

`xformType`

The type of transformation to make, one of: `direct`, `linear` or `range`

For more information about transformations, please refer to the Transform section of the Modbus option of the Properties window.

`xformArgs`

One of the following, that corresponds to the transformation you specified above for *`xformType`*.

- `direct`: an empty list (a list with zero elements).
- `linear`: a list containing two elements: (*`multiply`*, *`add`*) where *`multiply`* is the amount to multiply the original value, and *`add`* is the amount to add to the original value.
- `range`: a list containing these six elements: (*`modbusMin`*, *`modbusMax`*, *`pointMin`*, *`pointMax`*, *`clampMin`*, *`clampMax`*) where:
  - *`modbusMin`* is the minium value for the Modbus value.
  - *`modbusMax`* is the maximum value for the Modbus value.
  - *`pointMin`* is the minium value for the point value.
  - *`pointMax`* is the maximum value for the point value.

- *clampMin* is the minium clamp value.
- *clampMax* is the maximum clamp value.

conversion

A list of (*enabled*, *targetType*), where:

- *enabled* is `0` or `1`
- *targetType* is a type name, as a string, such as `"i4"` or `"r8"`

itemCount

A number greater than `0` indicating the number of points to define.

nameStart

A number indicating the starting number for point name incremental numbering.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command configures a range of Modbus points. For more information about ranges, please refer to the Ranges section of the Modbus option of the Properties window.

ModbusSlaveDeletePoint

ModbusSlaveDeletePoint — deletes point connections.

Synopsis

```
(ModbusSlaveDeletePoint slaveName pointNamePattern)
```

Arguments

slaveName
: The name of a Modbus slave connection, as a string.

pointNamePattern
: An alphanumeric string that matches the name(s) of one or more points.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command removes the connection in a DataHub instance for one or more points on the Modbus slave.

mult

mult — multiplies the value of a point.

Synopsis

```
(mult name number secs nano)
```

Arguments

name

The name of a point, which must be a number type.

number

A value to multiply by the value of the point.

secs

The time in seconds. If this is not specified, the current date and time in seconds is used.

nano

A fraction of a second, in nanoseconds. If this is not specified, the number of nanoseconds past the current date and time is used.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used to multiply the value of a point.

OPCActivate

OPCActivate — activates or deactivates an OPC group.

Synopsis

```
(OPCActivate label 0|1)
```

Arguments

label

The name for this connection, as displayed in the OPC option of the Properties window. If *label* is * then the command affects all currently configured connections.

0|1

If 1, the group is activated; if 0, it is deactivated.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command activates or deactivates the OPC group in the OPC server representing the connection specified by *label*. This sends a message to the OPC server to activate or deactivate the underlying group. The result of deactivating a group is that subsequent read and write attempts will fail until the group is activated again.

OPCAddItem2

OPCAddItem2 — adds OPC items to a connection.

Synopsis

```
(OPCAddItem2 label flags propid item (parent...))
```

Arguments

label

The name for this connection, as displayed in the OPC option of the Properties window.

flags

one or more of the following:

IS_BRANCH	= 0X0001
IS_LEAF	= 0X0002
IS_PROP	= 0X0004
PARENT_IS_LEAF	= 0X0008
IS_EXPLICIT	= 0X0010

The `IS_EXPLICIT` flag will be added automatically, if it is not present, when a DataHub instance writes the configuration file.

propid

If this point is a property of an OPC leaf item (`IS_PROP` is true), then the property ID must be entered here. Otherwise, enter `0`. This entry is ignored if `IS_PROP` is not true.

item

The name of the item on the OPC server, as a string.

(*parent...*)

A list of parent DataHub points (OPC branch nodes) that lead to this point, each as a string. If the point is a property (has a non-zero *propid*), then the last element of the list should be an OPC leaf node. OPC servers can use the "`.`" character in item names, so this hierarchy is not necessarily derivable from the point name.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command adds OPC items to an OPC server connection. It does not take effect until the **OPCApply** command is issued.

Example

```
(OPCAddItem2 "MyOPCServer" 2 0 "Tank3.Level" ("Tank3" "Level"))
```

OPCAEAttach

OPCAEAttach — creates an OPC A&E connection.

Synopsis

```
(OPCAEAttach label machine protocol server domain detail_domain flags
 retry_secs delay_secs)
```

Arguments

Many of these parameters correspond to a similarly named entry field or checkbox in the Configure OPC A&E Server dialog options in the OPC A&E option of the Properties window. The names that appear in that dialog are shown here in parentheses.

label
: A name used by a DataHub instance to identify the connection. (**Connection Name**)

machine
: The name or IP address of the computer running the OPC A&E server you want to connect to. (**Computer Name**)

protocol
: Is not yet documented.

server
: The name of the OPC A&E server that you are connecting to. (**OPC Server Name**)

domain
: The name of the DataHub domain in which the data points are received. (**Data Domain Name**)

detail_domain
: Is not yet documented.

flags
: Are not yet documented.

retry_secs
: The number of milliseconds to wait before retrying a failed connection. (**Retry Delay**)

delay_secs
: The number of milliseconds to wait before retrying a failed connection. (**Retry Delay**)

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates an OPC A&E connection, which corresponds to creating a new connection in the OPC A&E option of the Properties window.

OPCAEDetach

OPCAEDetach — deletes an OPC A&E connection.

Synopsis

```
(OPCAEDetach label)
```

Arguments

label
The name used by the DataHub instance to identify the connection.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command deletes an OPC A&E connection, like pressing the **Remove** button for a selected OPC A&E connection in the OPC A&E option of the Properties window.

OPCAEEnable

OPCAEEnable — enables an OPC A&E connection.

Synopsis

```
(OPCAEEnable label 0|1)
```

Arguments

`label`
: The name used by the DataHub instance to identify the connection.

`0|1`
: `1` enables the connection, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables an OPC A&E connection, like checking a check box in the OPC A&E client list in the OPC A&E option of the Properties window.

OPCAEEnableClient

OPCAEEnableClient — enables OPC A&E client behavior.

Synopsis

```
(OPCAEEnableClient 0|1)
```

Arguments

`0|1`
: `1` enables the behavior, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables OPC A&E client behavior, corresponding to the **Act as an OPC A&E Client to these servers** checkbox in the OPC A&E option of the Properties window.

OPCAEEnableServer

OPCAEEnableServer — enables OPC A&E server behavior.

Synopsis

```
(OPCAEEnableServer 0|1)
```

Arguments

`0|1`
: `1` enables the behavior, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables OPC A&E server behavior, corresponding to the **Act as an OPC A&E Server** checkbox in the OPC A&E option of the Properties window.

OPCAEFilter

OPCAEFilter — selects alarms and events by filtering criteria.

Synopsis

```
(OPCAEFilter label filters event_types minseverity maxseverity
 categories areas sources)
```

Arguments

Some of these parameters correspond to a similarly named entry field or checkbox in the Configure OPC A&E Server dialog options in the OPC A&E option of the Properties window. The names that appear in that dialog are shown here in parentheses.

label
: The name used by the DataHub instance to identify the connection.

filters
: Not yet documented.

event_types
: Three types of filtering options available (not yet documented). (**Filter by event type**)

- Simple - events not related to an alarm, and cannot be tracked.
- Tracking - events that originate outside the process being monitored, for example, an operator intervention.
- Condition - events that indicate that an alarm has been triggered.

minseverity
: An integer specifying the lowest configurable urgency for an alarm. (**Filter by severity - Minimum**)

maxseverity
: An integer specifying the highest configurable urgency for an alarm. (**Filter by severity - Maximum**)

categories
: Not yet documented. (**Filter by category**)

areas
: Not yet documented. (**Filter by area**)

sources
: Not yet documented. (**Filter by source**)

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command selects alarms and events by filtering criteria. It corresponds to using the **Filters** checkboxes in the OPC A&E option of the Properties window.

OPCAEServerInit

OPCAEServerInit — configures the OPC A&E server.

Synopsis

```
(OPCAEServerInit input_domain detail_domain flags)
```

Arguments

input_domain
The name of the DataHub domain in which the data points are received (corresponds to **Use data from this domain** in the user interface.)

detail_domain
Is not yet documented.

flags
Have not yet been documented.

- (**Accept incomplete acknowledgement information**)
- (**Send a shutdown to clients when event configuration changes**)
- (**Automatically refresh conditions when a client connects**)

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command configures the OPC A&E server, and corresponds to the **Act as an OPC A&E Server** option in the OPC A&E option of the Properties window.

OPCApply

OPCApply — applies changes to an outgoing connection.

Synopsis

```
(OPCApply [label])
```

Arguments

label

The name for this connection, as displayed in the OPC option of the Properties window. If *label* is * or absent, then the command affects all currently configured connections.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command applies any changes made to an outgoing OPC connection specified by *label*. The only changes that are not immediately applied are **OPCAddItem** and **OPCRemoveItem**. Therefore, you can call **OPCAddItem** and **OPCRemoveItem** multiple times and then must issue **OPCApply** once for the changes to take effect.

OPCAttach2

OPCAttach2 — sets up an OPC connection.

Synopsis

```
(OPCAttach2 label machine_name interface_name server_pattern domain
 point_pattern deadband_msec flags pollmsec read_method
 write_method (filters...) [connect_wait ready_wait])
```

Arguments

label
: The name for this connection, as displayed in the OPC option of the Properties window.

machine_name
: The name or IP address of the computer running the DataHub instance.

interface_name
: Is either: `"OPC Data Access 2.0"` or `"OPC Data Access 3.0"`. Currently only `"OPC Data Access 2.0"` is supported.

server_pattern
: The name or IP address of the server computer. Wildcard characters are allowed.

domain
: The data domain name.

point_pattern
: A point name filter. Wildcard characters are allowed. Only leaf items that match this pattern will be visible in the DataHub instance. Normally you should specify `*` as the pattern.

deadband_msec
: The maximum rate at which the server should send data to the client. In asynchronous advise mode, *deadband_msec* is transmitted to the server. The server limits the data rate to no more often than the *deadband_msec*. In polling modes, *deadband_msec* determines the polling rate.

flags
: Any combination of:

- `0x00000001` - `PROPERTIES` - Attempt to load item properties as items.
- `0x00000002` - `ENABLED` - This connection is enabled.
- `0x00000004` - `AUTOITEMS` - Tells the DataHub instance to read the entire data set from the server.
- `0x00000008` - `READ_ONLY` - Marks the connection as read-only. Data will not be

transmitted from the DataHub instance to the server.

- `0x00000010` - `MANUAL_ITEMS` - Tells the DataHub instance to connect to any manually configured items from the server.
- `0x00000020` - `OVERRIDE_TIME` - Force the time stamp on incoming data from the server to the local time on the DataHub instance's computer.

`pollmsec`

The number of milliseconds between reconnection attempts when trying to connect to a server. This parameter is currently ignored.

`read_method`

An integer that specifies the method to use to read data from the OPC server. This can be one of:

- `1` - Asynchronous Advise (DA2.0)
- `2` - Synchronous Cache Read (DA2.0)
- `3` - Asynchronous Read (DA2.0)
- `7` - Synchronous Device Read (DA2.0)

`write_method`

An integer that specifies the method to use to read data from the OPC server. This can be one of:

- `1` - Synchronous Write (DA2.0)
- `2` - Asynchronous Write (DA2.0)

(*`filters`*...)

A space-separated list of filters, each one as a string, such as are entered in the Define OPC Server dialog of the OPC option of the Properties window. For example, here is what you would enter if you have:

- **zero filters** `( )`
- **one filter** ("*filter*$_1$")
- **two filters** ("*filter*$_1$" "*filter*$_2$")
- etc.

`connect_wait`

Optional. The number of milliseconds to pause after the connection is made before continuing with the connection sequence. This gives the server time to start up and construct its data set. If specified, the *`connect_wait`* time has to transpire before the DataHub instance first queries the server's data set.

`ready_wait`

Optional. The maximum number of milliseconds to wait for the server to report a ready state after the *`connect_wait`* has expired. If the server reports that it is ready before the *`ready_wait`* time expires, the DataHub instance will move on immediately to the next step in the connection sequence. If not, then the full *`ready_wait`* time will transpire before the DataHub instance queries the server's data set.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you set up an OPC connection. It corresponds roughly to the **Define OPC Server** dialog box that you get when you click the **Add** button in the OPC option of the Properties window.

OPCConnect

OPCConnect — connects or disconnects from the OPC server.

Synopsis

```
(OPCConnect label 0|1)
```

Arguments

`label`

The name for this connection, as displayed in the OPC option of the Properties window. If *`label`* is `*` then the command affects all currently configured connections.

`0|1`

If `1`, connect; if `0`, disconnect.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command causes the outgoing OPC connection specified by *`label`* to connect to or disconnect from the OPC server. If the connection is disconnected, it will reconnect again according to its connection polling cycle. If you wish to disconnect such that the connection will not automatically be retried, use **OPCEnable**.

OPCDetach

OPCDetach — removes an outgoing OPC connection.

Synopsis

```
(OPCDetach label)
```

Arguments

label
: The **Connection** name as set by **OPCAttach** or displayed in the OPC option of the Properties window.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command detaches and deletes the outgoing OPC connection specified by *label*.

OPCEnable

OPCEnable — enables or disables outgoing OPC connections.

Synopsis

```
(OPCEnable label 0|1)
```

Arguments

label
: The name for this connection, as displayed in the OPC option of the Properties window. If *label* is `*` then the command affects all currently configured connections.

`0|1`
: If `1`, the connection is enabled; if `0`, it is disabled.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

If the argument is `1`, the outgoing OPC connection specified by the *label* is enabled. This is equivalent to checking the check-box for the specified OPC connection in the OPC option of the Properties window. If the argument is `0`, the specified connection is disabled.

OPCEnableClient

OPCEnableClient — enables or disables all OPC clients.

Synopsis

```
(OPCEnableClient 0|1)
```

Arguments

`0|1`
: If `1`, all OPC client connections that are individually enabled will be immediately started. If `0`, all OPC client connections (outgoing) are terminated.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

OPCEnableServer

OPCEnableServer — enables or disables DataHub OPC server behavior.

Synopsis

```
(OPCEnableServer 0|1)
```

Arguments

`0|1`
: If `1`, the DataHub program will be added to the list of available OPC servers on this computer and future incoming OPC connections will be accepted. If `0`, the DataHub program will be removed from the list of available OPC servers on this computer and all future incoming OPC connections will be denied when the client attempts to create an OPC group.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

OPCMinimumSecurity

OPCMinimumSecurity — overrides DCOM security settings.

Synopsis

```
(OPCMinimumSecurity 0|1)
```

Arguments

`0|1`
: If `1`, the DataHub instance will attempt to override DCOM security settings. If `0`, it will not.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command determines whether a DataHub instance attempts to override the current system COM security settings when it starts. If you change this setting, you must re-start the DataHub instance for the change to be effective. An argument of `1` is equivalent to checking the check-box **Attempt to override application DCOM setting with minimum security settings** in the OPC option of the Properties window.

OPCModify

OPCModify — modifies an existing OPC connection.

Synopsis

```
(OPCModify label machine_name interface_name server_pattern domain
 point_pattern deadband_msec flags pollmsec read_method
 write_method (filters...))
```

Arguments

label
: The name for this connection, as displayed in the OPC option of the Properties window.

machine_name
: The name or IP address of the computer running the DataHub instance.

interface_name
: Is currently ignored.

server_pattern
: The name or IP address of the server computer. Wildcard characters are allowed.

domain
: The data domain name.

point_pattern
: A point name filter. Wildcard characters are allowed. Only leaf items that match this pattern will be visible in the DataHub instance. Normally you should specify `*` as the pattern.

deadband_msec
: The maximum rate at which the server should send data to the client. In asynchronous advise mode, *deadband_msec* is transmitted to the server. The server limits the data rate to no more often than the *deadband_msec*. In polling modes, *deadband_msec* determines the polling rate.

flags
: Any combination of:

- `0x00000001` - `PROPERTIES` - Attempt to load item properties as items.
- `0x00000002` - `ENABLED` - This connection is enabled.
- `0x00000004` - `AUTOITEMS` - Tells the DataHub instance to read the entire data set from the server.
- `0x00000008` - `READ_ONLY` - Marks the connection as read-only. Data will not be

transmitted from the DataHub instance to the server.

- `0x00000010` - `MANUAL_ITEMS` - Tells the DataHub instance to connect to any manually configured items from the server.
- `0x00000020` - `OVERRIDE_TIME` - Force the time stamp on incoming data from the server to the local time on the computer running the DataHub instance.

`pollmsec`

The number of milliseconds between reconnection attempts when trying to connect to a server.

`read_method`

The method to use to read data from the OPC server. This can be one of:

- `1` - Asynchronous Advise (DA2.0)
- `2` - Synchronous Cache Read (DA2.0)
- `3` - Asynchronous Read (DA2.0)
- `7` - Synchronous Device Read (DA2.0)

`write_method`

The method to use to read data from the OPC server. This can be one of:

- `1` - Synchronous Write (DA2.0)
- `2` - Asynchronous Write (DA2.0)

(*`filters`*...)

A space-separated list of filters, each one as a string, such as are entered in the Define OPC Server dialog of the OPC option of the Properties window. For example, here is what you would enter if you have:

- **zero filters** `()`
- **one filter** ("$filter_1$")
- **two filters** ("$filter_1$" "$filter_2$")
- etc.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is identical to **OPCAttach2**, except that it applies its settings to an existing connection instead of creating a new connection.

OPCQueryConnection

OPCQueryConnection — provides information related to an OPC server connection.

Synopsis

```
(OPCQueryConnection label)
```

Arguments

label

A name used by the DataHub instance to identify the connection, as listed in the **Connection** column of the OPC DA option of the Properties window.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command provides information related to an OPC server connection. A detailed description of the values provided has not yet been documented.

Example

This is an example of the command being called from the Script Log, using the `datahub_command` function. A few carriage returns have been added to this example to make the output easier to read.

```
--> pretty_princ(datahub_command ("(OPCQueryConnection OPC004)", 1));
(OPCQueryConnection "OPC004" "localhost" "OPC Data Access 2.0"
 "Toolbox OPC Power Server 5.14" "TOP5" "*" 500 0x700312
 5000 1 2 () 1000 5000 "Running" 0x3f9f8f0)
t
```

OPCQueryConnections

OPCQueryConnections — lists OPC server connections.

Synopsis

```
(OPCQueryConnections [pattern])
```

Arguments

pattern
A pattern that matches names of OPC connections, such as `OPC00*`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lists OPC server connections.

Example

This is an example of the command being called from the Script Log, using the `datahub_command` function.

```
--> pretty_princ(datahub_command ("(OPCQueryConnections OPC00*)", 1));
(OPCQueryConnection "OPC000" "OPC001" "OPC004")
t
```

OPCQueryPoint

OPCQueryPoint — provides data about an OPC point.

Synopsis

```
(OPCQueryPoint label pointname)
```

Arguments

label

A name used by the DataHub instance to identify the connection, as listed in the **Connection** column of the OPC DA option of the Properties window.

pointname

The name of a DataHub point only (no domain name) within the domain that has been configured for the OPC connection.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command provides data about a point within a configured OPC connection. Details regarding the nature of the data have not been documented.

Example

This is an example of the command being called from the Script Log, using the `datahub_command` function. A few carriage returns have been added to this example to make the output easier to read.

```
--> pretty_princ(datahub_command
                  ("(OPCQueryPoint OPC004 Channel_0.Ramp.Ramp1)", 1));
(OPCQueryPoint OPC004 ("OPC004" "Channel_0.Ramp.Ramp1" 18 0
 "Channel_0.Ramp.Ramp1" ("Channel_0" "Ramp" "Ramp1")))
t
```

OPCQueryPointPattern

OPCQueryPointPattern — provides data about multiple OPC points.

Synopsis

```
(OPCQueryPointPattern label pattern)
```

Arguments

label

A name used by the DataHub instance to identify the connection, as listed in the **Connection** column of the OPC DA option of the Properties window.

pattern

A pattern that matches names of OPC connections, such as `OPC00*`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command provides data about multiple OPC points.

Example

This is an example of the command being called from the Script Log, using the `datahub_command` function. A few carriage returns have been added to this example to make the output easier to read.

```
--> pretty_princ(datahub_command
                 ("(OPCQueryPointPattern OPC004 *Ramp*)", 1));
"(OPCQueryPointPattern OPC004
   ("OPC004" "Channel_0.Ramp.Ramp1" 18 0 "Channel_0.Ramp.Ramp1"
      ("Channel_0" "Ramp" "Ramp1"))
   ("OPC004" "Channel_0.Ramp.Ramp2" 18 0 "Channel_0.Ramp.Ramp2"
      ("Channel_0" "Ramp" "Ramp2"))
   ("OPC004" "Channel_0.Ramp.Ramp3" 18 0 "Channel_0.Ramp.Ramp3"
      ("Channel_0" "Ramp" "Ramp3"))
)"
t
```

OPCQueryPoints

OPCQueryPoints — provides a list of explicitly configured OPC tags in a connection.

Synopsis

```
(OPCQueryPoints label [pattern])
```

Arguments

label

A name used by the DataHub instance to identify the connection, as listed in the **Connection** column of the OPC DA option of the Properties window.

pattern

A pattern that matches names of OPC connections, such as `OPC00*`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command provides a list of OPC tags that have been explicitly (manually) configured for a connection. Details regarding the nature of the data have not been documented.

Example

This is an example of the command being called from the Script Log, using the `datahub_command` function. A few carriage returns have been added to this example to make the output easier to read.

```
--> pretty_princ(datahub_command
                 ("(OPCQueryPoints OPC004)", 1));
(OPCQueryPoints OPC004 "Channel_0.Ramp.Ramp1"
                       "Channel_0.Ramp.Ramp2"
                       "Channel_0.Ramp.Ramp3"
                       "_System")
t
```

OPCRefresh

OPCRefresh — sends a **Refresh2** command to the OPC server.

Synopsis

```
(OPCRefresh [label])
```

Arguments

label

The name for this connection, as displayed in the OPC option of the Properties window. If *label* is * or absent, then the command affects all currently configured connections.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command causes the outgoing OPC connection specified by *label* to send an OPC **Refresh2** command to the server. This instructs the OPC server to retransmit the current values for all items to which this connection is subscribed.

OPCReload

OPCReload — reloads the data set from an OPC server.

Synopsis

```
(OPCReload [label [reconnect]])
```

Arguments

label
: The name for this connection, as displayed in the OPC option of the Properties window. If *label* is `*` or absent, then the command affects all currently configured connections.

reconnect
: Either `1` or no argument causes a disconnect and reconnect during the reload cycle. A `0` prevents a disconnect from the OPC server during reload.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command cauSes the outgoing OPC connection specified by *label* to reload its data set from the OPC server. If the *reconnect* argument is absent or is `1`, the connection will be disconnected and then reconnected during the reload cycle. If *reconnect* is `0`, then the data set will be reloaded without disconnecting from the server.

OPCRemoveItem

OPCRemoveItem — removes an item based on its DataHub point name.

Synopsis

```
(OPCRemoveItem label point_name)
```

Arguments

label
: The name for this connection, as displayed in the OPC option of the Properties window.

point_name
: The name of a DataHub point, as a string, without the data domain name.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command removes an OPC item based on its DataHub point name. OPC items are mapped in a one-to-many relationship with DataHub points. The command removes only the item mapping associated with the given point name. The point name must not be qualified with the data domain name. The *label* is the label supplied to **OPCAttach** or **OPCAttach2**.

This command does not take effect until the **OPCApply** command is issued.

private_attribute

private_attribute — creates a private attribute.

Synopsis

```
(private_attribute domain assemblyname attrname type rw dflt_value
 [dflt_conf])
```

Arguments

domain
: The domain to which this property applies.

assemblyname
: The name of the assembly to which this attribute applies.

attrname
: The name of the attribute.

type
: A type for the private attribute.

rw
: One of:

- `r` for read-only.
- `w` for write-only.
- `rw` for read-write.

dflt_value
: A default value.

dflt_conf
: A default confidence level. If nothing is entered, the system assumes `0`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a private attribute. For information on the difference between an attribute and a private attribute, please refer to the section called “Attributes and Types”.

property

property — creates a property for an assembly.

Synopsis

```
(property domain attrname propid propname type rw dflt_value
 [dflt_conf])
```

Arguments

domain
The domain to which this property applies.

attrname
The name of the attribute to which this property applies.

propid
An ID number, or `AUTO` to have the DataHub instance assign an ID automatically.

propname
A name for the property.

type
A type for the property.

rw
One of:

- `r` for read-only.
- `w` for write-only.
- `rw` for read-write.

dflt_value
A default value.

dflt_conf
A default confidence level. If nothing is entered, the system assumes `0`.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a property. For more information and an example, please refer to the section called "Assemblies, Subassemblies, Attributes, and Properties".

quality

quality — assigns a quality to a point.

Synopsis

```
(quality name new_quality)
```

Arguments

name

The name of a point, as a string.

new_quality

The quality to be assigned to the point, as a number. Quality numbers are:

Quality Flag	Hex	Dec	String
OPC_QUALITY_BAD	0x0	0	Bad
OPC_QUALITY_UNCERTAIN	0x40	16	Uncertain
OPC_QUALITY_GOOD	0xc0	192	Good
OPC_QUALITY_CONFIG_ERROR	0x4	4	Config Error
OPC_QUALITY_NOT_CONNECTED	0x8	8	Not Connected
OPC_QUALITY_DEVICE_FAILURE	0xc	12	Device Failure
OPC_QUALITY_SENSOR_FAILURE	0x10	16	Sensor Failure
OPC_QUALITY_LAST_KNOWN	0x14	20	Last Known
OPC_QUALITY_COMM_FAILURE	0x18	24	Comm Failure
OPC_QUALITY_OUT_OF_SERVICE	0x1c	28	Out Of Service
OPC_WAITING_FOR_INITIAL_DATA	0x20	32	Waiting For Initial Data
OPC_QUALITY_LAST_USABLE	0x44	68	Last Usable
OPC_QUALITY_SENSOR_CAL	0x50	80	Sensor Cal
OPC_QUALITY_EGU_EXCEEDED	0x54	84	EGU Exceeded
OPC_QUALITY_SUB_NORMAL	0x58	88	Sub Normal
OPC_QUALITY_LOCAL_OVERRIDE	0xd8	216	Local Override

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command assigns a quality to a point. Typical qualities include `Good` and `Bad`.

read

read — reads a complete point definition.

Synopsis

```
(read name)
```

Arguments

name

The name of a point.

Returns

The complete point definition in a message, with this syntax:

```
(point name type value [conf security locked seconds nanoseconds
 flags quality])
```

where:

name

The name of the point.

type

The data type of the point, one of integer, floating point, or character string.

value

The value of the point.

conf

The confidence level of the point, `0` - `100` percent, unused by most applications.

security

The security level of the point, `0` to `32768`, where higher numbers represent higher security.

locked

`0` for locked, or `1` for unlocked.

seconds

The operating system time in seconds when the point was read.

nanoseconds

The number of nanoseconds after *seconds* when the point was read.

flags

User-defined flags.

`quality`

A constant representing a quality of the connection, assigned by the DataHub instance for this point, such as `Good`, `Bad`, `Last known`, `Local override`, etc. The possible values are those supported by OPC in Microsoft Windows.

Description

This command reads the current value of a point, along with all the other information it contains. See also **cread**.

report

report — requests notification of changes to a data point.

Synopsis

```
(report name)
```

Arguments

name
: The name of a data point.

Returns

A message each time any of the following occurs:

- The point value changes.
- The point quality changes.
- The point timestamp changes and the General property option **Do not transmit insignificant changes** is unchecked.
- A value is written to the point by force, such as with the **force** or **cforce** command, or by using the **set_canonical** command with the *force* option set.

The message contains a complete definition of the point, according to this syntax:

```
(point name type value [conf security locked seconds nanoseconds
 flags quality])
```

where:

name
: The name of the point.

type
: The data type of the point, one of integer, floating point, or character string, where:.

  - `0` indicates string.
  - `1` indicates floating point.
  - `2` indicates integer.

value
: The value of the point.

conf
: The confidence level of the point, `0` - `100` percent. This is unused by most applications.

security

The security level of the point, `0` to `32768`, where higher numbers represent higher security. This is unused by most applications.

locked

`1` for locked, or `0` for unlocked. This is unused by most applications.

seconds

The seconds portion of the point's timestamp.

nanoseconds

The nanoseconds portion of the point's timestamp, as an integer.

flags

System-defined flags, for internal use.

quality

A integer constant representing the quality of the point value, such as `Good`, `Bad`, `Last known`, `Local override`, etc. The possible values are shown in the **quality** command reference page.

Description

This command requests the DataHub instance to report changes (also called exceptions) to the value or quality of a point, as soon as a change takes place. See also **creport**.

report_domain

report_domain — registers points and requests information on a whole domain.

Synopsis

```
(report_domain domain flags)
```

Arguments

domain
The desired domain.

flags
Any bitwise-or combination of:

DH_REG_ALL	0x01	Register all points on this domain.
DH_REG_FUTURE	0x02	Register any new points created on this domain subsequent to this call.
DH_REG_QUALIFY	0x04	Tell the DataHub instance to emit all point names with the domain prepended, as in *domain*:*point_name*.
DH_REG_ONCEONLY	0x08	Tell the DataHub instance to send each point value exactly once.
DH_REG_MODEL	0x10	Tell the DataHub instance to send the data model as well as the point values.
DH_REG_SYNC	0x20	Reserved.
DH_REG_UNREG	0x40	Unregister all registered points in this domain. All other flags are ignored if this is specified. Setting this flag has the same effect as sending the unreport_domain command.
DH_REG_METAINFO	0x80	Available in DataHub version 10 only. Request metadata (engineering units, range, description) for registered points.

Returns

One or more messages, depending on the *flag*(s) chosen. Each message contains the complete definition of the point.

Description

This command lets TCP client connections decide on a per-domain basis whether to informed of the data model for the domain, and whether to get future updates, fully-qualified domain names, or new points.

report_errors

report_errors — controls the reporting of errors.

Synopsis

```
(report_errors 0|1 [error_point])
```

Arguments

`0|1`
: If `0` (the default), errors in transmitting an exception will not be reported to the client. If `1`, an error string will be generated.

`error_point`
: (Optional) The name of a point to contain the error string. If no name is given here, the error string will be written as the value of the point in which the error occurred.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command allows a client to specify how a failure to transmit a point change should be reported, either by modifying the point data and trying again, or by emitting an "error" point with the message in its data. The default is no reporting at all. In any case, if the attempt to emit the exception with the error information also fails, no further action is attempted by the DataHub instance.

request_initial_data

request_initial_data — gets current data when client connection is made.

Synopsis

```
(request_initial_data yes|no|0|1)
```

Arguments

`yes|no|0|1`
: Choose `yes` or `1` to request the data, or no or `0` to not make the request.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command causes a DataHub instance to send the current value of all points when the client connects.

save_config

save_config — forces a DataHub instance to save its configuration.

Synopsis

```
(save_config)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command allows an external client to force the DataHub instance to save its configuration.

secure

secure — adjusts the security level of a point.

Synopsis

```
(secure name my_sec new_sec)
```

Arguments

name
: The name of a DataHub point, as a string.

my_sec
: The user's security level.

new_sec
: The new security level to be assigned to the point.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command adjusts the security level of a DataHub point. If a point has a non-zero security level then any attempt to change the point value will fail if the writer claims to have a security level lower than the point's security level. The term "security level" is something of a misnomer because it is up to the writer to state what security level it has, and the writer could claim to have any security level. There is no validation of the claim by the DataHub instance. Consequently, this security level is co-operative. It acts to stop errors among trusted programs, but does not act to limit access by untrusted programs.

The default security level for a point is 0.

set

set — sets the value of a point.

Synopsis

```
(set name value [confidence])
```

Arguments

name

The name of the point. This is a string.

value

A string representation of the value for the point. The point value will be interpreted as integer, float or string based on the contents of the value string. This function tries each type in order, and uses the first type for which the value parameter is a valid representation. Double quotes around the value parameter are ignored. For example:

- `123` is an integer.
- `123.4` is a float.
- `1.234e2` is a float.
- `"123"` is an integer.
- `123abc` is a string.

confidence

A confidence factor in the range of `0` to `100` (optional). This is not used by the DataHub instance, so is available to programs that produce graduated confidence, such as expert systems. If this value is not specified, it is set to `100`.

All strings can be surrounded by double-quotes if the string contains spaces or special characters. The backslash character (`\`) escapes double quotes and backslashes within the string. Newline, carriage return, form feed and tab are represented with `\n`, `\r`, `\f`, `\t` respectively. Strings must not contain newline characters.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets the value of a point. When this value is set, the following attributes of the point are set as follows:

- `seconds` and `nanoseconds` are set to the current time on the machine running the DataHub instance.

- `locked`, `sec`, and `quality` are all maintained at their previous values for this point.
- `flags` is set to `0`.

Please refer to the **write** command for more information about these parameters. See also **cset**, **force**, and **cforce**.

set_access

set_access — is new, not yet documented.

Synopsis

```
(set_access pointname rw)
```

Description

This command has not yet been documented.

set_authoritative

set_authoritative — sets the type of a point.

Synopsis

```
(set_authoritative domain flag)
```

Arguments

domain

The name of the data domain.

flag

A value of `1` indicates that this application is authoritative. A value of `0` indicates that the DataHub instance should be authoritative .

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command tells the DataHub instance that this application should be considered the authoritative source of data for this data domain. The DataHub instance will keep track of which data points this application has written to it, and will automatically mark those points as being `Not Connected` quality when the application disconnects. This provides a mechanism for the DataHub instance to provide quality information even if the source application exits unexpectedly.

There should only ever be one authoritative source of data for any data point, though the DataHub instance will not enforce this. If more than one application claims to be authoritative for a data point, that point will be given a `Not Connected` quality even if another authoritative application is still connected.

The command `(set_authoritative domain 0)` does NOT mean "turn off authoritative status". It informs the DataHub instance that the application is explicitly non-authoritative, and by extension that DataHub instance should behave as if it is authoritative. Normally this is only meaningful between DataHub instances constructing a tunnel. An application should not send `(set_authoritative domain 0)` to a DataHub instance. If an application does not want to be authoritative for a data domain, it simply should not send a **set_authoritative** command.

set_canonical

set_canonical — sets the type of a point.

Synopsis

```
(set_canonical pointname canonical_type [force])
```

Arguments

pointname
: The full name of the point, with domain.

canonical_type
: Either a number with a legal numeric VT_TYPE value, or one of: I1, I2, I4, UI1, UI2, UI4, CY, DATE, BOOL, BSTR, R4, R8, EMPTY, I1 ARRAY, I2 ARRAY, I4 ARRAY, UI1 ARRAY, UI2 ARRAY, UI4 ARRAY, CY ARRAY, DATE ARRAY, BOOL ARRAY, BSTR ARRAY, R4 ARRAY, R8 ARRAY.

force
: A value of 1 forces a change in canonical type. A value of 0, or the omission of this optional parameter, will allow the canonical type to change only if it is currently EMPTY.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command sets the canonical type of a point. Normally a point's canonical type is EMPTY, meaning that it will maintain the data type of whatever data is written to it. If the canonical type is other than EMPTY, then any data written to the point will be converted to that type before it is stored.

When a point has a non-empty canonical type it is possible that the conversion could fail, in which case the point value is not changed.

show_data

show_data — displays the Data Browser.

Synopsis

```
(show_data 0|1)
```

Arguments

`0|1`
: Use `1` to show the Data Browser, or `0` to hide it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command shows or hides the Data Browser.

show_debug_messages

show_debug_messages — show or hide debugging messages in the Data Browser.

Synopsis

```
(show_debug_messages 0|1)
```

Arguments

`0|1`

Use `1` to show debugging messages in the Data Browser, or `0` to not show them.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you toggle the functionality of the **Debug** button in the Event Log on or off programmatically. The Debug option is very verbose, and could put a high demand on system resources.

show_event_log

show_event_log — displays the Event Log.

Synopsis

```
(show_event_log 0|1)
```

Arguments

`0|1`
Use `1` to show the Event Log, or `0` to hide it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command shows or hides the Event Log.

show_icon

show_icon — displays the system tray icon.

Synopsis

```
(show_icon 0|1)
```

Arguments

`0|1`
: Use `1` to display the system tray icon, or `0` to hide it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you show or hide the system tray icon ( ).

show_properties

show_properties — displays the Properties window.

Synopsis

```
(show_properties 0|1)
```

Arguments

`0|1`
Use `1` to display the Properties window, or `0` to hide it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command shows or hides the Properties window.

show_script_log

show_script_log — displays the Script Log.

Synopsis

```
(show_script_log 0|1)
```

Arguments

`0|1`
: Use `1` to display the Script Log, or `0` to hide it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command shows or hides the Script Log.

subassembly

subassembly — creates a subassembly.

Synopsis

```
(subassembly domain assemblyname subassemblyname instancename)
```

Arguments

domain
: The name of the domain in which this subassembly will be created.

assemblyname
: The name of the parent assembly.

subassemblyname
: The name for this subassembly.

instancename
: The instance name for this instance of the subassembly.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a subassembly level of a data organization. Unlike assemblies, each subassembly is instantiated when it is created, and therefore needs an instance name. For more information about assemblies and subassemblies with an example, please refer to the section called "Assemblies, Subassemblies, Attributes, and Properties".

success

success — sets up a `success` message.

Synopsis

```
(success command resultstring)
```

Arguments

command
: The name of a command for which this success string will be used.

resultstring
: A message string to be send to the issuer of a command when the command executes successfully. Also see Return Syntax.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is used to create messages that are sent from the DataHub instance to participating programs whenever a given *command* is successfully executed.

tcp_service

tcp_service — sets a TCP service name or port number for incoming slave connections.

Synopsis

```
(tcp_service service|port)
```

Arguments

`service|port`
: The TCP service name or port number for incoming slave connections.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command informs a DataHub instance acting as a master which TCP service name or port number it should listen on for incoming slave connections.

timeout

timeout — suspends data flow.

Synopsis

```
(timeout ms)
```

Arguments

ms

The number of milliseconds to pause.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command causes the DataHub instance to stop sending data to the client for *ms* milliseconds.

transmit_insignificant

transmit_insignificant — permits transmission of insignificant changes.

Synopsis

```
(transmit_insignificant 0|1)
```

Arguments

`0|1`
: Use `1` to transmit insignificant changes, or `0` to not transmit them.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command permits transmission of insignificant changes. A change is considered insignificant if a point change differs from the existing value only by its `timestamp`. A change is considered significant if any attribute other than `timestamp` changes. That would include `lock`, `security`, `confidence`, `quality`, `value`. This command does not put any kind of deadband on the value.

TunnelDelete

TunnelDelete — deletes specified tunnel/mirror Slave connections.

Synopsis

```
(TunnelDelete host_pattern [remote_domain_pattern])
```

Arguments

host_pattern
: The name of the host (the remote machine), or a pattern that matches several host names.

remote_domain_pattern
: The domain on the remote host, or a pattern that matches several domains. If not specified, all domains on that host will be selected.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command deletes all tunnel slave connections whose host name matches *host_pattern* and whose remote domain name matches *remote_domain_pattern*. This corresponds to the **Remove** button in the Tunnel/Mirror option of the Properties window.

TunnelEnable

TunnelEnable — enables specified tunnel/mirror Slave connections.

Synopsis

```
(TunnelEnable 0|1 host_pattern [remote_domain_pattern])
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

`host_pattern`
: The name of the host (the remote machine), or a pattern that matches several host names.

`remote_domain_pattern`
: The domain on the remote host, or a pattern that matches several domains.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables tunnelling to the host(s) and domain(s) that match a1 pattern. This corresponds to checking the check boxes on configured slave connections in the Tunnel/Mirror option of the Properties window.

TunnelEnablePlain

TunnelEnablePlain — enables plain-text tunnel/mirror Master connections.

Synopsis

```
(TunnelEnablePlain 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables plain-text tunnel/mirror Master connections, and corresponds to the **Accept plain-text connections on service/port** checkbox in the Tunnel/Mirror option of the Properties window.

TunnelEnableSlave

TunnelEnableSlave — enables all tunnel/mirror Slave connections.

Synopsis

```
(TunnelEnableSlave 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables all tunnel/mirror Slave connections, and corresponds to the **Act as a tunnel/mirror slave to these masters** checkbox in the Tunnel/Mirror option of the Properties window.

TunnelEnableSSL

TunnelEnableSSL — enables SSL tunnel/mirror Master connections.

Synopsis

```
(TunnelEnableSSL 0|1)
```

Arguments

`0|1`
: `1` enables the capability, `0` disables it.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables SSL tunnel/mirror Master connections, and corresponds to the **Accept secure connections on service/port** checkbox in the Tunnel/Mirror option of the Properties window.

TunnelPlainPort

TunnelPlainPort — specifies the port for incoming plain-text tunnels.

Synopsis

```
(TunnelPlainPort port)
```

Arguments

port

A TCP port number

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command specifies the port for incoming plain-text tunnels, and corresponds to the entry field for **Accept plain-text connections on service/port** checkbox in the Tunnel/ Mirror option of the Properties window.

TunnelSaveConfig

TunnelSaveConfig — saves the tunnel configuration.

Synopsis

```
(TunnelSaveConfig)
```

Arguments

None

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command causes the DataHub Tunnel/Mirror plugin to immediately save its current configuration to its configuration file. This will not capture any changes that have been manually configured in the Properties window. Manual changes must be saved by pressing the **Apply** button in that window.

TunnelSlaveStatus

TunnelSlaveStatus — provides status information on tunnel/mirror Slave connections.

Synopsis

```
(TunnelSlaveStatus host_pattern)
```

Description

This command provides status information on tunnel/mirror Slave connections. Details regarding the nature of the status data have not been documented.

Example

This is an example of the command being called from the Script Log, using the `datahub_command` function. A few carriage returns have been added to this example to make the output easier to read.

```
--> pretty_princ(datahub_command
                 ("(TunnelSlaveStatus developers.cogentrts.com)", 1));
(TunnelSlaveStatus ("slave" "developers.cogentrts.com" "4502" ""
 "4502" "test" "test" "" "" 0x22300000 5000 1000 5000 1 "Running"))
t
```

TunnelSSLCert

TunnelSSLCert — specifies the certificate for incoming SSL-enabled tunnels.

Synopsis

```
(TunnelSSLCert filename)
```

Arguments

filename

The directory and filename of the SSL certificate.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command specifies the security certificate for incoming SSL-enabled tunnels. This corresponds to the entry field for the **SSL Certificate** in the Tunnel/Mirror option of the Properties window.

TunnelSSLPort

TunnelSSLPort — specifies the port for incoming SSL-enabled tunnels.

Synopsis

```
(TunnelSSLPort port)
```

Arguments

port
A TCP port number

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command specifies the port for incoming SSL-enabled tunnels. This corresponds to the entry field for the **Accept Secure connections on service/port** checkbox in the Tunnel/Mirror option of the Properties window.

type

type — creates a type.

Synopsis

```
(type domain attrname [superattrname])
```

Arguments

domain
: The domain in which this type applies.

attrname
: The name of this type, which is the same as the name of the attribute.

superattrname
: An attribute from which this type is derived.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a type. For more information and an example, please refer to the section called “Attributes and Types”.

UAApplyEdit

UAApplyEdit — applies edits to OPC UA configuration.

Synopsis

```
(UAApplyEdit)
```

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command applies any edits made to a temporary copy of OPC UA configuration created by **UABeginEdit**, and makes it the current configuration. The modified configuration gets written to disk and the temporary configuration is discarded upon completion. See **UAEnable** for an example.

UABeginEdit

UABeginEdit — creates a temporary copy of the OPC UA configuration for editing.

Synopsis

```
(UABeginEdit)
```

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command creates a temporary copy of the OPC UA configuration that can be used for editing. See **UAEnable** for an example.

UACancelEdit

UACancelEdit — cancels edits to the OPC UA configuration.

Synopsis

```
(UACancelEdit)
```

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command cancels any temporary edits to the OPC UA configuration created by **UABeginEdit** without applying them.

UAEnable

UAEnable — enables or disables an individual OPC UA client connection.

Synopsis

```
(UAEnable label 0|1)
```

Arguments

label
  The client connection label, as a string.

0|1
  Use `1` to enable, or `0` to disable.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command enables or disables an individual OPC UA client connection by label. It must be called within a temporary edit session started with **UABeginEdit** and ending with **UAApplyEdit**.

Example

```
require ("Application");

class UaTest Application
{
}

method UaTest.enableUa(label, enabled)
{
    datahub_command("(UABeginEdit)", 1);
    datahub_command(format("(UAEnable %s %d)",
                           stringc(label),
                           number(enabled)), 1);
    datahub_command("(UAApplyEdit)", 1);
}

method UaTest.constructor ()
{
    .enableUa("OPCUA000", 1);
```

```
}

ApplicationSingleton (UaTest);
```

UAEnableClient

UAEnableClient — enables or disables OPC UA client functionality.

Synopsis

```
(UAEnableClient 0|1)
```

Arguments

0|1

Use `1` to enable, or `0` to disable.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command acts like the check-box that enables and disables the client functionality in the OPC UA option of the Properties window. To start or stop an individual OPC UA client connection, see **UAEnable**.

UAEnableServer

UAEnableServer — enables or disables OPC UA server functionality.

Synopsis

```
(UAEnableServer 0|1)
```

Arguments

0|1

Use `1` to enable, or `0` to disable.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command acts like the check-box that enables and disables the server functionality in the OPC UA option of the Properties window. There is no command to start or stop an individual OPC UA server connection.

unload_plugin

unload_plugin — unloads a plugin. (*experimental*)

Synopsis

```
(unload_plugin plugin_name)
```

Arguments

plugin_name
The name of a plugin.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you instruct the DataHub instance to unload a plugin.

The commands related to plugins are currently experimental.

unreport

unreport — allows a client to stop receiving data value changes to a point.

Synopsis

```
(unreport name)
```

Arguments

name
: The name of the point to stop receiving values for.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command allows a client to stop future changes from being sent on a specified point.

unreport_domain

unreport_domain — allows a client to stop receiving data value changes in a whole domain.

Synopsis

```
(unreport_domain domain)
```

Arguments

domain
The name of a DataHub domain.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

Typically this command is sent by a client to the DataHub instance, allowing the client to stop receiving data value changes in the specified domain. Sending this command has the same effect as setting the `DH_REG_UNREG` flag in the report_domain commaand.

version

version — returns the current version number.

Synopsis

```
(version)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command gives the current version number of the DataHub instance.

write

write — writes information to a point.

Synopsis

```
(write name type value conf sec locked seconds nanoseconds
 [flags quality])
```

Arguments

name
: The name of the point. This is a string.

type
: The type of point. One of

- `0` = string
- `1` = float (8-byte double)
- `2` = integer (32-bit integer)

value
: A string representation of the value for the point. It will be interpreted into the type specified by the *type* parameter.

conf
: A confidence factor in the range of `0` to `100`. This is not used by the DataHub program, so is available to programs that produce graduated confidence, such as expert systems.

sec
: A security level for this point. This is rarely used. If a point's security level is set to a non-zero value then attempts to write to that point must claim a security level equal to or greater than the security level of the point. This uses a "good citizen" model - the writer can claim any security it wants, and is assumed to be honest - so there is no strong security here. It is intended for systems that want to avoid accidental changes to values. Security level can be from `0` to `32767`.

locked
: An indication that the point is locked, and cannot be changed. Can be `0` or `1`. Attempts to write to a locked point will fail.

seconds
: The UNIX epoch - seconds since Jan. 1, 1970, as produced by the `time()` function.

nanoseconds
: The number of nanoseconds inside this second. Cannot exceed `1,000,000,000`.

flags

User level code should always send a `0` for this value.

quality

A quality indicator consistent with the OPC DA specification. This is not a bit field. It can be one of:

PT_QUALITY_BAD	0
PT_QUALITY_UNCERTAIN	0x40
PT_QUALITY_GOOD	0xc0
PT_QUALITY_CONFIG_ERROR	0x04
PT_QUALITY_NOT_CONNECTED	0x08
PT_QUALITY_DEVICE_FAILURE	0x0c
PT_QUALITY_SENSOR_FAILURE	0x10
PT_QUALITY_LAST_KNOWN	0x14
PT_QUALITY_COMM_FAILURE	0x18
PT_QUALITY_OUT_OF_SERVICE	0x1c
PT_QUALITY_WAITING_FOR_INITIAL_DATA	0x20
PT_QUALITY_LAST_USABLE	0x44
PT_QUALITY_SENSOR_CAL	0x50
PT_QUALITY_EGU_EXCEEDED	0x54
PT_QUALITY_SUB_NORMAL	0x58
PT_QUALITY_LOCAL_OVERRIDE	0xd8

All strings can be surrounded by double-quotes if the string contains spaces or special characters. The backslash character (\) escapes double quotes and backslashes within the string. Newline, carriage return, form feed and tab are represented with `\n`, `\r`, `\f`, `\t` respectively. Strings must not contain newline characters.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command lets you manually write information to a point. See also **cwrite**.

Obsolete and Unused Commands

This reference contains commands that are deprecated, obsolete, and no longer used, as well as commands that are for internal use only. These commands should rarely if ever be used.

asyncsocket

asyncsocket — sets up asynchronous communication on a socket.

Synopsis

```
(asyncsocket socket)
```

Arguments

socket
The socket address, as a string.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command tells the DataHub instance to communicate asynchronously on the specified *socket*.

authgroup

authgroup — is deprecated.

Synopsis

```
(authgroup name bits max_concurrent_logins max_logins expiry)
```

authuser

authuser — is deprecated.

Synopsis

```
(authuser name group hash bits max_concurrent_logins max_logins
 login_count expiry)
```

bandwidth_reduce

bandwidth_reduce — is for internal use only.

Synopsis

deleted

deleted — checks if a point has been deleted.

Synopsis

```
(deleted pointname [domain])
```

Arguments

pointname
: A string containing the name of the point.

domain
: The domain of the point. If not specified, the `default` domain is used.

Returns

A message indicating whether the point has been deleted.

Description

This command checks if the given *point* has been deleted.

We do not recommend deleting points, as it could cause unexpected behavior for other users of the point.

drop_license

drop_license — is for internal use only.

Synopsis

echo

echo — is for internal use.

Synopsis

```
(echo name type value [conf security locked seconds nanoseconds flags
 quality])
```

Description

This command is only used between two DataHub instances. A non-DataHub client should never issue an **echo** command.

enable_connect_server

enable_connect_server — is deprecated.

Synopsis

```
(enable_connect_server 0|1)
```

EnableDDEServer

EnableDDEServer — is for internal use only.

Synopsis

```
(EnableDDEServer 0|1)
```

Description

This command is for internal use only. To enable the DDE server, please refer to **enable_dde_server**.

exception_buffer

exception_buffer — is deprecated.

Synopsis

```
(exception_buffer bytes)
```

failed_license

failed_license — is for internal use only.

Synopsis

flush

flush — flushes output to a terminal (Linux).

Synopsis

```
(flush)
```

Arguments

none

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is not used at all in Windows, and even in Linux and QNX there is really not much need for it. The command sends a flush to the terminal, so that if the DataHub instance is printing to a terminal and has not completely flushed its output, this will cause all pending printed characters to appear.

flush_log

flush_log — is deprecated.

Synopsis

```
(flush_log)
```

master_host

master_host — is deprecated in favor of **mirror_master**.

Synopsis

```
(master_host name|IP)
```

master_service

master_service — is deprecated in favor of **mirror_master**.

Synopsis

```
(master_service service|port)
```

on_change

on_change — is for internal use only.

Synopsis

OPCAddItem

OPCAddItem — is deprecated in favor of **OPCAddItem2**.

Synopsis

```
(OPCAddItem label flags propid item (parent...))
```

Arguments

label
: The name for this connection, as displayed in the OPC option of the Properties window.

flags
: one or more of the following:

`IS_BRANCH`	= 0X0001
`IS_LEAF`	= 0X0002
`IS_PROP`	= 0X0004
`PARENT_IS_LEAF`	= 0X0008

propid
: If this point is a property of an OPC leaf item (`IS_PROP` is true), then the property ID must be entered here. Otherwise, enter `0`. This entry is ignored if `IS_PROP` is not true.

item
: The name of the item on the OPC server, as a string.

(*parent...*)
: A list of parent DataHub points (OPC branch nodes) that lead to this point, each as a string. If the point is a property (has a non-zero *propid*), then the last element of the list should be an OPC leaf node. OPC servers can use the "`.`" character in item names, so this hierarchy is not necessarily derivable from the point name.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is deprecated in favor of **OPCAddItem2**, but is available to facilitate upgrading from earlier versions of the DataHub program. It adds OPC items to an OPC server connection. It does not take effect until the **OPCApply** command is issued.

Example

```
(OPCAddItem "MyOPCServer" 2 0 "Tank3.Level" ("Tank3" "Level"))
```

OPCAttach

OPCAttach — is deprecated in favor of **OPCAttach2**.

Synopsis

```
(OPCAttach label machine_name interface_name server_pattern domain
 point_pattern [deadband_msec])
```

Arguments

label

A name for this connection, as a string.

machine_name

The name or IP address of the computer running the DataHub instance.

interface_name

Is either: `"OPC Data Access 2.0"` or `"OPC Data Access 3.0"` Currently only `"OPC Data Access 2.0"` is supported.

server_pattern

The name or IP address of the server computer. Wildcard characters are allowed.

domain

The data domain name.

point_pattern

A point name filter. Wildcard characters are allowed. Only leaf items that match this pattern will be visible in the DataHub instance. Normally you should specify `*` as the pattern.

deadband_msec

The maximum rate at which the server should send data to the client.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is deprecated in favor of **OPCAttach2**, but is available to facilitate upgrading from earlier versions of the DataHub program. It lets you set up an OPC connection. It corresponds roughly to the **Define OPC Server** dialog box that you get when you click the **Add** button in the OPC option of the Properties window.

OPCInit

OPCInit — is deprecated.

Synopsis

```
(OPCInit)
```

point

point — is used internally.

Synopsis

```
(point name type value [conf security locked seconds nanoseconds
 [quality]])
```

Arguments

name
: The name of the point.

type
: The type of the point.

value
: The value of the point.

conf
: The confidence level of the point.

security
: The security level of the point.

locked
: The locked status of the point.

seconds
: The current time in seconds.

nanoseconds
: The number of nanoseconds past *seconds* .

quality
: The quality of the point.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is the string that the DataHub instance sends to all clients when a point value changes (i.e. a point exception occurs). the DataHub instance also listens for a **point** command because this is the mechanism that it uses to get updates from another DataHub instance that it is tunnelling/mirroring. This is not a command that a user would normally emit. Point changes should be sent to the DataHub instance using the **write** or **cwrite** commands.

qnx_name_attach

qnx_name_attach — does nothing.

Synopsis

```
(qnx_name_attach node name)
```

qnx_receiver

qnx_receiver — does nothing.

Synopsis

```
(qnx_receiver name)
```

readid

readid — should *not* be used.

Synopsis

```
(readid pointnumber)
```

Arguments

`pointnumber`
: The n^{th} point in the sender's `default` domain.

Returns

A message indicating success or error. Please refer to Return Syntax for details.

Description

This command is like read but not as useful or robust. It reads the n^{th} point in the point table of the sender's `default` domain. This is neither useful nor not robust, since deleting a point will cause unpredictable behavior. Avoid using this command.

register_datahub

register_datahub — replaced by **report_domain**.

Synopsis

```
(register_datahub domain)
```

report_all

report_all — replaced by **report_domain**.

Synopsis

```
(report_all future domain_needed)
```

report_datahubs

report_datahubs — does nothing.

Synopsis

```
(report_datahubs yes|no)
```

request

request — replaced by **report_domain**.

Synopsis

```
(request pointname)
```

run

run — does nothing.

Synopsis

```
(run command [argument...])
```

script_register

script_register — is for internal use only.

Synopsis

```
```

script_symbol

script_symbol — is for internal use only.

Synopsis

```

```

slave

slave — is for internal use only.

Synopsis

```
```

sync

sync — is for internal use only.

Synopsis

```

```

taskdied

taskdied — is for internal use.

Synopsis

```
(taskdied name domn qu nodename node pid chid)
```

taskstarted

taskstarted — is for internal use.

Synopsis

```
(taskstarted name domn qu nodename node pid chid)
```

using_license

using_license — is for internal use only.

Synopsis

warn_of_license_expiry

warn_of_license_expiry — is deprecated.

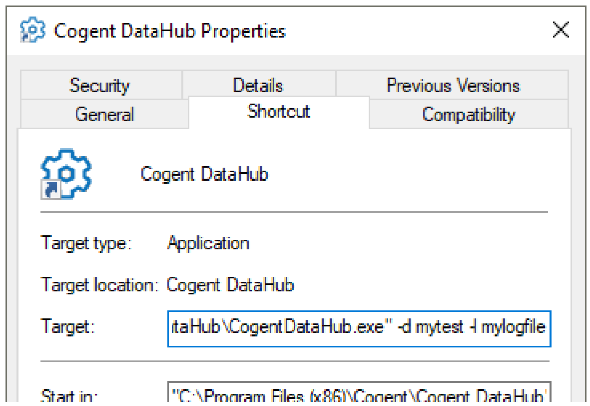
Synopsis

```
(warn_of_license_expiry 0|1)
```

Appendix A. Command Line Options

For more control of a Cogent DataHub instance on startup, you can use its command line options. These options let you specify data domains, ports, and several other configuration items each time a DataHub instance starts. You need to enter these options in the Properties section of the DataHub shortcut icon.

1. Right click on the DataHub shortcut icon and select **Properties.** The DataHub Properties window will appear, with the **Shortcut** tab selected:



2. Enter the options in the **Target** field, after the quotation marks, as illustrated above. The available options are as follows:

`-a`

Transmit all point messages to all registered clients, even if the value does not change.

`-b` *`size`*

The maximum message buffer size.

`-d` *`domain`*

The domain name for this DataHub instance. This option can be used multiple times to get multiple domains on a single DataHub instance.

`-D`

Applies to the Cascade DataHub in Linux only. Do not detach from the controlling tty. Normally the DataHub instance will detach itself and become immune to interrupts and termination on the controlling tty. If this option is used, then an & is necessary to run **datahub** in the background.

`-f` *`file`*

Load this configuration file.

`-h`

Applies to the Cascade DataHub in Linux only. Print a help message showing a summary of all these arguments.

`-H` *`home_path`*

The full path to the directory that will contain the configuration and license files. This takes precedence over `-S` and `-U`. If the directory cannot be found or created, the files will be stored in the installation directory.

`-I`

Hide the system tray icon when the DataHub instance starts. Only works in Windows.

`-l` *`file`*

Log messages to this file.

`-m` *`port`*

Acting as a TCP slave, attach to a TCP master on this port or service. The port is the matching port number of the master, usually `4502`;

`-M` *`address`*

Acting as a TCP slave, attach to a TCP master on this host. The address is a machine name, such as `developers.cogentrts.com` or a machine address, such as `192.168.3.15`.

`-n` *`domain`*

Acting as a TCP slave, tunnel/mirror this domain from the TCP master. The named domain on the master will be tunneled/mirrored to a domain of the same name in the slave.

`-p` *`port`*

Act as a TCP master and listen on this port/service.

`-P`

Show the properties window when the DataHub instance starts. This is on by default in the desktop icon and Start menu entry.

`-q` *`queue`*

Specify an alternate queue name for this DataHub instance. Normally **datahub** chooses its own queue name to be unique on the network.

`-s`

Synchronized: The DataHub instance will ignore changes to a point if the point's current timestamp is more recent.

`-S` *`name`*

Specify a name, as a string, for the DataHub instance, which will appear in the DataHub title bar and pop-up menu. This name will also be appended to the DataHub configuration file name and default configuration folder name, if not explicitly specified by the `-H` option.

`-t`

Automatically generate a timestamp on unstamped points.

`-U`

The DataHub instance should NOT create a directory within the user's personal `Application Data` directory to store the configuration and license files, but rather in the application installation directory. This has a lower precedence than `-H`.

`-v`

Applies to the Cascade DataHub in Linux only. Generate copious debugging information to the standard output. (Implies use of `-D`).

`-V`

Applies to the Cascade DataHub in Linux only. Print the version number.

`-X`

Applies to the Cascade DataHub in Linux only. Exit immediately (usually used with `-V`).

3. Click **OK** and restart the DataHub instance. The options you have chosen should take effect. Keep in mind that if your configuration file has different values for these options, it will override what you have entered here.

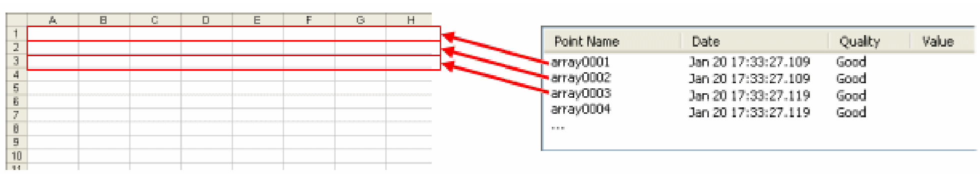
Appendix B. Excel Macro Library

This set of Excel macros each work on a 100 row x 40 column table of data in `Sheet1` of the worksheet, starting at cell position `A1`. We have tried to make these macros generic so you can easily modify them to suit your needs.

Configure Excel to receive data from the DataHub instance (using DDEAdvise)

These macros normally need to be run only once, when first setting up a spreadsheet to receive data.

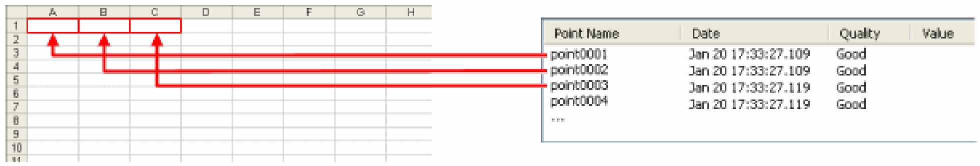
- **Attach array data in the DataHub instance, one array per row, to a table of values in Excel.** It is often more convenient to transmit large sets of Excel data as an array because this significantly reduces the bandwidth requirements and increases the speed of transmission. This macro sets up **DDEAdvise** loops from the DataHub instance to Excel, so that each row of the table is linked to an array point in the DataHub instance.



Each data point represents a row of data. This macro assumes the names are "array0001", "array0002", etc.

```
---------------------------------------------------
Sub register_arrays()
    Dim pname As String

    For i = 1 To 100
        pname = Format(i, "0000")
        pname = "=datahub|default!array" & pname
        Worksheets("Sheet1").Range(Cells(i, 1), _
         Cells(i, 40)).FormulaArray = pname
    Next i
End Sub
---------------------------------------------------
```

- **Attach individual point data in the DataHub instance, one point per cell, to a table of values.** This macro sets up **DDEAdvise** loops from the DataHub instance to Excel, so that each cell in the table is linked to a point in the DataHub instance.



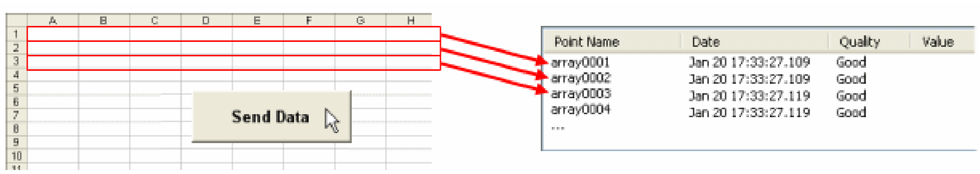
This macro assumes that the data points are named "point0001", "point0002", etc.

```
---------------------------------------------------
Sub register_points()
    Dim pname As String

    For i = 1 To 100
        For j = 1 To 40
            pname = Format((i - 1) * 40 + j, "0000")
            pname = "=datahub|default!point" & pname
            Worksheets("Sheet1").Cells(i, j).Formula = pname
        Next j
    Next i
End Sub
---------------------------------------------------
```

Write data from Excel - User initiated (using DDEPoke)

These macros are useful for writing data out from Excel on demand. In other words, the user decides when to write the data, and does so by running one of these macros (usually from an assigned button click).

- **Transmit array data, one array per row, to points in the DataHub instance.** Triggering this macro writes all the data from the table in Excel to the DataHub instance. The macro writes each row of the table as an array point in the DataHub instance. All rows of the table get transmitted, one after another.

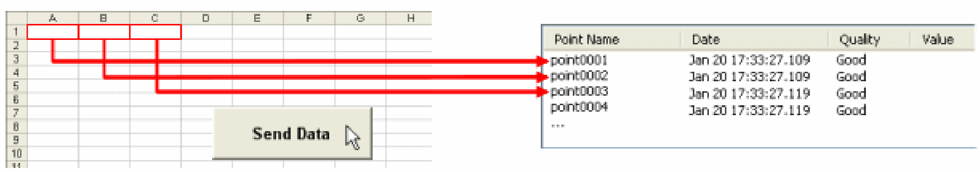


This macro assumes that the data points are named "array0001", "array0002", etc.

```
---------------------------------------------------
Sub transmit_arrays()
    Dim chan As Integer
    Dim pname As String

    chan = DDEInitiate("datahub", "default")
    For i = 1 To 100
```

```
        pname = Format(i, "0000")
        pname = "array" & pname
        DDEPoke chan, pname, _
         Worksheets("Sheet1").Range(Cells(i, 1), Cells(i, 40))
    Next i
    DDETerminate (chan)
End Sub
---------------------------------------------------
```

- **Transmit individual point data, one point per cell, to points in the DataHub instance.** Triggering this macro writes all the data from the Excel table to the DataHub instance. The macro writes each cell of the table in turn to a single point in the DataHub instance.



This macro assumes that the data points are named "point0001", "point0002", etc.

```
---------------------------------------------------
Sub transmit_points()
    Dim chan As Integer
    Dim pname As String

    chan = DDEInitiate("datahub", "default")
    For i = 1 To 100
        For j = 1 To 40
            pname = Format((i - 1) * 40 + j, "0000")
            pname = "point" & pname
            DDEPoke chan, pname, Worksheets("Sheet1").Cells(i, j)
        Next j
    Next i
    DDETerminate (chan)
End Sub
---------------------------------------------------
```

Write data from Excel - Automatically on value change (using DDEPoke)

These macros are useful for automatically transmitting data from Excel into the DataHub instance.

- **Emit new cell values to the DataHub instance.** Whenever a user enters a new value, this macro checks to see if that cell is named. If so, the macro emits the new value to a DataHub point of the same name. The subroutine name "Worksheet_Change" is special

- it is called by Excel whenever a change occurs on the Worksheet due to user input or recalculation (though not a change due to a DDE message; for that see Other Useful Macros).

```
---------------------------------------------------
Sub Worksheet_Change(ByVal Target As Range)
    Dim rname As String
    Dim channel As Variant

    On Error Resume Next
    rname = Target.name.name
    If Not rname = "" Then
        channel = DDEInitiate("datahub", "default")
        DDEPoke channel, rname, Target
        DDETerminate (channel)
    End If
End Sub
---------------------------------------------------
```

- **Transmit changes to a range.** This pair of macros determines that a cell within a particular named range has changed through user input, and transmits the contents of the range to the DataHub instance. This is useful because you do not have to configure each cell you want to write out to the DataHub instance;. If the cell that is changed lies within a defined range, then all values in that range are automatically written out to the DataHub instance.

  The `Worksheet_Change` routine determines the enclosing range for the change, and if the range matches one of a predefined set, it will send that range to the DataHub instance. The `NameOfParentRange` function determines the name of the cell range that intersects a given range. If more than one named range in the worksheet intersects the given range, it returns only the first one.

  Add to Workbook Macro Code:

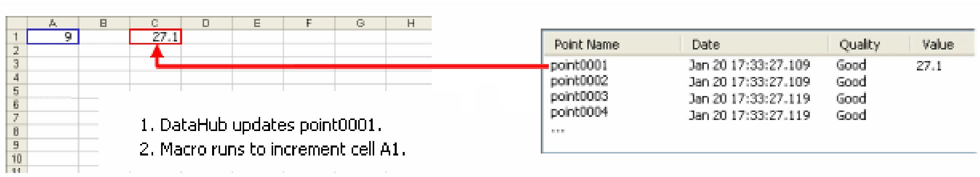
```
---------------------------------------------------
Function NameOfParentRange(Rng As Range) As String
    Dim Nm As Name
    For Each Nm In ThisWorkbook.Names
        If Rng.Parent.Name = Nm.RefersToRange.Parent.Name Then
            If Not Application.Intersect(Rng, Nm.RefersToRange) _
            Is Nothing Then
                NameOfParentRange = Nm.Name
                Exit Function
            End If
        End If
    Next Nm
    NameOfParentRange = ""
End Function
---------------------------------------------------
```

Add to Sheet1 macro code:

```
--------------------------------------------------
Sub Worksheet_Change(ByVal r As Range)
    Dim pname As String
    Dim chan As Integer

    pname = ThisWorkbook.NameOfParentRange(r)
    If Not pname = "" Then
        On Error Resume Next
        chan = DDEInitiate("datahub", "default")
        DDEPoke chan, pname, Worksheets("Sheet1").Range(pname)
        DDETerminate (chan)
    End If
End Sub
--------------------------------------------------
```

Other Useful Macros

- **Cause a macro to run when a DataHub point changes value.** Here is one macro that runs another macro every time a certain cell's value is updated by a DDE message. The macro that gets run is `link_updated`. It simply increments the value in cell `A1`. You can easily change this example to meet your needs. The `set_link` macro tells the workbook to run the `link_updated` macro whenever the DataHub instance sends a DDE message about `point0001`. You can also change the name of the DataHub point as needed.



Add to Sheet1 macro code:

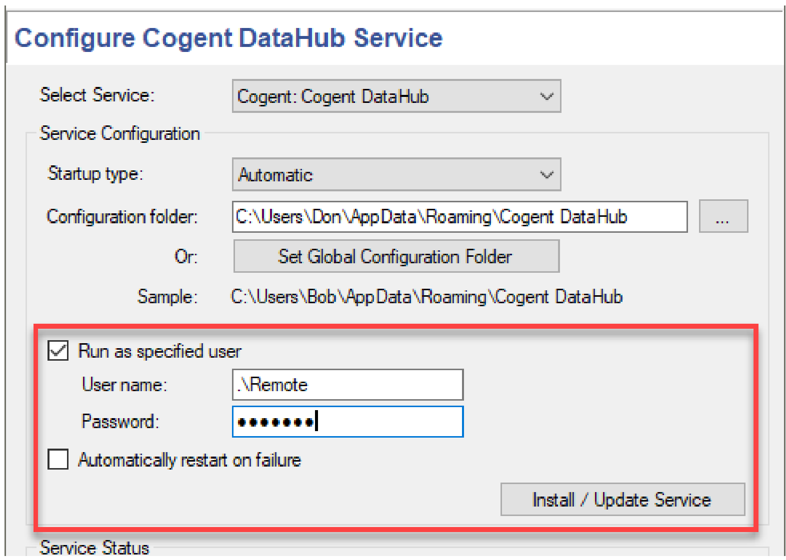
```
--------------------------------------------------
Sub link_updated()
    Cells(1, 1) = Cells(1, 1) + 1
End Sub
--------------------------------------------------
```

Run once to establish the link:

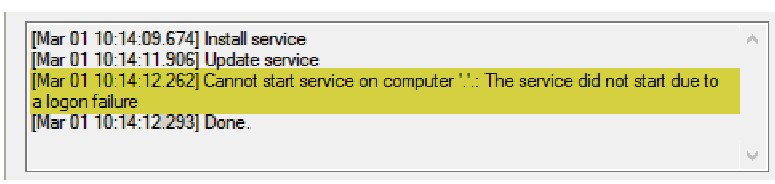
```
--------------------------------------------------
Sub set_link()
    ThisWorkbook.SetLinkOnData "datahub|default!'point0001'", _
    "Sheet1.link_updated"
End Sub
--------------------------------------------------
```

Appendix C. Running as a Windows Service (Specified User)

The following information relates to running the DataHub service as a specified user. **We recommend not doing this as the properties are only available on the service console of the SYSTEM user account.** But in some cases this may be unavoidable.



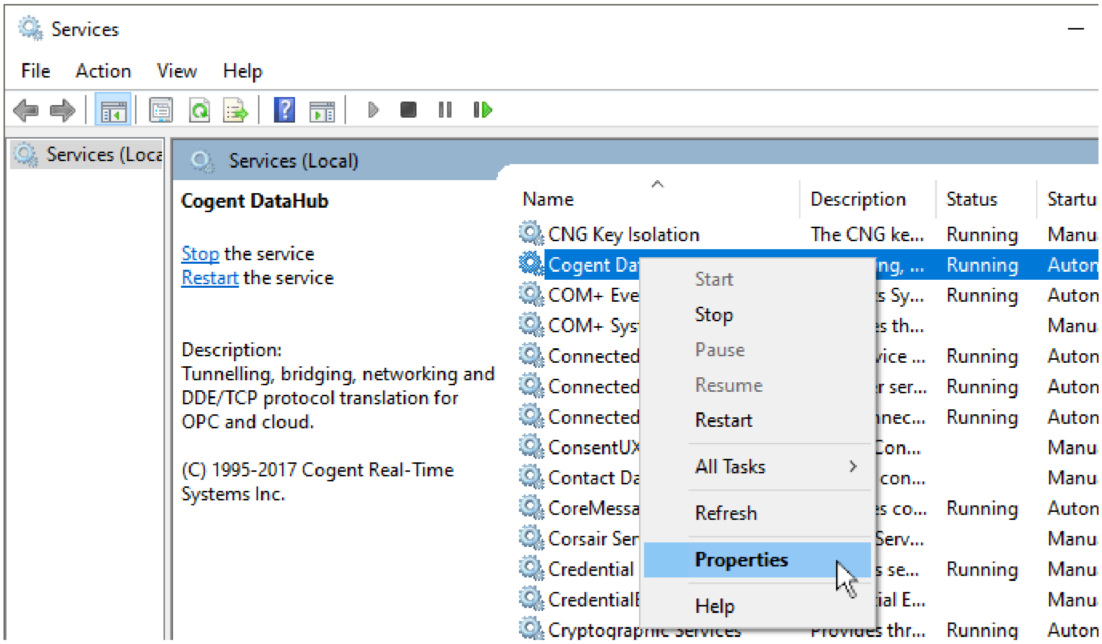
If you try to install the DataHub service as a specified user as explained in the section called "Installing as a Service" then you may find that the service does not run, and you get an error message related to a logon failure, such as this:



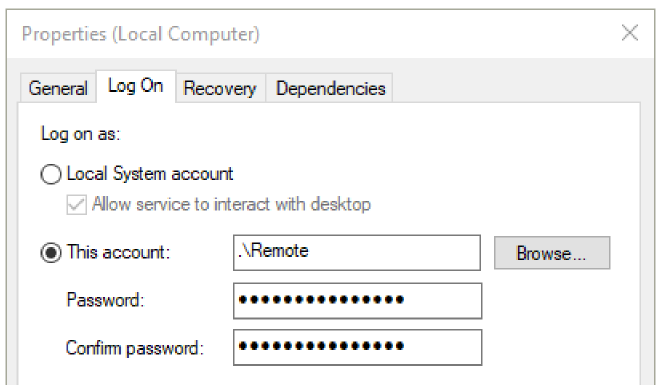
This error occurs when a user who is going to run the DataHub service does not have the permission, or right, to log on as a service in Windows.

One way to set this permission/right is as follows:

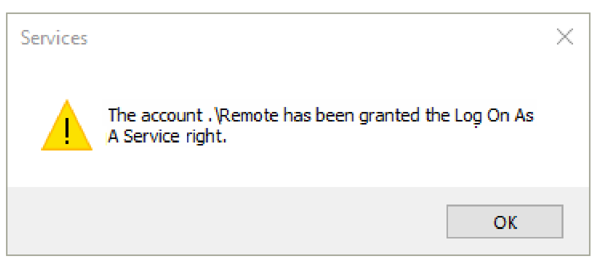
1. Open the Windows **Services** window from the **Control Panel** by selecting **Administrative Tools** and then **Services**.
2. Right click on **Cogent DataHub** and select **Properties**.



3. Click on the **Log On** tab and then retype the password for the user account you are trying to use. Then click **Apply**.



4. You should see a Windows message acknowledging that the right to log on as a service has been granted.



5. Now if you try to start the service from the DataHub Services Manager again it should work.

Appendix D. Windows Services File for Tunnel/ Mirror

If you enter a name for the **Master service/port** in the **Tunnel/Mirror** tab of the Properties window, that name must be listed in the Windows `services` file.

Finding the `services` file

Since each manufacturer's `services` file is different, you must find the `services` file that your TCP/IP protocol stack is currently using. A Microsoft TCP/IP implementation typically puts the `services` file in the `C:\Windows` (or equivalent) directory. Most third party software either installs the `services` file in the same directory that their software was installed or into a directory named `C:\ETC`. Refer to your TCP/IP documentation for the location of this file.

- In Windows NT, the installation program attempts to edit a `services` file in the `\winnt\system32\drivers\etc` directory.
- In Windows XP, the installation program currently does not attempt to edit the `services` file. The default directory for that file is `C:\WINDOWS\system32\drivers\etc\`.

Editing the `services` file

Once you have found the `services` file, you must add the line:

```
service_name    ####/TCP
```

using a text editor. For example, to assign the name `datahub` to port `4502`, you would add the line:

```
datahub     4502/TCP
```

Remember that if you edit the services file with Notepad, it will attach a `.txt` suffix when it saves the file so that you will not in fact have edited the system services file, but instead created a new file, named `services.txt`. You should rename that file `services`, without the `.txt` extension.

Appendix E. DataHub Registry Entries

The DataHub program places registry entries in `HKEY_CURRENT_USER\Software\Cogent\Cogent DataHub`. Many of those entries are used by the DataHub instance to store window position and size. Some of these are user-modifiable to adjust the DataHub instance's behaviour. The following table contains the user-modifiable entries. If an entry does not exist, then the user can create it to achieve the effect. In most cases the DataHub instance must be restarted for the registry entry to apply.

Registry Value Name	Type	Effect
`NetworkComputerPoll`	`DWORD`	Controls the polling for network computer names. By default a DataHub instance will poll the network periodically for the Windows names of all computers. This may cause unwanted network traffic. Setting this value will have the following effect: • `0` = Do not poll for network computer names • `1` = Poll for network computer names exactly once when the DataHub instance starts • `1000` or higher = Poll periodically with a base polling rate of this many milliseconds Numbers < `0` are treated as `0`. Numbers between `2` and `1000` are treated as `1000`. If the key is absent then the DataHub instance defaults to `10,000`ms.
`EmitConsoleEvents`	`DWORD`	Cause the Event Log to be emitted to the debugger console. This is only useful if the DataHub instance is running within a debugger (Visual Studio or WinDbg). • `0` = Do not emit the Event Log to the debug console. • `1` = Emit the Event Log to the debug console.
`EmitConsoleDebug`	`DWORD`	Cause debug-level messages to be emitted to the debugger console. This will only take effect if `EmitConsoleEvents` is also enabled. • `0` = Do not emit debug-level events to the debugger console. • `1` = Emit debug-level events to the debugger console.

Registry Value Name	Type	Effect
`StatusDomainVisible`	`DWORD`	The DataHub instance maintains an internal data domain called “Status” that contains information about its state. This domain is normally not visible in the data viewer, nor visible in queries of available data domains. This value will make the `Status` domain visible. • `0` = Status domain is not visible. • `1` = Status domain is visible.
`MainThreadPriority`	`DWORD`	Sets the operating system thread priority for the main DataHub thread.
`TimerResolution`	`DWORD`	Sets the maximum timer resolution in milliseconds. The DataHub instance will adjust the system “multimedia timer” to this resolution. If this value does not exist then the DataHub instance will query the operating system for the highest available resolution and use that. This number must be at least `1`.
`AdjustTimer`	`DWORD`	Enables multimedia timer adjustment. If this value exists and is not zero then the DataHub instance will adjust the system-wide multimedia timer resolution to the value described in `TimerResolution`. • `0` = Do not adjust the system multimedia timer. • `1` = Adjust the system multimedia timer. The default is `1`.
`DDEAllowBusyAdvise`	`DWORD`	Allow the DataHub instance to process a DDE Advise message while another DDE message is being processed. This is generally dangerous, as the DDE protocol can become confused over which messages belong to a specific transaction. Enabling this could result in failed DDE transactions. • `0` = Do not allow DDE Advise while another DDE message is in process. • `1` = Allow DDE Advise while another DDE message is in process. The default is `0`.

Registry Value Name	Type	Effect
`SslMethod`	`String`	Force the DataHub instance to use a specific SSL method. If this registry entry does not exist then the DataHub instance will use the best available method. Can be one of: • `SslV23` • `SslV3` • `Tls` • `Tls1.1` • `Tls1.2`
`EventLogFontSize`	`DWORD`	The font size of the Event Log window.
`EventLogDirectWrite`	`DWORD`	Event Log display technology selection. This can be one of: • `0` = default • `1` = `DirectWrite` • `2` = `DirectWrite Retain` • `3` = `DirectWrite` to 2D device context.
`EventLogFont`	`String`	The name of the font to use in the Event Log window.
`TCPLicenseTimeoutSecs`	`DWORD`	A DataHub instance waits for 30 seconds after a client connects before verifying the client's license. If the client does not transmit licensing information within the 30 second window, the DataHub instance will assume that the connection is from a custom application using a direct TCP connection, and will attempt to assign a TCP Link license to that client. If no TCP Link license is available, the DataHub instance will terminate the connection with a "no license" error. You can modify this licensing window up to 60 seconds by creating this DWORD registry entry. If you are attempting to tunnel data on a very slow network, it is possible that the slave (client) the DataHub instance sends its licensing information within the 30 second window, but the master DataHub instance does not receive it in time. In this case the DataHub instance will

Registry Value Name	Type	Effect
		report a `no license` error even though both the slave and master are correctly configured with tunnelling licenses. If you encounter this case, try increasing the license window to 60 seconds, or improve the performance of the network. Older versions of the DataHub program set this licensing window to 5 seconds, and did not read the registry entry. If you are encountering issues with a 5-second licensing timeout, please upgrade at least the master DataHub instance to a more recent version.
`TCPMaxQueuedBytes`	`DWORD`	The number of bytes of output that a TCP socket can buffer before the socket is considered "hung" as is closed. The default is `50,000,000`.
`TCPHungQueuedBytes`	`DWORD`	The number of bytes of output that a TCP socket can buffer before the socket starts refusing new data point updates. This is a throttling mechanism that results in old data point values being dropped when newer values for the same data point become available. When the socket buffer is cleared then the DataHub instance automatically stops throttling. The default is `200,000`.
`DisableTCPKeepalive`	`DWORD`	• `0` = Enable TCP keepalive messages. • `1` = Disable TCP keepalive messages. The default is `0`.
`BrowseDA3`	`DWORD`	Force the OPC DA Classic item browser to use a specific technology (OPC DA2 or DA3). If this value does not exist then browsing will use the selected technology from the OPC client configuration dialog. • `0` = Use OPC DA2 when browsing items. • `1` = Use OPC DA3 when browsing items.
`OPCClientGroupName`	`String`	Normally the DataHub instance will set its OPC DA client group name to the program name. If this registry entry exists then this value will be used as the OPC DA client group name instead.

Registry Value Name	Type	Effect
`OPCClientSequentialGroups`	`DWORD`	This entry tells the DataHub instance to append a sequence number to the OPC client group name. This can be useful if you are tracking an issue with repeated DCOM disconnections. • `0` = Do not add a sequence number to the group name. • `1` = Add a sequence number to the group name.
`OPCClientGroupSequenceNumber`	`DWORD`	This entry sets the current sequence number for the OPC client group. It persists through starts and stops of the DataHub instance.
`OPCCheckMemory`	`DWORD`	This entry enables an additional memory check for some OPC DA operations. This option increases CPU usage substantially, so only use this if you suspect an OPC-related memory problem. • `0` = Do not enable additional memory checks. • `1` = Enable additional memory checks.
`OpcAeSkipAttributes`	`DWORD`	This entry will instruct all OPC A&E client (outbound) connections to ignore condition attributes. This can save memory when there are a large number of conditions with attributes. • `0` = Retain condition attributes. • `1` = Ignore condition attributes.

Appendix F. OPC Overview

OPC is a software interface standard that allows HMIs and other programs to communicate with industrial hardware devices.

The acronym "OPC" originally came from "OLE for Process Control". Since OLE (Object Linking and Embedding) is based on the Windows COM (Component Object Model) standard, under the hood OPC was essentially COM. Due to limitations of the COM standard related to networking, security, and reliance on the Windows operating system, the OPC Foundation introduced OPC UA (for "Universal Architecture"), and renamed the original OPC "OPC Classic." They changed the "OPC" acronym to now stand for "Open Platform Communication".

OPC Classic comprises several standards, the first and most important of which is OPC Data Access (DA). There are also standards for Alarms & Events (A&E), Historical Data Access (HDA), and others. OPC UA implements these types of functionality, while running on both Windows and non-Windows operating systems, and providing better networking support and a more sophisticated security model than OPC Classic. Nevertheless, OPC Classic has been highly successful for many years, is widely available, and has a very large installed user base. For these reasons, both OPC Classic and OPC UA are expected to be popular industrial data communications protocols for some time to come.

OPC is implemented in server/client pairs. The **OPC server** is a software program that converts the hardware communication protocol used by a PLC[1] into the OPC protocol. The **OPC client** software is any program that needs to connect to the hardware, such as an HMI[2] . The OPC client uses the OPC server to get data from or send commands to the hardware.

The value of OPC is that it is an open standard, which means lower costs for manufacturers and more options for users. Hardware manufacturers need only provide a single OPC server for their devices to communicate with any OPC client. Software vendors simply include OPC client capabilities in their products and they become instantly compatible with thousands of hardware devices. Users can choose any OPC client software they need, resting assured that it will communicate seamlessly with their OPC-enabled hardware, and vice-versa.

[1]Programmable Logic Controller: a small industrial computer that controls one or more hardware devices.

[2]Human-Machine Interface: a graphical interface that allows a person to interact with a control system. It may contain trends, alarm summaries, pictures, or animation.

The typical OPC connection scenario is a single server-client connection on a single computer as illustrated above, but there are more possibilities. For example, you might need to:

- Connect an OPC client to several OPC servers. This is called aggregation.
- Connect an OPC Classic DA client to an OPC Classic DA server over a network. This can be done with tunnelling.
- Connect an OPC server to another OPC server to share data. This is known as bridging.

The DataHub program is uniquely designed to do all of these tasks, and more. It combines OPC server and OPC client functionality (OPC Classic DA and A&E, as well as UA) to supports multiple connections. Thus it can connect to several OPC servers simultaneously, for aggregation and bridging. Two DataHub instances can mirror data across a TCP network to provide tunnelling, typically used for OPC Classic DA. And because it supports both OPC Classic and OPC UA, the DataHub program can be used as a protocol converter between these two.

In addition to enhancing OPC server and client connections, the DataHub program can connect any OPC server or client to other applications as well, such as Excel, a web browser, or any ODBC database.

Appendix G. DDE Overview

DDE (Dynamic Data Exchange) is a well-established mechanism for exchanging data among processes in MS-Windows. The mechanism was intentionally designed to be easy to use and to represent data as simply as possible. DDE is implemented in many popular programs that run in Windows, such as Microsoft Excel and Microsoft Word. This widespread availability makes DDE a good choice for general data sharing.

The competition with DDE is COM, with its variants for OLE: OPC and ActiveX. By comparison, DDE is simpler, and therefore faster, than the equivalent COM interface if implemented as a separate process. DDE is much easier to implement in code, and offers a particular data model as (name, value) pairs. In the case of real-time data, this model is well suited, and therefore offers the best cost/benefit ratio when programming for real-time data.

However, DDE was not designed to be used over a network. The Cogent solution for this shortcoming is to tunnel/mirror two DataHub instances over a network or the Internet using TCP. Thus, two programs that use only DDE can exchange data across a robust, TCP-enabled link.

Data Definitions

DDE defines data in terms of (service, topic, item), explained as follows:

service
: A name used by a DDE server to identify its service to DDE clients. The default DDE service name for the DataHub program is `datahub`. Unlike most Windows programs, the DataHub program lets you change this name, or add more names if you'd like.

topic
: A way to categorize items. This corresponds to a DataHub *data domain*.

item
: A variable that holds a value. This corresponds to a DataHub *point*.

Here are some service and topic names for several Windows programs:

Application	DDE Service Name	DDE Topic Name
Cogent DataHub	Multiple names can be assigned. The default name is `datahub`.	Any DataHub domain name, the default domain is `default`.
Microsoft Excel	`EXCEL`	The name of the spreadsheet, chart, macro, etc. For example: `mysheet.xls`

Application	DDE Service Name	DDE Topic Name
Microsoft Access	MSACCESS	The name of the table, SQL query, or macro to run.
Microsoft Word	WINWORD	The name of the document, including the .doc extension.
FoxPro	FOXPRO	
InTouch Viewer	VIEW	TAGNAME
FIX DMACS	DMDDE	DATA
National Instruments' Lookout	LOOKOUT	The name of the application, without the `.lkp` extension.
Asymetrix Toolbook	TOOLBOOK	The name of the toolbook application, with the `.tbk` extension.

Here are a few service and topic names for financial data feeds:

Data Feed	DDE Service Name	DDE Topic Name	Symbol Example
ADP Shark	ML	LP	IBM.N.Q
Bloomberg	BLP	M	IBM EQUITY,[LAST TRADE]
Bridge	BDDE	TKR	@USH8/LS
FXCM	FXPS	BID	EUR/USD
Future Source (CalcSource)	CALCSRC	P	USH8.LAST
Future Source (ProfNet)	PROFDDE	LIVE	APIU02,LAST
Knight Rider Profit Center	QMASTER	QUOTE	USH8.LAST
METATRADER	MT	BID	USDCHF
METATRADER v. 4	MT4	BID	USDCHF
MGFOREX	MGFOREX	RATES	USD
Moneycast	WBSERVER	SES	19/L (19 is a stock code)
Reuters	REUTER	IDN	USH8 /IBM ,LAST
Telerate WorkStation	TWINDDE	QUOTES	USH8.3 LAST
Universal Market Data Server	USDDE	QUOTE	US8H;LAST

Client and Server

In DDE, the role of client and server in data exchange is fairly clear. A client initiates the activity, and the server responds. To facilitate two-way data transfer, each DataHub instance can each act as both client and server. This is what allows Excel spreadsheets to share data bidirectionally across a network.

Sending and Receiving Data

There are three ways to send and receive ordinary data over DDE. Here is a brief explanation, using a DataHub instance and Microsoft Excel as examples:

Poke The client sends data for an item directly to the server. In Excel, this is done with a macro. The server does not necessarily reply. The actual data flow is from client to server —from Excel to the DataHub instance.

Request The client asks the server to send an item's data. In Excel, this is done with a macro. The client receives either the requested value, or `NULL` if the server can't send the value. The actual data flow is from server to client—from the DataHub instance to Excel.

Advise The client asks to be notified of any change in the data for an item. If the server agrees to the request, it sends the new value for the item each time its value changes. The DataHub instance can conduct two-way communication with Excel using only this advise capability, as follows:

- To receive data into Excel from the DataHub instance, you set the DataHub instance to act as a DDE server, which requires you to enter a service name. This identifies the DataHub instance to Excel. Then you can drag and drop a point name from the DataHub instance into a cell of an Excel spreadsheet.
- To send data from Excel to the DataHub instance, you set the DataHub instance to act as a DDE client, which requires you to enter service, topic, and item names. These identify the item in the spreadsheet to the DataHub instance. Then, in Excel, you name a cell with the DataHub point name.

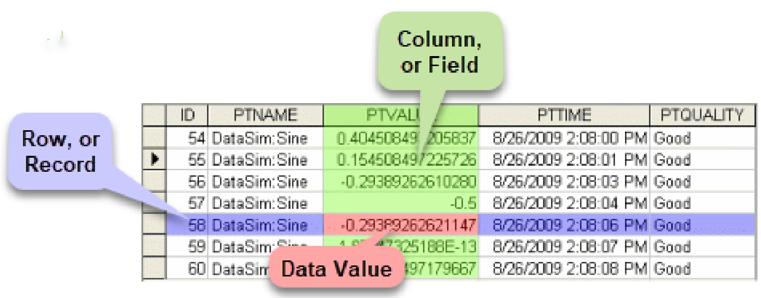
Appendix H. ODBC Database Concepts

Database Terminology and Concepts

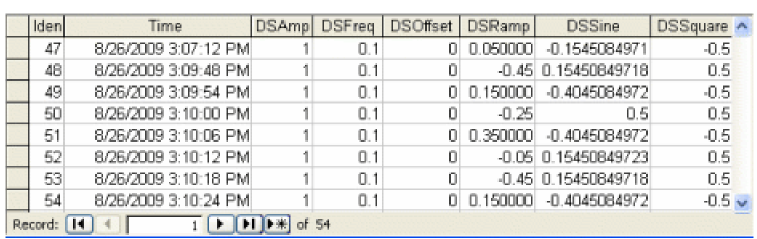
In general, a *database* is a collection of information. Computerized databases store data in *tables*, which are accessed through a *database management system* or *DBMS*, such as SQL Server, MS Access, MySQL, Oracle, etc. All of these are capable of storing data in related, linked tables, which taken together are called a *relational database*. Most modern computerized databases are relational databases.

A database *table* is a logical grouping of related data, organized by the common attributes or characteristics of individual data items. Each *column* or *field* in the table contains a particular attribute, and is of one particular *data type*. Typical data types include boolean, string, numeric, date/time, etc. Each *row* or *record* in the table contains a complete set of every *data value* related to a single item.

For example, a table containing data from the DataHub instance might have columns (fields) for a point name, value, timestamp, and quality. Each row (record) would show the various data values logged for that point at different times:



A different kind of table might have one column for a timestamp, and then additional columns containing the values of different DataHub points logged at each time, like this:



Iden	Time	DSAmp	DSFreq	DSOffset	DSRamp	DSSine	DSSquare
47	8/26/2009 3:07:12 PM	1	0.1	0	0.050000	-0.1545084971	-0.5
48	8/26/2009 3:09:48 PM	1	0.1	0	-0.45	0.15450849718	0.5
49	8/26/2009 3:09:54 PM	1	0.1	0	0.150000	-0.4045084972	-0.5
50	8/26/2009 3:10:00 PM	1	0.1	0	-0.25	0.5	0.5
51	8/26/2009 3:10:06 PM	1	0.1	0	0.350000	-0.4045084972	-0.5
52	8/26/2009 3:10:12 PM	1	0.1	0	-0.05	0.15450849723	0.5
53	8/26/2009 3:10:18 PM	1	0.1	0	-0.45	0.15450849718	0.5
54	8/26/2009 3:10:24 PM	1	0.1	0	0.150000	-0.4045084972	-0.5

Record: 1 of 54

A database table may require each row (or record) to be uniquely identified. This is commonly done through a *key column*, whose main and (sometimes only) purpose is to provide a unique identifying value to the row. Most DBMSs allow this value to be assigned manually by the database user, or automatically through an *auto-incrementing counter* or other mechanism. It is possible for a table to have multiple key columns, but some functions in the DataHub instance will only write to tables with a single key column. For more information about configuring database tables with the DataHub program, please refer to the section called "Configuring a Database Table"

Connecting to a Database: ODBC

Connecting to a database is done through the DBMS, which normally offers two possibilities: *native drivers* and *ODBC* (Open Database Connectivity). Native drivers are inconvenient to use because each requires its own programming interface. ODBC, on the other hand, specifies a standardized, common interface that is available from almost every database vendor, including SQL Server, MS Access, MySQL, Oracle, and many, many more. The DataHub program uses ODBC to connect to databases.

ODBC supports communication with a DBMS locally or across a network, using an *ODBC driver*. Every ODBC-compliant DBMS provides an ODBC driver, which needs to be installed on the user's machine. For example, there is an ODBC driver for MS Access, for SQL Server, for MySQL, and so on.

You can use the Windows **ODBC Data Source Administrator** to configure a connection between the ODBC driver and the specific database you want to work with. That configuration is called the *Data Source Name*, or *DSN*. For example, the DataHub instance references the DSN and uses the configured connection for the ODBC driver to connect to the database.

Configuring the DSN is straightforward, varying slightly depending on the ODBC driver you are working with. Usually you need to select an ODBC driver, create a name for the DSN, and select a database. Other information, such as a login name or password may be required or optional. For more information, please refer to the section called "Setting up the DSN (Data Source Name)"

User Name and Password

According to Microsoft: "If used in an OLE DB or ODBC connection string, a login or password must not contain the following characters:

```
[] {}() , ; ? * ! @
```

These characters are used to either initialize a connection or separate connection values."

In addition to this, the single and double quote characters (' and ") may not work, depending on the database.

Accessing Data: SQL

Once connected to a database, any *queries* (requests) to retrieve, modify, add, or delete data must be made through a language. The most popular database query language is SQL (Structured Query Language), pronounced "sequel" or "ess-kyu-el". Created in the 1960s, this language has become a widely-used standard supported by most DBMSs, although there are some minor variations in certain commands offered.

The DataHub program uses SQL to write to and read from databases. When you configure the Data Logging interface to write DataHub point values, under the hood the commands used are written in SQL. DataHub scripts also use SQL commands to write and read data. For example, the following line from the `ODBCTutorial3.g` script uses an SQL **SELECT** command to pull all of the data from a database table.

```
result = .conn.QueryToClass (.tableclass,
                             string ("select * from ", .tablename));
```

The **SELECT** command is often used with the `FROM` and `WHERE` operators, in queries such as this:

```
SELECT data_element_1
FROM table_1
WHERE data_element_1 > 32 and data_element_1 < 212;
```

The syntax of SQL is fairly simple, and there are many books and online tutorials that can help you learn. The information presented here about SQL, ODBC, and databases in general should be enough to get started logging data with the DataHub program.

Appendix I. Error Messages

This section presents error numbers that the developer may encounter when using the DataHub program.

Windows Error Numbers

Number	Error String	Error Description
0	EOK	No error.
1	EPERM	No permissions, or the user is not the process owner.
2	ENOENT	No such file or directory.
3	ESRCH	No such process.
4	EINTR	Interrupted system call.
5	EIO	I/O error.
6	ENXIO	No such device or address.
7	E2BIG	Argument list is too big.
8	ENOEXEC	Executable format is not recognized.
9	EBADF	Bad file number or invalid file descriptor.
10	ECHILD	No child processes exist.
11	EAGAIN	Resource temporarily unavailable or operation would block.
12	ENOMEM	Out of memory.
13	EACCES	Permission denied.
14	EFAULT	Bad memory address.
15	ENOTBLK	Block operation attempted on non-block device.
16	EBUSY	Device or resource busy, or operation already in progress.
17	EEXIST	File exists.
18	EXDEV	Cross-device link.
19	ENODEV	No such device.
20	ENOTDIR	Not a directory.
21	EISDIR	Is a directory.
22	EINVAL	Invalid argument.
23	ENFILE	File table overflow.

Number	Error String	Error Description
24	EMFILE	Too many open files.
25	ENOTTY	Character operation on non-character device.
26	ETXTBSY	Text file is busy.
27	EFBIG	File is too large.
28	ENOSPC	No space left on device.
29	ESPIPE	Illegal seek attempted on a pipe.
30	EROFS	Attempted write to a read-only file system.
31	EMLINK	Too many links.
32	EPIPE	Broken pipe.
33	EDOM	Math argument out of data domain of function.
34	ERANGE	Result too large.
35	EUCLEAN	
36	EDEADLOCK	Deadlock avoided.

Windows TCP Error Numbers

Number	Error String	Error Description
10035	EWOULDBLOCK	Resource temporarily unavailable or operation would block.
10036	EINPROGRESS	Operation now in progress.
10037	EALREADY	Device or resource busy, or operation already in progress.
10038	ENOTSOCK	Socket operation on non-socket.
10039	EDESTADDRREQ	Destination address required.
10040	EMSGSIZE	Message too long.
10041	EPROTOTYPE	Protocol wrong type for socket.
10042	ENOPROTOOPT	Protocol not available.
10043	EPROTONOSUPPORT	Protocol not supported.
10044	ESOCKTNOSUPPORT	Socket type not supported.
10045	EOPNOTSUPP	Operation not supported.
10046	EPFNOSUPPORT	Protocol family not supported.
10047	EAFNOSUPPORT	Address family not supported by protocol family.

Number	Error String	Error Description
10048	EADDRINUSE	Address already in use.
10049	EADDRNOTAVAIL	Can't assign requested address.
10050	ENETDOWN	Network is down.
10051	ENETUNREACH	Network is unreachable.
10052	ENETRESET	Network dropped connection on reset.
10053	ECONNABORTED	Software caused connection abort.
10054	ECONNRESET	Connection reset by peer.
10054	ECONNRESET	Connection reset by peer.
10055	ENOBUFS	No buffer space available.
10056	EISCONN	Socket is already connected.
10057	ENOTCONN	Socket is not connected. Note: If this error appears with this message: `TCP master service initialization failed: 10057` it could mean that a program is holding open port `4502`. This is may be caused by the DataHub instance not shutting down properly for some reason and it is still running, even though the icon is not showing. To check, look in the Windows Task List and see if you can see a DataHub instance running. If it is, then you can kill it in the list and restart the DataHub instance. If it's not in the list, then you need to use a firewall program to check to see which program is using port 4502.
10058	ESHUTDOWN	Can't send after socket shutdown.
10059	ETOOMANYREFS	Too many references: can't splice.
10060	ETIMEDOUT	Connection timed out.
10061	ECONNREFUSED	Connection refused.
10062	ELOOP	Too many symbolic link or prefix loops.
10063	ENAMETOOLONG	Name too long.

Number	Error String	Error Description
10064	EHOSTDOWN	Host is down.
10065	EHOSTUNREACH	No route to host.
10066	ENOTEMPTY	Directory not empty.
10067	EPROCLIM	Process count limit reached.
10068	EUSERS	User count limit reached.
10069	EDQUOT	Quota limit reached.
10070	ESTALE	Potentially recoverable i/o error.
10071	EREMOTE	Too many levels of remote in path.

Windows DDE Error Numbers

Number	Error String	Error Description
16384	DMLERR_ADVACKTIMEOUT	Timeout waiting for an advise acknowledge.
16385	DMLERR_BUSY	Recipient is busy.
16386	DMLERR_DATAACKTIMEOUT	Timeout waiting for an advise data acknowledge
16387	DMLERR_DLL_NOT_INITIALIZED	DDEML.DLL is not initialized.
16388	DMLERR_DLL_USAGE	General DDE library usage error.
16389	DMLERR_EXECACKTIMEOUT	Timeout waiting for an exec acknowledgment.
16390	DMLERR_INVALIDPARAMETER	Invalid parameter to DDEML function call.
16391	DMLERR_LOW_MEMORY	Memory is becoming low.
16392	DMLERR_MEMORY_ERROR	Memory is exhausted.
16393	DMLERR_NOTPROCESSED	Receiving task was not interested in message.
16394	DMLERR_NO_CONV_ESTABLISHED	No DDE conversation could be established.
16395	DMLERR_POKEACKTIMEOUT	Timeout waiting for a poke acknowledge.
16396	DMLERR_POSTMSG_FAILED	Attempt to post a window message failed.
16397	DMLERR_REENTRANCY	The DDE library was re-entered during a blocking call.
16398	DMLERR_SERVER_DIED	DDE server has died.

Number	Error String	Error Description
16399	DMLERR_SYS_ERROR	A DDE call has caused a system error.
16400	DMLERR_UNADVACKTIMEOUT	Timeout waiting for an unadvised acknowledge.
16401	DMLERR_UNFOUND_QUEUE_ID	DDE queue id could not be found.

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SHTTPD

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Version 2, June 1991

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Version 2.1, February 1999

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Section 1

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   (For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must be optional: if the application does not supply it, the square root function must still compute square roots.)

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This option is useful when you wish to copy part of the code of the Library into a program that is not a library.

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Section 5

A program that contains no derivative of any portion of the Library, but is designed to work with the Library by being compiled or linked with it, is called a “work that uses the Library”. Such a work, in isolation, is not a derivative work of the Library, and therefore falls outside the scope of this License.

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If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may distribute the object code for the work under the terms of Section 6. Any executables containing that work also fall under Section 6, whether or not they are linked directly with the Library itself.

Section 6

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a. Accompany the work with the complete corresponding machine-readable source code for the Library including whatever changes were used in the work (which must be distributed under Sections 1 and 2 above); and, if the work is an executable linked with the Library, with the complete machine-readable “work that uses the Library”, as object code and/or source code, so that the user can modify the Library and then relink to produce a modified executable containing the modified Library. (It is understood that the user who changes the contents of definitions files in the Library will not necessarily be able to recompile the application to use the modified definitions.)
b. Use a suitable shared library mechanism for linking with the Library. A suitable mechanism is one that (1) uses at run time a copy of the library already present on the user's computer system, rather than copying library functions into the executable, and (2) will operate properly with a modified version of the library, if the user installs one, as long as the modified version is interface-compatible with the version that the work was made with.
c. Accompany the work with a written offer, valid for at least three years, to give the same user the materials specified in Subsection 6a, above, for a charge no more than the cost of performing this distribution.
d. If distribution of the work is made by offering access to copy from a designated place, offer equivalent access to copy the above specified materials from the same place.
e. Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

For an executable, the required form of the “work that uses the Library” must include any data and utility programs needed for reproducing the executable from it. However, as a special exception, the materials to be distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

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b. Give prominent notice with the combined library of the fact that part of it is a work based on the Library, and explaining where to find the accompanying uncombined form of the same work.

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###lt;one line to give the library's name and a brief idea of what it does.###gt; Copyright (C) ###lt;year###gt; ###lt;name of author###gt;

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###lt;signature of Ty Coon###gt;, 1 April 1990 Ty Coon, President of Vice

That's all there is to it!

Cogent DataHub™ service for Azure

Version 11.0

A Microsoft Azure Managed Application based on Cogent DataHub™ software for making secure, real-time data connections between machines, applications, and embedded systems.

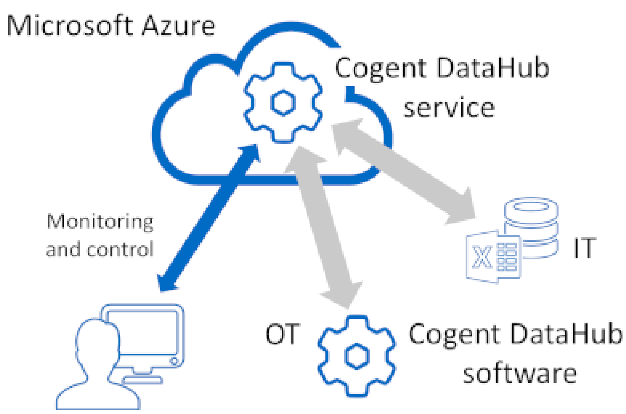
Table of Contents

Overview

The Cogent DataHub service is available as a Microsoft Azure Managed Application, which allows you to make secure connections between machines, applications and embedded systems that utilize real-time data. Based on industry-leading technology, the Cogent DataHub service can help you:

- Aggregate data from multiple sources into a common data set for analysis and storage.
- Make data from your plants available to remote users.
- Feed data from multiple locations into other Azure Managed Applications.

The connection between the data in your plant and your Microsoft Azure VM is established using DataHub technology on both sides. At the plant you install the Cogent DataHub program (or use an ETK-enabled device), to send data to a DataHub instance in the cloud, running as a provisioned Azure Managed Application. You can also connect other programs to the DataHub instance running on Azure, such as databases, historians, and Microsoft Excel.



Connections between DataHub software and services use the DHTP (DataHub Transport Protocol), a secure network protocol designed to optimize and protect data transmitted over public and private networks. DHTP lets you make outbound connections through firewalls, keeping all inbound firewall ports closed on your plant. It supports SSL, connections through DMZs, and network proxies to ensure secure OT/IT connections.

The Cogent DataHub service offers these optional features, which you can activate as needed:

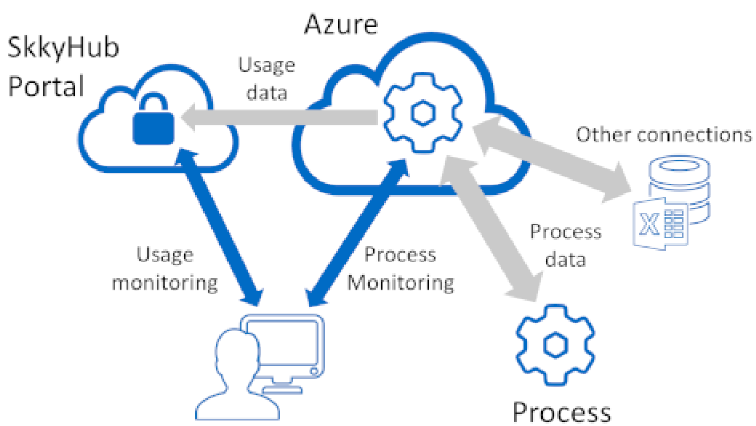
- AVEVA Historian – Read and write data to AVEVA Historian and Insight.
- InfluxDB – Read and write data to InfluxDB. Required for store-and-forward.
- Amazon Kinesis – Write data to Amazon Kinesis with optional store-and-forward.
- MQTT Broker - MQTT Smart Broker with robust MQTT protocol conversion.
- MQTT Client - Connect to MQTT brokers with advanced parsing, protocol conversion

and optional store-and-forward.

- OPC UA - Connect and aggregate OPC UA clients and servers.
- OPC AC – Aggregate and serve OPC UA A&C Alarms and Conditions.
- Notifications - Generate alarms, email, SMS and actions based on data changes.
- Bridging – Zero-latency server-to-server bridging.
- OSIsoft PI System Historian – Read and write data to OSIsoft PI System.
- Redundancy - Resolve identical incoming data streams to a single output.
- REST Historian – Read and write data to the REST Historian.
- WebView – Visualize data with full featured multi-user SCADA HMI.

In addition to these, you can also connect Microsoft Excel worksheets, using the DataHub Add-in for Excel.

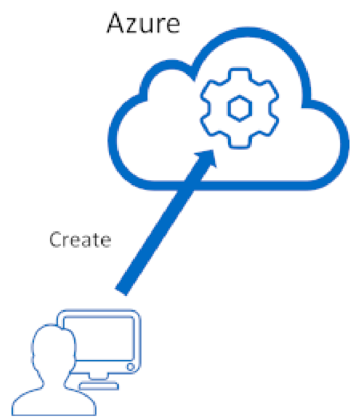
When you register for the Cogent DataHub service, you are billed monthly through your Microsoft account for services used in the previous month. You will also have access to the SkkyHub portal which allows you to monitor your usage.



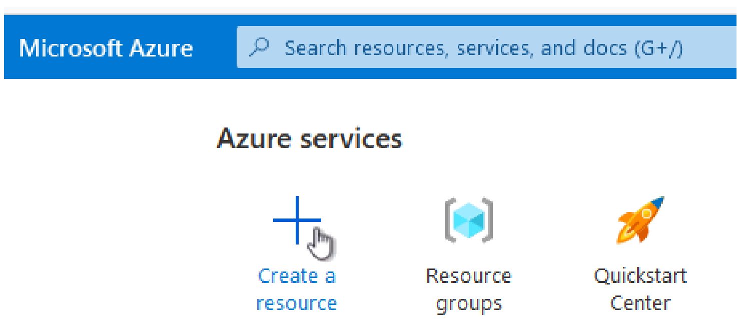
This manual contains the information you need to get started with the Cogent DataHub service. Please feel free to contact Skkynet for additional assistance as needed.

Creating the Azure Resource

To run the DataHub service, you need to create an instance of the Cogent DataHub Azure Managed Application.

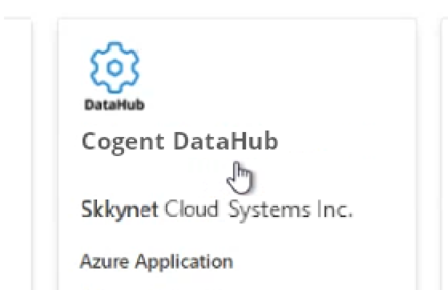


1. Go to https://portal.azure.com and sign in using your Microsoft credential for the Microsoft Commercial Marketplace.
2. Click **Create a resource**

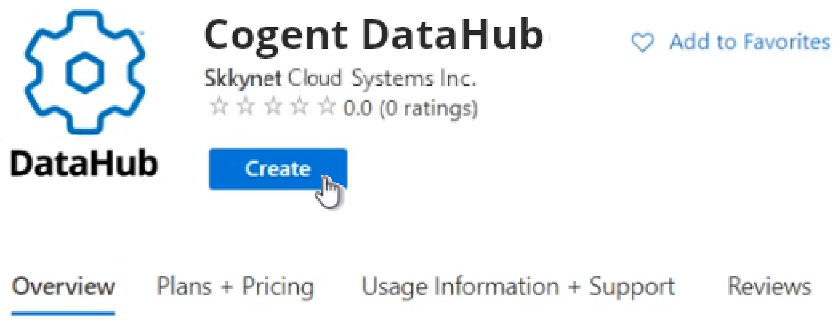


3. Enter `Skkynet` in the search bar.

4. Choose **Cogent DataHub**.

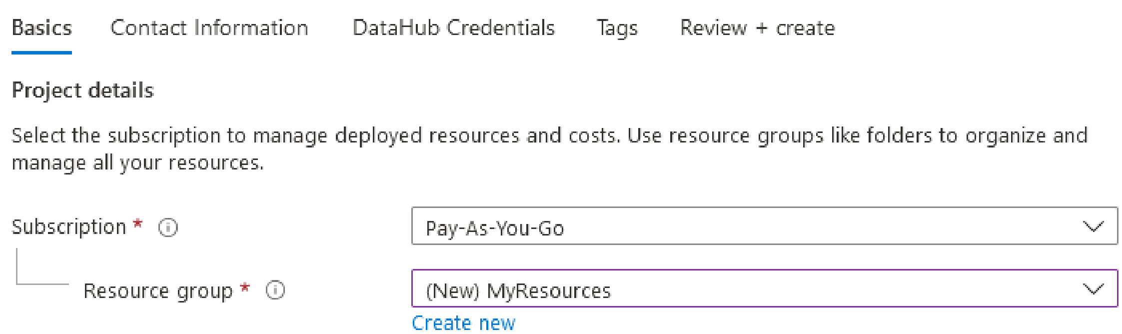


5. Review the information in **Overview** and **Plans** to ensure you understand the features and benefits of the service. For a comprehensive explanation of pricing, see Pricing Information on the Skkynet; website. When you are ready, click **Create** to register.



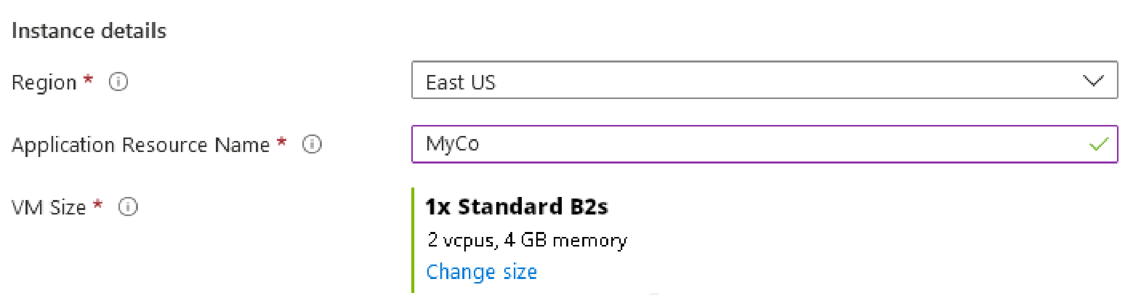
6. Now you need to configure the deployment options for a new Azure Managed Application instance.

   a. **Basics** for this deployment.



Subscription and **Resource Group**

Select the Subscription, and select or create the Resource Group that will contain this resource.



Region

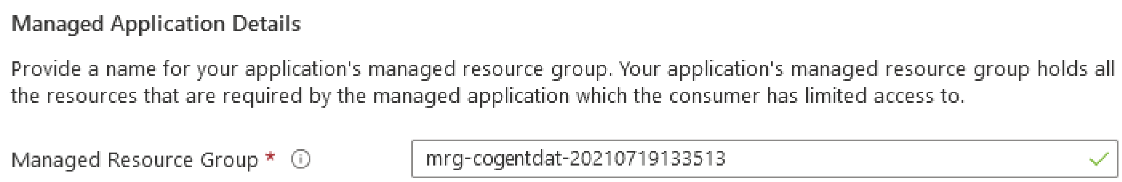
Choose a deployment region appropriate for your business location and source data, primarily to minimize latency.

Application Resource Name

Choose a name for this application. This string will be used as a prefix to name some of the resources, including the public DNS name. We suggest using a word that represents your organization or project, and avoiding generic terms like `MyApp` or `DataHub`.

VM Size

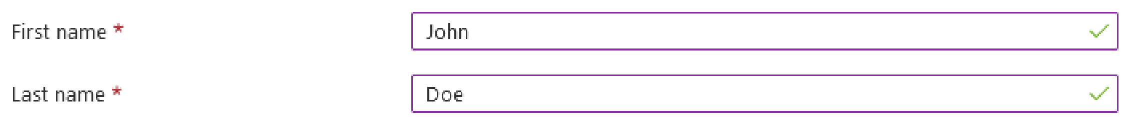
The default size should be adequate for most solutions. If you are configuring a large-scale deployment, you may wish to select a higher-end option.



Managed Resource Group

You can accept the default name.

b. **Contact Information** Your contact information will be kept private, in accordance with Skkynet's privacy policy.



First name and **Last name**

Required, used for communications with Skkynet.

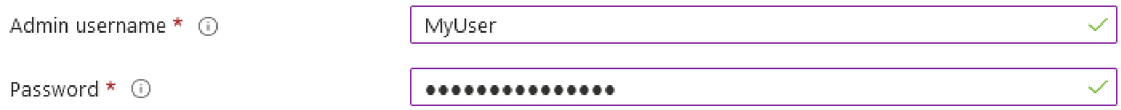
Email address

Required, used for communications with Skkynet. When deployment is complete, a welcome email will be sent to this address containing information you need to access your service.

Phone, **Company name**, and **Company address**

These are optional. Entering them will help Skkynet serve you better.

c. **DataHub Credentials** for accessing this DataHub service. These credentials will be used for the administrator account for your DataHub service as well as for your SkkyHub Portal account.



Admin user name

A single alpha-numeric string with no spaces. The string `Admin` is not permitted.

Password

Must start with a letter and be at least 12 alpha-numeric characters including at least one uppercase letter, one lowercase letter, and one number.

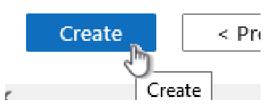
> Your password cannot be retrieved by Skkynet. You must remember it.

d. **Codes** gives you the option to enter an affiliate code, coupon code, or install branch, if desired. Typically these are provided by Skkynet.

e. **Tags** gives you the option to label resources, if desired.

f. **Review + create** lets you look over the terms of the agreement and your entries. When you are sure everything is correct, check the **I agree ...** box.

Review your entries one final time, and if all is correct, click the **Create** button at the bottom.



You will see a **Deployment is in progress** message. At this point, Microsoft begins deploying the VM infrastructure resources needed for your Azure Managed Application. Resources include the VM, disk, virtual network, network interface, network security group, and others.

7. When deployment completes, you can click the **Go to resource** button to access your managed application, and you should see a welcome message.

DataHub

Welcome to the Cogent DataHub Service

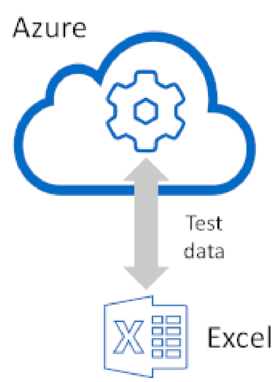
8. After this message is displayed, Skkynet begins provisioning software for the Cogent DataHub service. This includes configuring the DataHub instance to run as a Windows service, generating a certificate to support SSL communication, ensuring the Windows firewall is correctly configured, authenticating the DataHub instance with back-end Azure services, and registering your Managed Application with the SkkyHub Portal. Typically the service is fully deployed and running in less than 30 minutes.

    Once complete, you will receive an email with important information, including your Launch Page and links to help you get started. Keep this information handy. You will need it to access your DataHub service.

Accessing Your DataHub Service

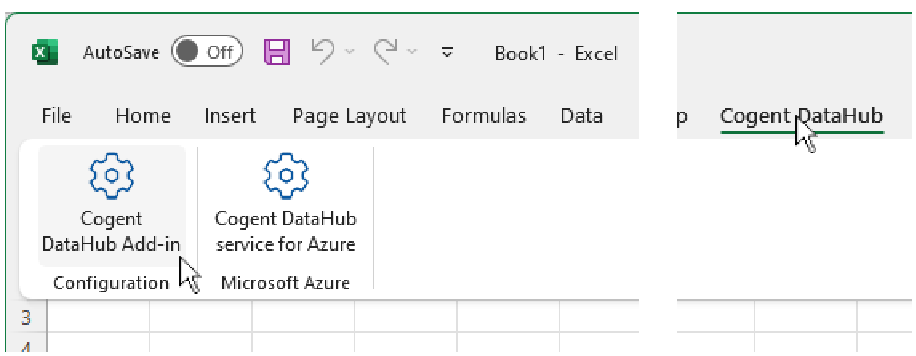
Connecting Test Data

The easiest way to test your Cogent DataHub service is with an Excel spreadsheet on your local machine.

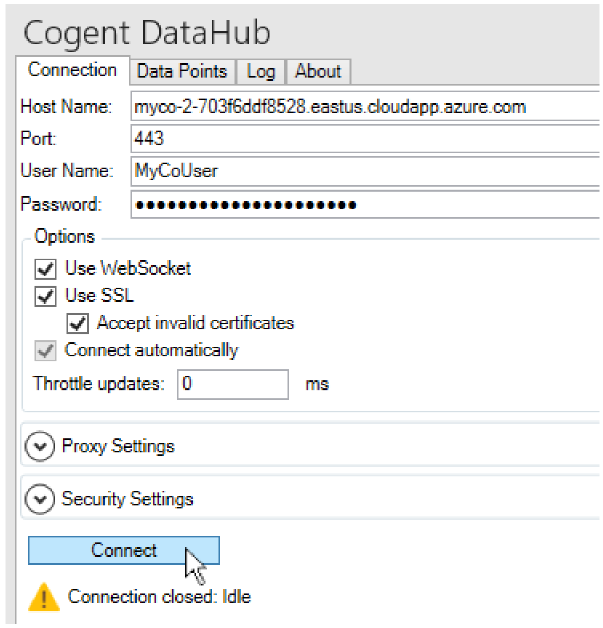


This is done using Cogent DataHub Add-in for Excel. Here's how:

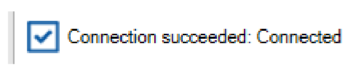
1. Download the DataHub Add-in archive from here.
2. Close Excel if it is open, double-click on the DataHub Add-in archive and follow the instructions to install it. After the installation is complete, re-open Excel. It should have a **Cogent DataHub** option on the menu bar.
3. Select the **Cogent DataHub** option to display the **Configuration** button.



4. Click the **Configuration** button to display the **Cogent DataHub** configuration panel.



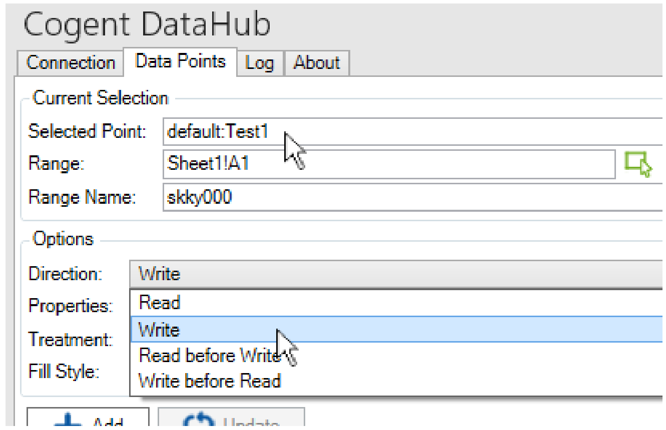
5. Enter the information from the welcome email you received from Skkynet, including **Host Name**, **User Name** and **Password**. For **Port** use 443. Check the boxes **Use WebSocket**, **Use SSL**, and **Accept invalid certificates**.
6. Click the **Connect** button. You should see a success message.



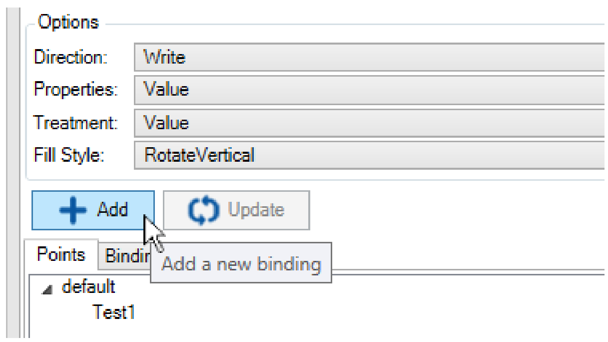
Now you are ready to send and receive data.

1. With cell `A1` active in the worksheet, select the **Data Points** tab, and in the **Selected Point** field, enter `default:Test1`.

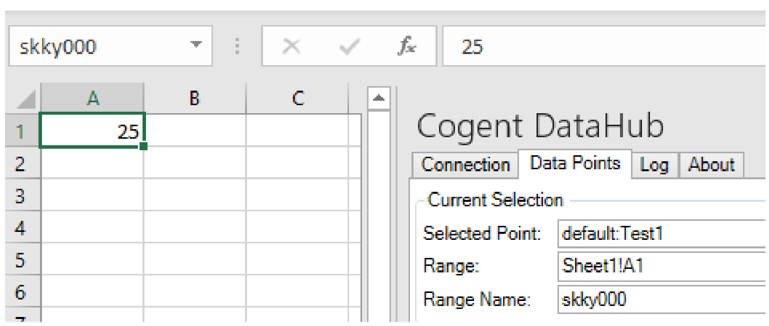
This is the name of a DataHub point. The word `default` identifies the data domain, the colon (`:`) is a separator, and the point name is `Test1`.



2. From the **Direction** drop-down list, choose **Write**.
3. Click the **Add** button. You will see the `default` domain appear in the Points list, and within it, the `Test1` point.

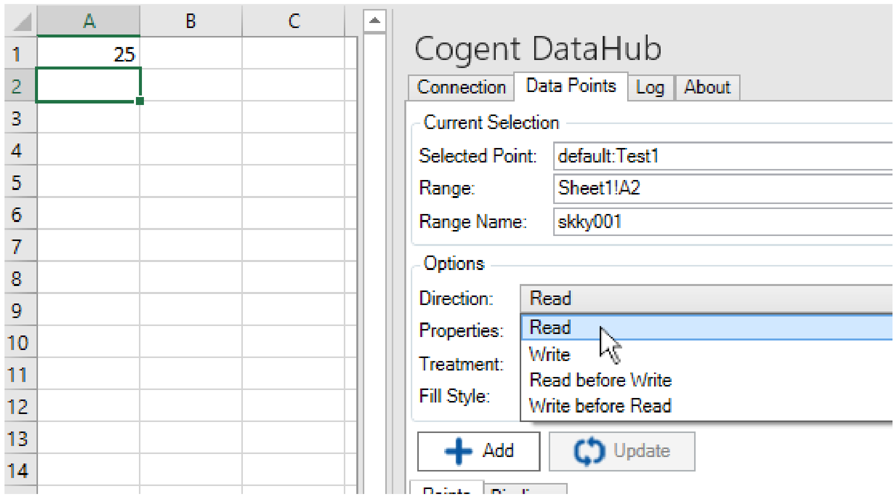


4. Enter a value in the A1 cell.

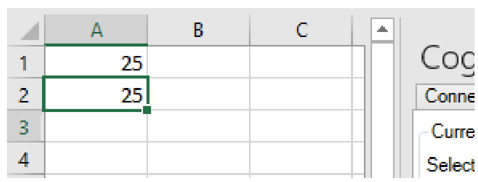


This value gets sent to the DataHub instance running on Azure. To check that, we can configure another cell to read the data.

5. Select cell A2 in the worksheet, and for the **Selected Point** field, enter `default:Test1` again.

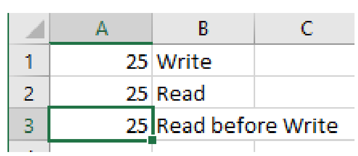


6. This time choose **Read** from the **Direction** drop-down list.
7. Click the **Add** button. That cell will read the value from the Cogent DataHub service, and display it.



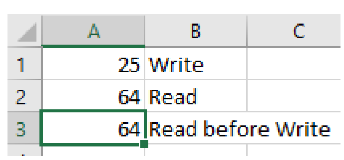
Try changing the value in A1, and you'll see the updates in A2.

8. Here is one more example. Select cell A3, and once again use the `default:Test1` point. But this time make it a **Read before Write** connection. This means it will first read from the Cogent DataHub service, and then write to it if you change the value. You can also add some labels to the cells.



Notice that its value gets filled in automatically.

9. If you change the value in cell A3, the read value in cell A2 changes. The value in A1 doesn't change because it is write-only.



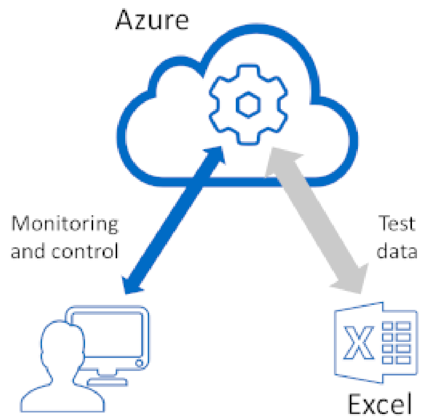
If you change the value in cell A1, both of the other two values change.

This is just one example for connecting a client to the Cogent DataHub service. For more information on Cogent DataHub Add-in for Excel, please refer to the documentation.

Next we can take a look at the service itself, using the Remote Config application.

Using Remote Config

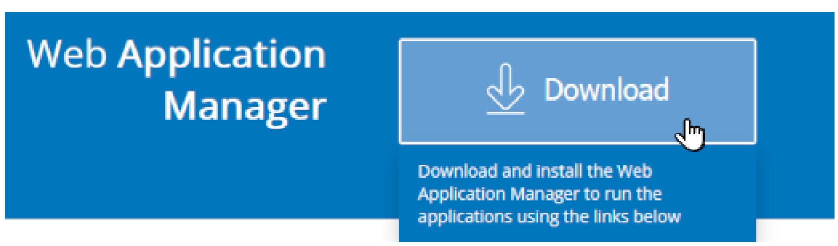
You can use the Remote Config application to access your DataHub service and view data.



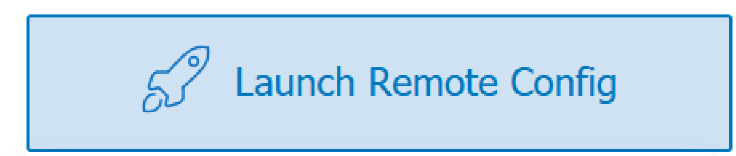
1. Download and run the Skkynet Web Application Manager by clicking the Web Launch Page link in the email you received from Skkynet.

   - **Host:** myco-2-703f6ddf8528.eastus.cloudapp.azure.com
   - **Web Launch Page:** https://myco-2-703f6ddf8528.eastus.cloudapp.azure.com

2. Click the **Download the Web Application Manager** button.

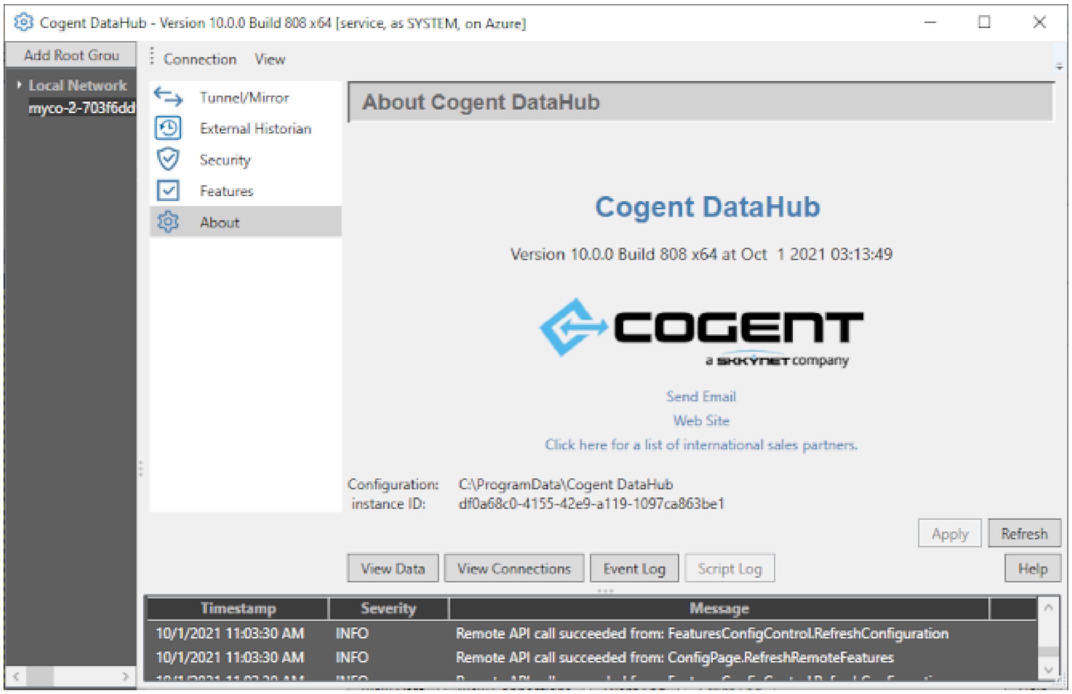


3. Click the **Launch** button for Remote Config.

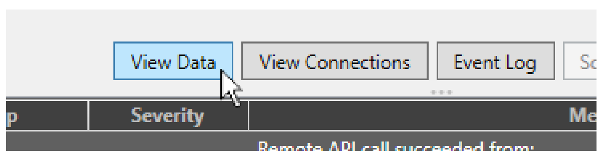


The first time you run this, a dialog will ask if you want to switch to the Web Application Manager. If so, click **Accept**, and use the Web Application Manager as described here to enable the launch of the Remote Config application.

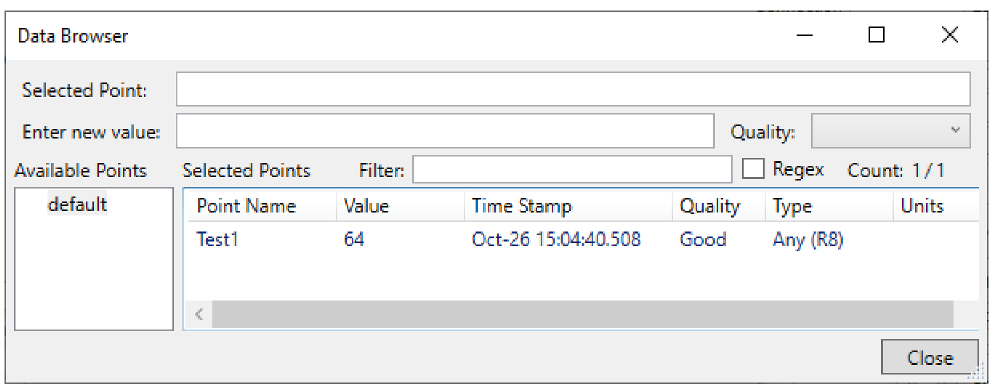
4. The Remote Config application will launch:



5. Click the **View Data** button to open the DataHub Data Browser.

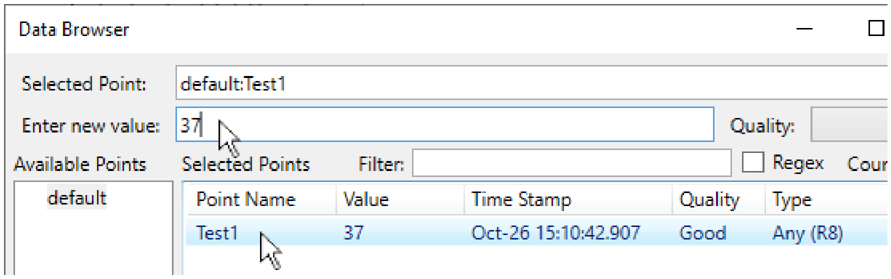


6. You should see the data point and value from your worksheet.

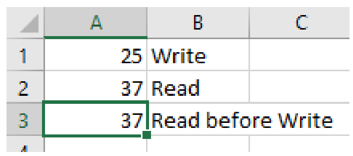


The data shown here was created previously in the Connecting Test Data section.

7. You can try changing the value of the point by clicking on the point name, and then entering a new value.



8. The value should propagate to your worksheet.

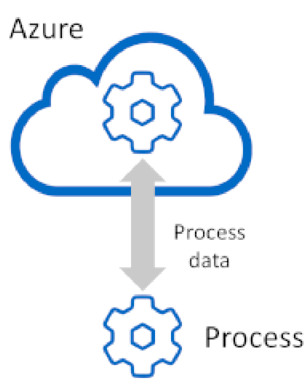


	A	B	C
1	25	Write	
2	37	Read	
3	37	Read before Write	

Please see Remote Config for more information about using Remote Config.

Connecting Process Data

The Cogent DataHub service is often used to monitor and interact with industrial control systems that work with live data. You can use a local installation of the Cogent DataHub software to connect to such processes. For this test, we will use a local DataHub instance connected to a data simulator called DataPid.

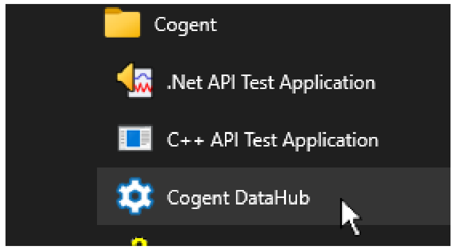


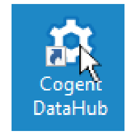
If you don't have the DataHub program installed locally, you can download the DataHub software from the Cogent DataHub website. For information on installation and configuration, please refer to the Cogent DataHub software manual in this set of documentation.

To access process data, you need to connect the local DataHub instance to your Cogent DataHub service using a tunnel connection. The local DataHub instance will act as a tunnel slave, while the Cogent DataHub instance running on Azure will be the tunnel master. Here is how to do it:

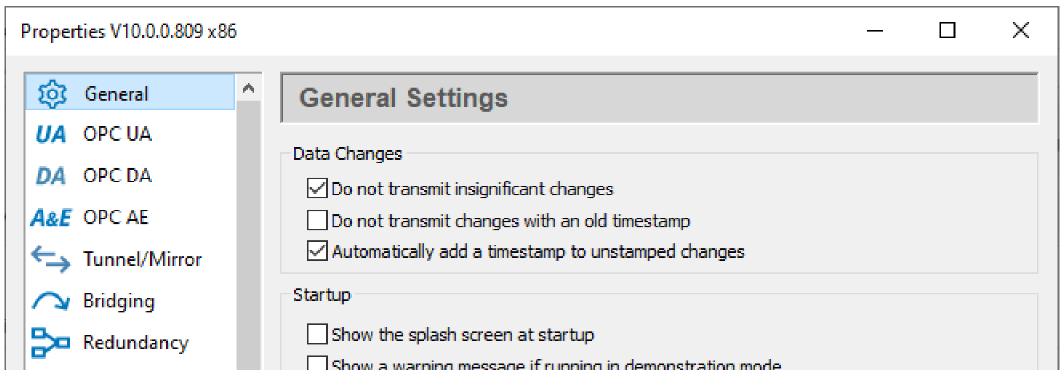
1. Start the DataHub program installed on your local computer. Select it from the

Windows **Start** menu, or double click the DataHub shortcut icon.

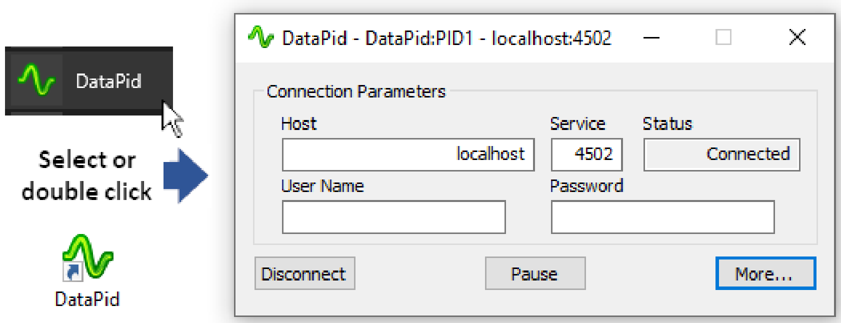




Once started, the DataHub instance opens the Properties window.

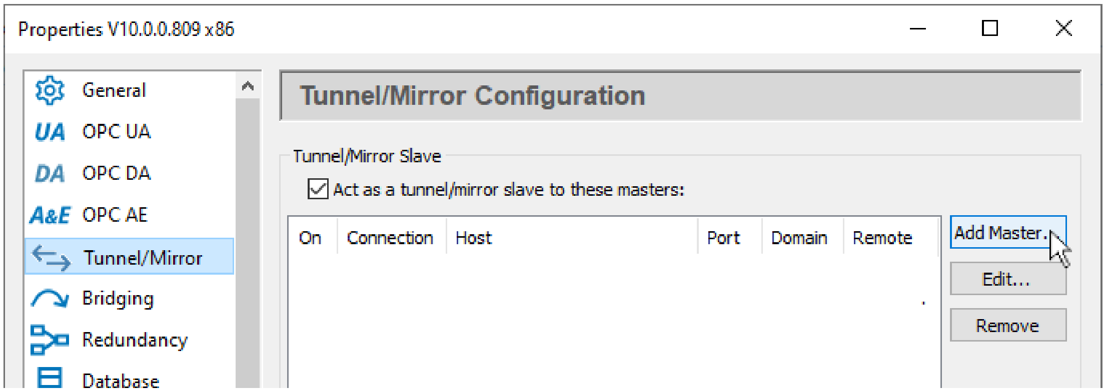


2. Start the DataPid program and ensure it is connected and sending data to your local DataHub instance.

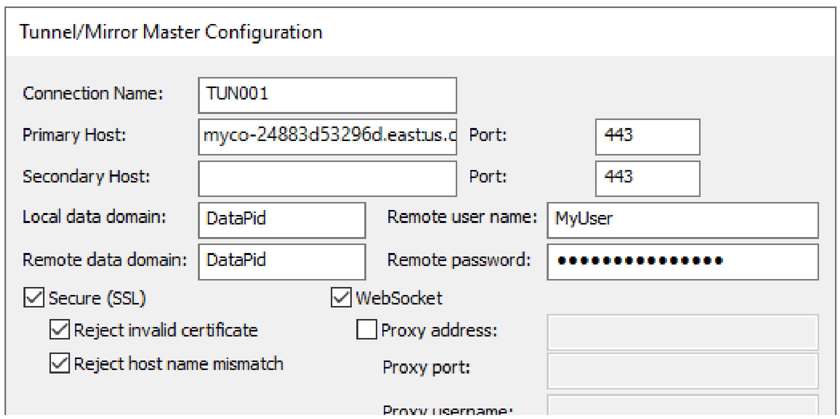


This program produces live data to simulate an industrial process.

3. In the DataHub Properties window, select the **Tunnel/Mirror** option.

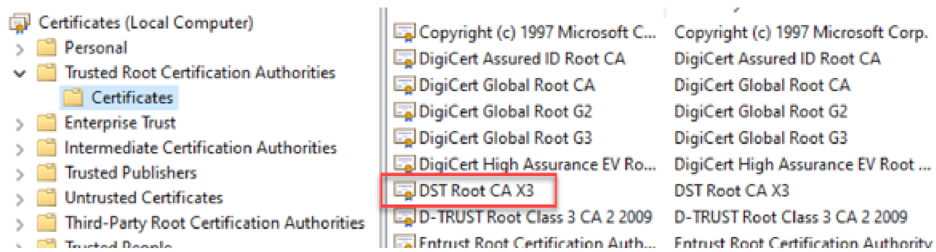


4. Click the **Add Master** button and configure a tunnel slave connection to the DataHub instance on Azure (the tunnel master) as follows:



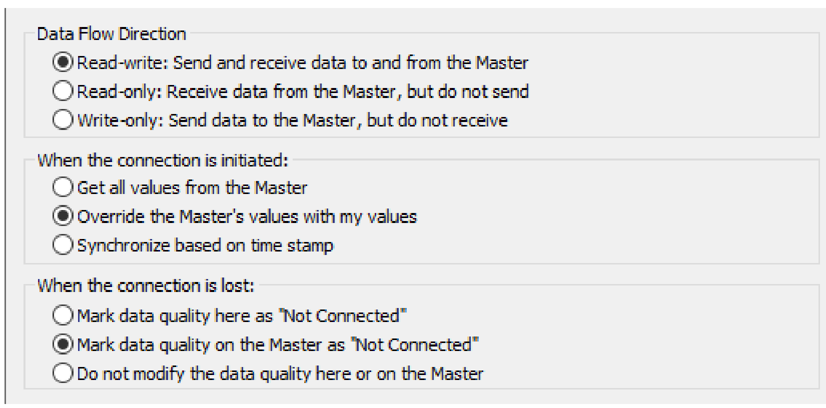
- **Connection Name**: A unique name for this connection, with no spaces in it.
- **Primary Host**: The Host string provided in the email you received from Skkynet.
- **Port**: The port number 443 will be entered automatically when you choose the **Secure (SSL)** and **WebSocket** option.
- **Local data domain**: Enter `DataPid`, to send DataPid data.
- **Remote data domain**: Enter `DataPid`, to receive the DataPid data.
- **Remote user name**: Enter the User Name for this account. It is in the email you received from Skkynet.
- **Remote password**: Enter the password associated with the **User Name**. Remember, this password cannot be recovered, and you will likely be using it again, so be sure to remember or record it in a safe, responsible way.
- **Secure (SSL)**: Check this box. Also check **Reject invalid certificate** and **Reject host name mismatch**, since certificates for the DataHub service should always be valid.

The Cogent DataHub service uses certificates signed by R3, Let's Encrypt with a root certificate authority of **DST Root CA X3**. If you get errors indicating the certificate is not trusted, you can run Windows Update to ensure the root CA is added to your Trusted Root Certification Authorities.



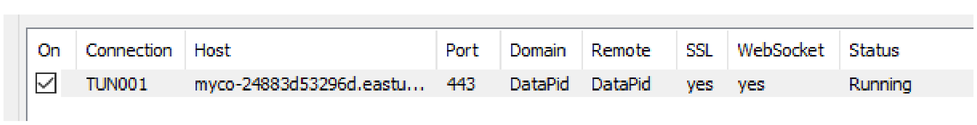
- **WebSocket**: Check this box.

Configure the connection options as follows:

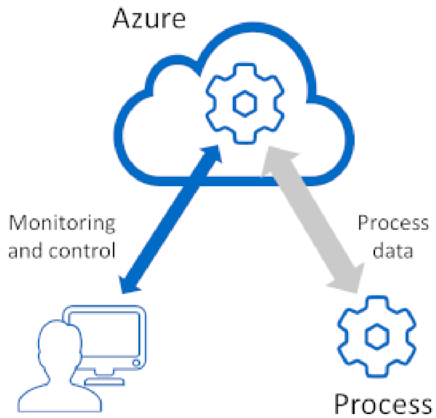


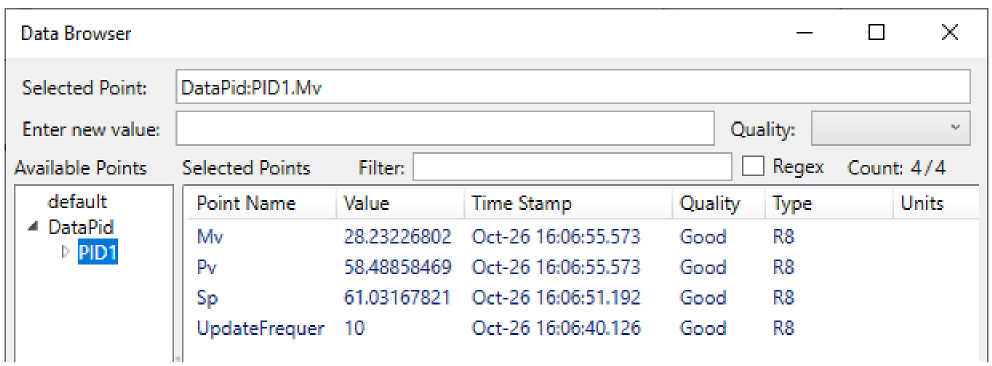
- **Data Flow Direction**: make this **Read-write** for now.
- **When the connection is initiated**: should be set to **Override the Master's values with my values.** This way, after a disconnect, the DataHub service will get the latest values from this DataHub instance when it reconnects.
- **When the connection is lost**: should be set to **Mark data quality on the Master as "Not Connected"**. Again, since this DataHub instance is the authoritative source of the data, you want the lost connection to register on the DataHub service, the destination.

5. Click **OK** and **Apply**. The **Status** for this tunnel should change to **Running**, which means you are now tunnelling data to your DataHub service.

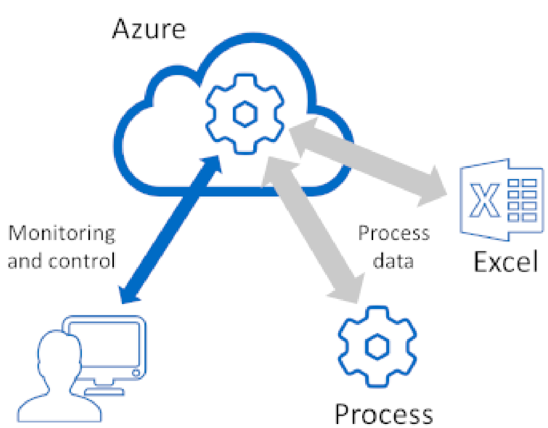


You can access your DataHub service and view the tunnelled data using the Remote Config application, as explained previously.

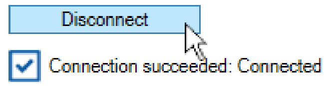




You can also view your process data in Excel.

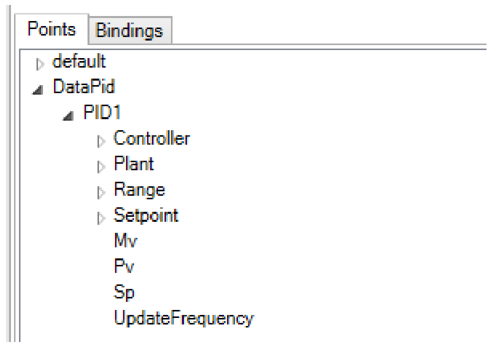


1. If you haven't done so already, follow the steps in Connecting Test Data to see how to use DataHub Add-in for Excel and do the necessary configuration.
2. In the DataHub Add-in configuration panel, go to the **Connection** tab, and then click the **Disconnect** button.

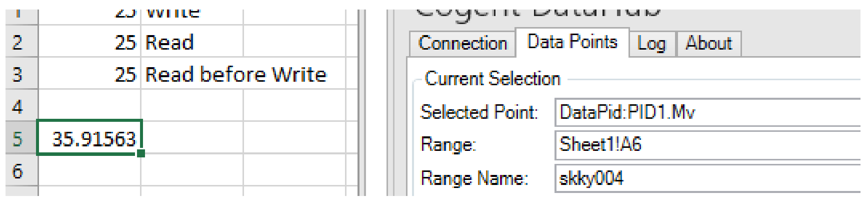


The button text will change to **Connect**.

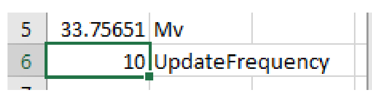
3. Click the **Connect** button. This disconnect/reconnect cycle will reload the data set from the Cogent DataHub service.
4. Go back to the **Data Points** tab. You will now see a **DataPid** entry under **Points**.



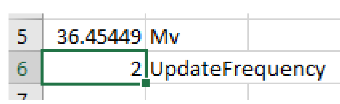
5. In the worksheet, select cell A5, and then in the DataHub Add-in configuration, double click on the **Mv** point in the list. The point configuration will get filled in for you, and the data will start coming in.



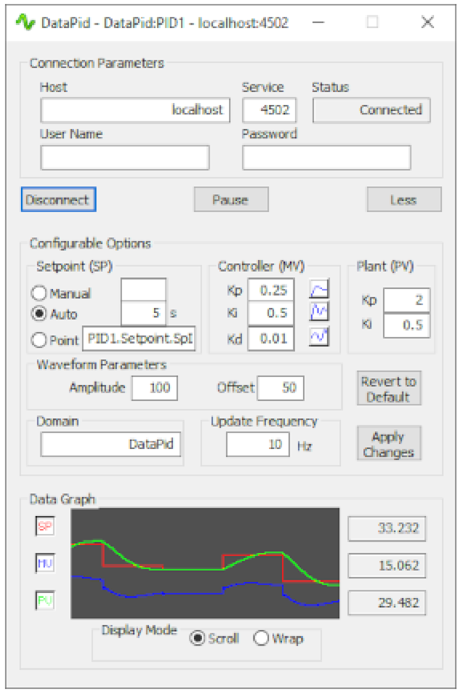
6. To simulate controlling a process, select cell A6, and in the DataHub Add-in **Points** configuration, double click on the **UpdateFrequency** point. The value of 10 should appear in cell A6. You can also add labels to these two cells in B5 and B6.



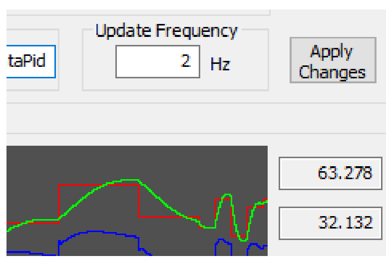
7. If you change the value in A6 from `10` to `2`, you should see the Mv data update twice per second instead of ten times per second.



8. To check, go to the DataPid interface, and click the **More** button to open the full DataPid window:



You will see that the **Update Frequency** value has changed from `10` to `2`.



Changing the value in DataPid will change the value in the worksheet, and vice-versa.

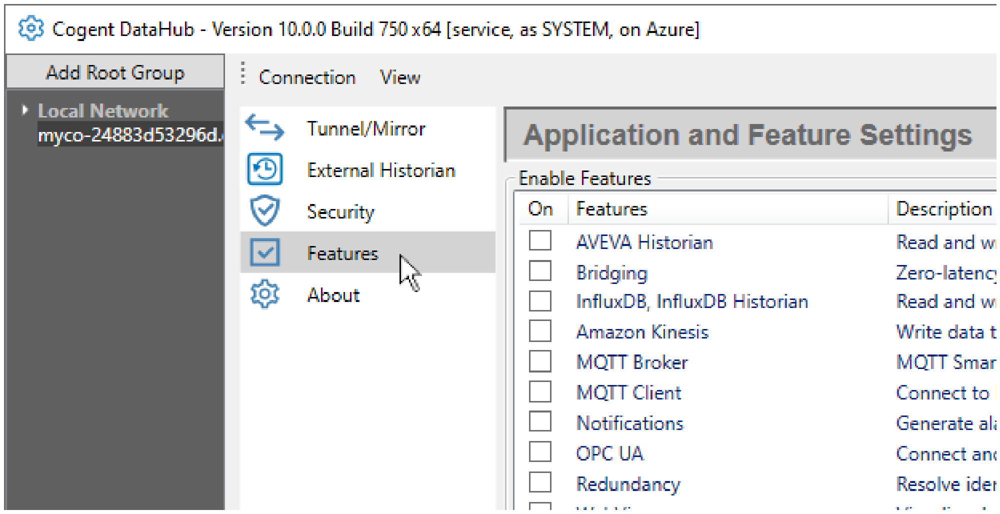
This is a simple example of how you can send live process data to the Cogent DataHub service, access it from a connected client, and then send control signals back to the process. Of course, using the Cogent DataHub software you can connect virtually any industrial or local process, and with the Cogent DataHub service you can connect any client running on Azure or elsewhere.

Activating Features

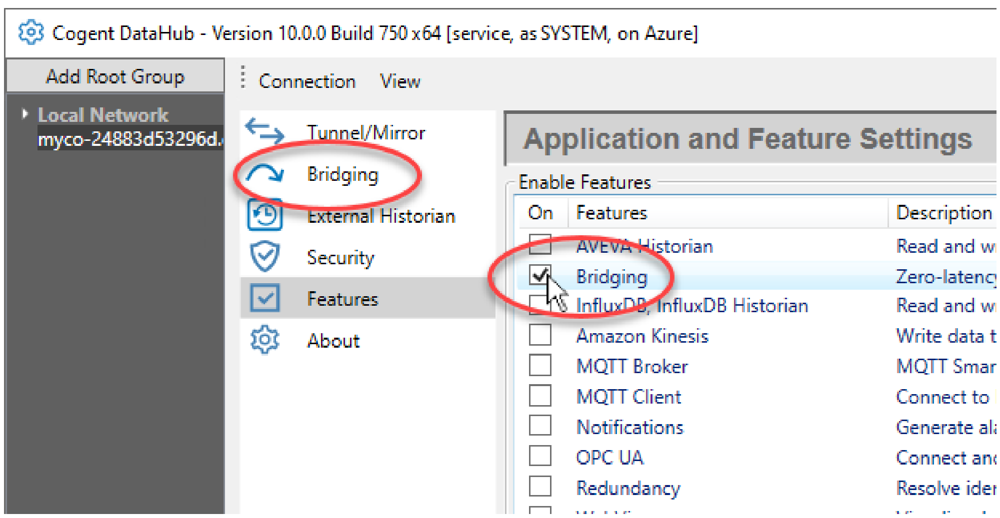
You can easily extend the capabilities of your DataHub service using the **Features** option in Remote Config.

This option is currently only available for the Cogent DataHub service. Each feature is billed hourly. Usage can be monitored through the SkkyHub Portal.

1. In Remote Config, select the **Features** option.



2. Check the box of the feature(s) you want, and click **Apply**.



The feature(s) you have selected are now available. You can remove a feature at any time by unchecking its box.

Disabling a feature stops its underlying service and discards its configuration.

These optional features are currently available:

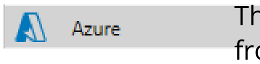
- AVEVA Historian – Read and write data to AVEVA Historian and Insight.
- InfluxDB – Read and write data to InfluxDB. Required for store-and-forward.
- Amazon Kinesis – Write data to Amazon Kinesis with optional store-and-forward.
- MQTT Broker - MQTT Smart Broker with robust MQTT protocol conversion.
- MQTT Client - Connect to MQTT brokers with advanced parsing, protocol conversion

and optional store-and-forward.

- OPC UA - Connect and aggregate OPC UA clients and servers.
- OPC AC – Aggregate and serve OPC UA A&C Alarms and Conditions.
- Notifications - Generate alarms, email, SMS and actions based on data changes.
- Bridging – Zero-latency server-to-server bridging.
- OSIsoft PI System Historian – Read and write data to OSIsoft PI System.
- Redundancy - Resolve identical incoming data streams to a single output.
- REST Historian – Read and write data to the REST Historian.
- WebView – Visualize data with full featured multi-user SCADA HMI.

When you register for the Cogent DataHub service, you are billed monthly through your Microsoft account for services used in the previous month. You will also have access to the SkkyHub portal which allows you to monitor your usage.

Configuring Azure Services



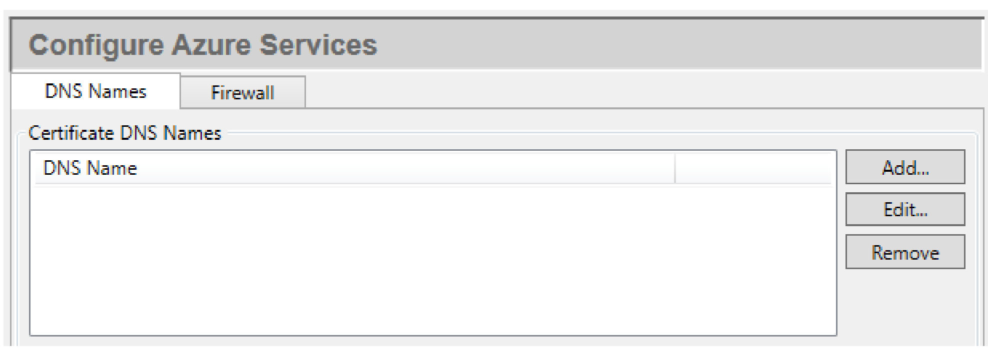
The Azure option in the Cogent DataHub service for Azure accessible from Remote Config lets user-administrators of the service configure DNS names and firewall rules.

DNS Names

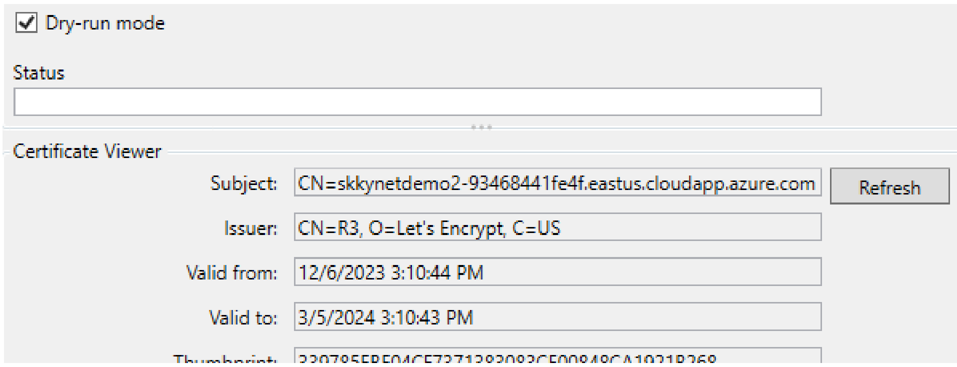
Here you can configure DNS names that will allow users to access the system with an alternate DNS name that you specify using your own DNS servers. When you create a DataHub for Azure deployment, Microsoft creates a server with a host name that is not particularly user-friendly, such as `skkynetdemo2-93468441fe4f.eastus.cloudapp.azure.com`. Choosing your own DNS name can better represent your company, product or solution, as well as being easier to remember and type.

Enabling DNS name support on your DataHub for Azure requires two steps:

1. Use your DNS server to create a `CNAME` record for the desired alternate name, routing it to the host name created by Microsoft for your DataHub for Azure service.
2. Use Remote Config to connect to your DataHub for Azure service and add the alternate DNS name to the certificate that the DataHub instance generates that supports SSL web server traffic.



The **Add** and **Edit** buttons open a dialog where you can add a DNS name, or edit the one currently selected. The **Remove** button removes the selected DNS name.



Dry run mode

Checking this box means that the current certificate will not be replaced. This is useful for testing certificate creation. The certificate creation tool limits the number of certificates that can be generated to a maximum of five per week. This option lets you test certificate creation without risking exceeding the limit. Once you confirm everything is correct, uncheck the checkbox and click **Apply** to generate and deploy the production certificate. Then re-check the box and click **Apply** again. This will help avoid accidentally creating another certificate.

Status

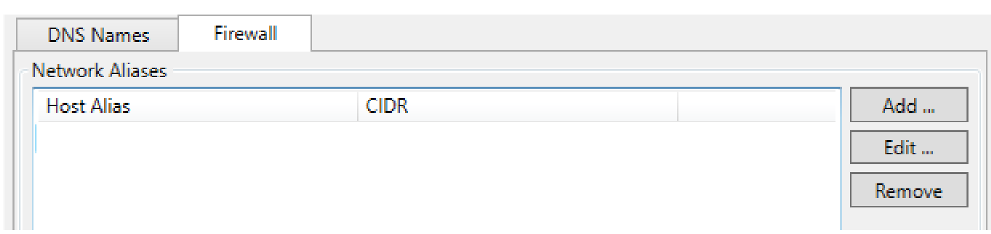
Displays the current status of user interactions with the system. When you click **Apply** to create a certificate, the results will be displayed in the **Status** area. Review the messages to confirm the required DNS names have been correctly added to the certificate as alternates.

Certificate Viewer

Lists details about the certificate. Review the **Subject Alternative Names** to confirm the certificate includes the alternates DNS names you require.

Firewall

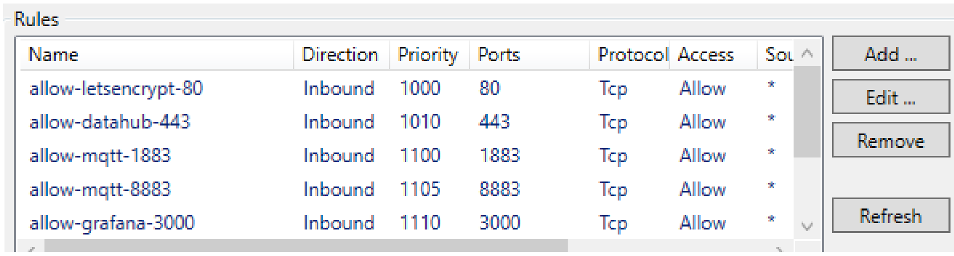
This tab provides a way to configure firewall rules for network aliases, which can be used to give qualified users access to restricted functionality on the system. Only certain inbound ports can be edited. These include 80 and 443, as well as the ports for MQTT, Grafana and OPC UA. Typically, you may wish to limit access to these ports to well-known source IP addresses, for example, the subnet of your plant environment.



Network Aliases

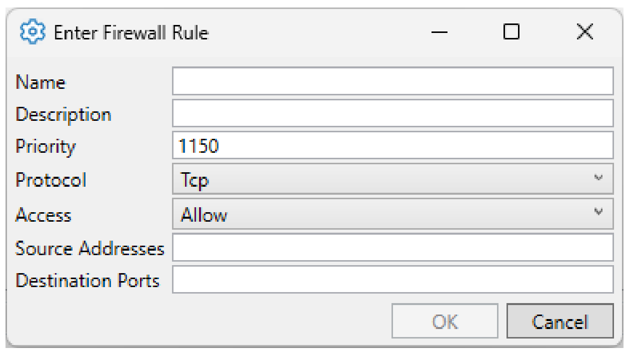
The **Add** button opens a dialog where you can add a host alias for a network, and its corresponding IP address in CIDR notation. The **Edit** button lets you edit the current selection, while the **Remove** button lets you remove it.

Rules



The **Add** and **Edit** buttons open a dialog where you can add a firewall rule, or edit the one currently selected. The **Remove** button removes the selected rule. The **Refresh** button refreshes the list.

Each firewall rule is defined as follows:



Name

A single string with no spaces used to identify this rule.

Description

An optional detailed description of the rule.

Priority

The priority for enforcing this rule, over others. Priorities are applied in ascending order.

Protocol

The protocol to which this rule applies. Protocols currently supported are TCP, UDP, LCMP, or any of those three.

Access

Select **Allow** or **Deny**, as applicable.

Source Address

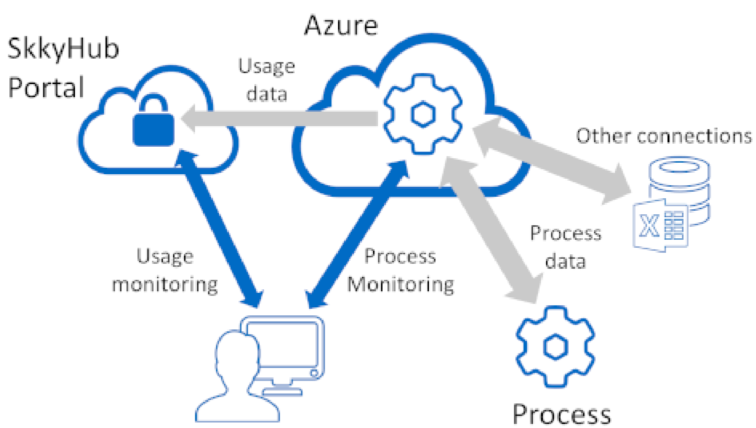
An IP address, IP pattern, or host alias (see above).

Destination Ports

The port or ports to which this rule applies.

Usage Monitoring

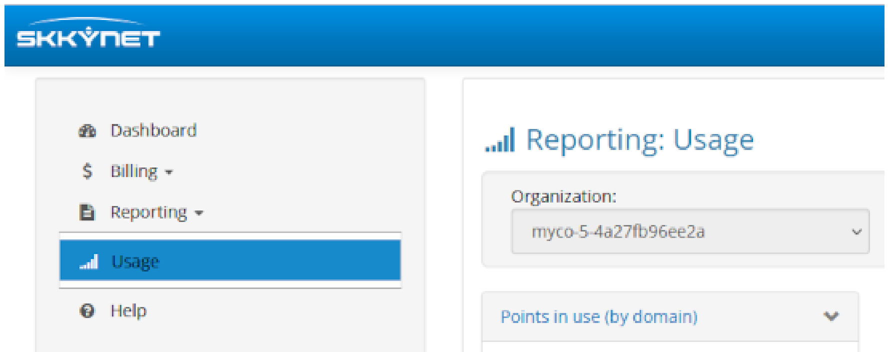
Using the SkkyHub Portal you can monitor your DataHub service usage and billing charges by point counts, updates, connection time, and other factors. Usage data is updated hourly, and usage charges are submitted to Microsoft hourly.



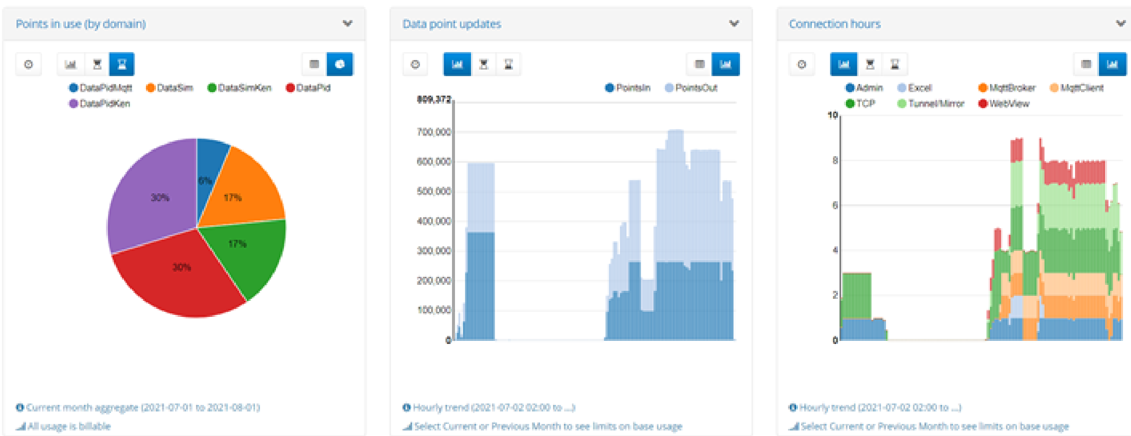
Usage

1. Go to portal.skkynet.com
2. Log in using the **Organization ID** and **User Name** from the email you received from Skkynet, and the **Password** that goes with them.

3. In the **Reporting** drop-down list, choose **Usage**.



This displays a page showing various charts.



The statistics are updated every hour on the hour. You will not see any data until at least one update.

For each chart you can configure these parameters:

Selected Period

Choose a time range of **Hour**, **Day**, **Week**, **Month**, **Quarter**, or **Year**.

Trend / Previous / Current

Choose how to display your usage: as a trend, or as a pie chart for the previous or current period.

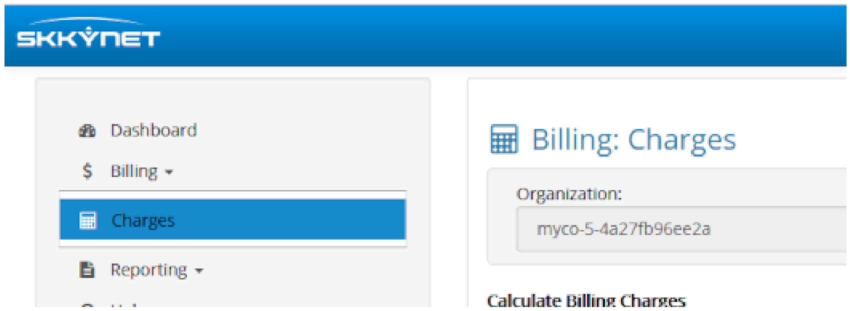
Show Table / Show Chart

Toggle between a table or chart display.

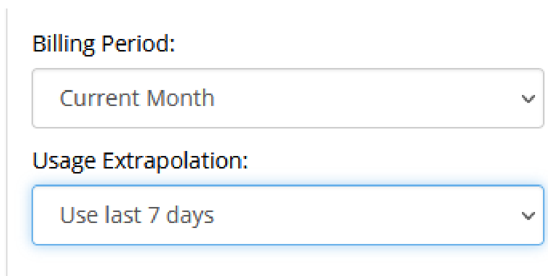
Billing Charges

Billing charges for the Cogent DataHub service are based on the features and extensions you enable. From the SkkyHub Portal you can create a report that shows the various charges.

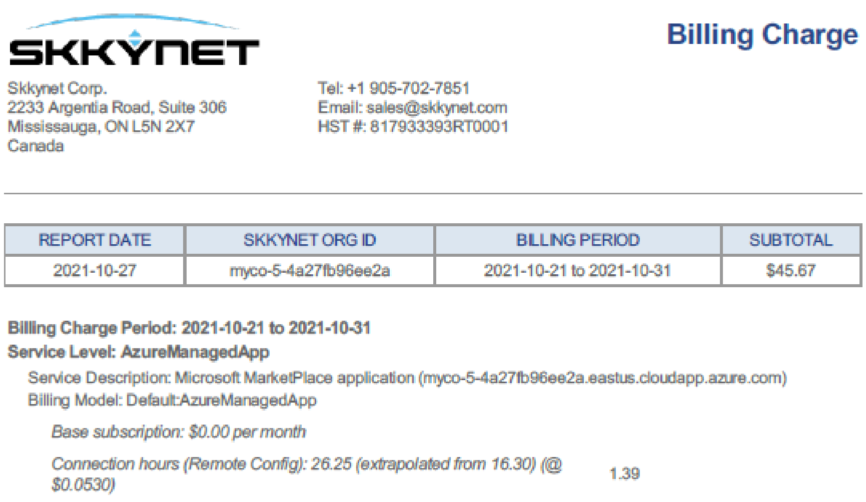
1. In the **Billing** drop-down list, choose **Charges**.



2. Specify a time period and a usage extrapolation, as needed.



3. Click the **Generate Report** button.



Billing Charge

Skkynet Corp.
2233 Argentia Road, Suite 306
Mississauga, ON L5N 2X7
Canada

Tel: +1 905-702-7851
Email: sales@skkynet.com
HST #: 817933393RT0001

REPORT DATE	SKKYNET ORG ID	BILLING PERIOD	SUBTOTAL
2021-10-27	myco-5-4a27fb96ee2a	2021-10-21 to 2021-10-31	$45.67

Billing Charge Period: 2021-10-21 to 2021-10-31
Service Level: AzureManagedApp

Service Description: Microsoft MarketPlace application (myco-5-4a27fb96ee2a.eastus.cloudapp.azure.com)
Billing Model: Default:AzureManagedApp

Base subscription: $0.00 per month

Connection hours (Remote Config): 26.25 (extrapolated from 16.30) (@ $0.0530) 1.39

This report is for your reference. Your bill will come from Microsoft.

Cogent DataHub™ Applications

Version 11.0

Applications supporting Cogent DataHub software and services.

Table of Contents

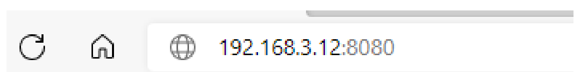
Web Application Manager

Cogent DataHub applications access the Remote Config and WebView applications via the Web Application Manager. This is downloaded from a launch page that has been pre-configured according to the application you are using.

Current Cogent DataHub software users: The Remote Config and WebView applications get installed in Windows during the DataHub installation, and are available from the Windows Start menu. For more details, please see Configuring a Local DataHub Instance for using Remote Config locally, and Run Locally for using WebView.

Getting Started

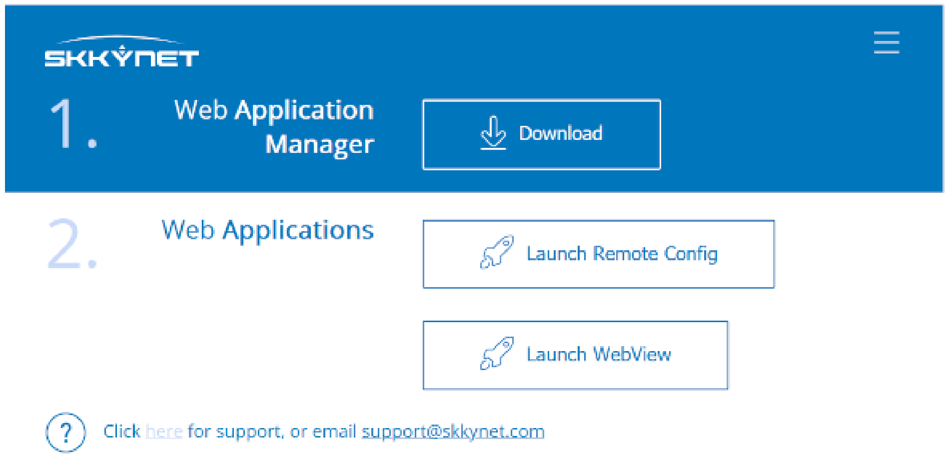
1. Open the Web Application Manager launch page.

Software/Service	**How to access the launch page**
Cogent DataHub program	Enter the IP address or network name for a running DataHub instance into a web browser. (More details) 
Cogent DataHub service	Click the Web Launch Page link in the email you received from Skkynet. 

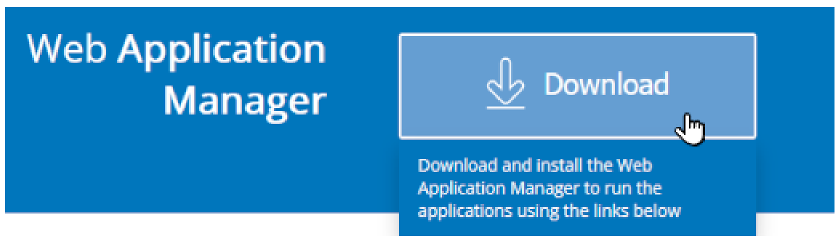
For security reasons, each launch page is pre-configured for the DataHub instance it connects to. Only it can launch the Remote Config or WebView applications keyed to that DataHub instance. Thus, for each host, you should access the launch page specific for that host. If you have multiple DataHub programs or services running, you must use the corresponding launch page for each one.

Cogent DataHub software installs with both Remote Config and WebView, which can be run locally without using the Web Application Manager. However, the Web Application Manager is needed when running these applications remotely.

Each of the above options opens the launch page for the corresponding Skkynet Web Application Manager:



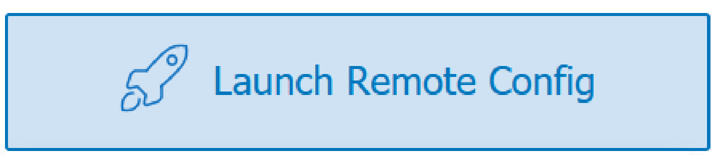
2. Click the **Download the Web Application Manager** button.



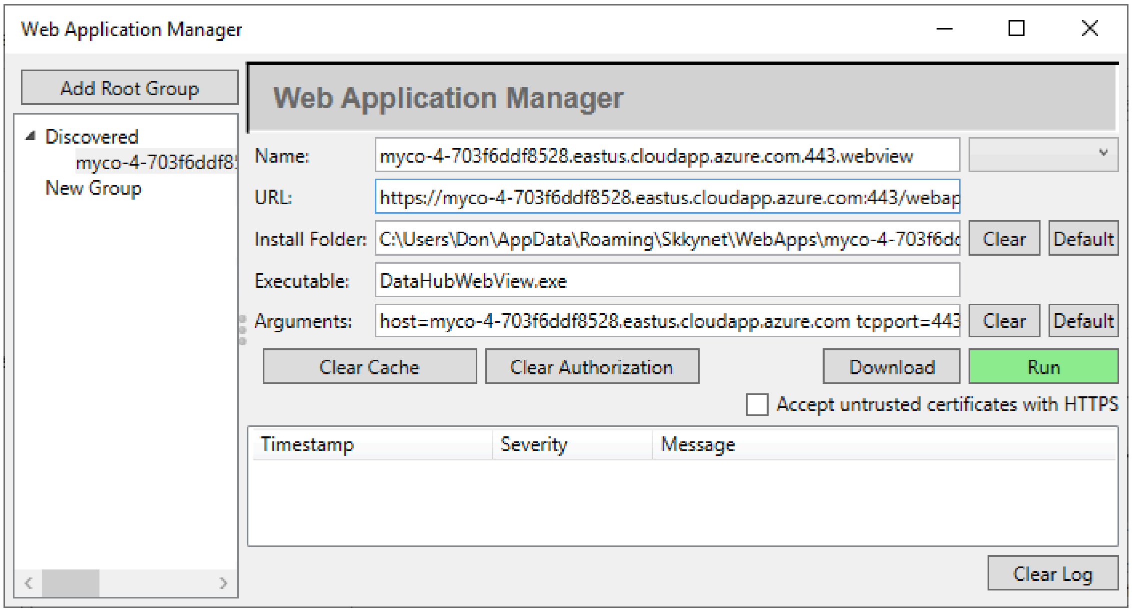
3. Install the Web Application Manager.

Launching Applications

1. Once the Web Application Manager is installed, you can use it to launch the Remote Config application or the WebView application. Both of these are accessed in the same way.
2. From the launch page, click on the **Launch** button for the application you need.

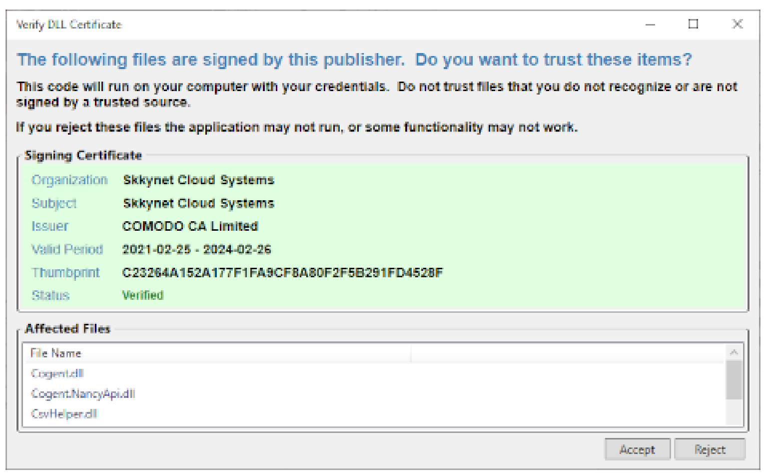


   The first time you run this, a dialog will ask if you want to switch to the Web Application Manager.
3. Click **Accept**. The Web Application Manager will open, populated with the parameters required for you to connect to the remote DataHub service or instance and download the application.



4. Click the green **Run** button.

   The files needed to run the application will be downloaded, and a dialog window will display information about the program files, with details of the security certificate used to sign them.



Please see SSL Certificates in the Cogent DataHub manual for more information about SSL certificates for the DataHub program.

5. Check the signing certificate and affected files to determine whether or not to accept them, based on the following criteria:

   - If the **Signing Certificate** region of this dialog is not green, then the **Status** will be **Invalid**. That indicates that the certificate cannot be verified. Do not click **Accept** unless you know why you are seeing a rejected certificate.

- If the **Signing Certificate** is from an organization other than Skkynet Cloud Systems Inc. then it indicates that another company's software has been installed on the server and is being delivered as part of the application. If you do not believe this to be legitimate, do not click **Accept**.
- **If you click Accept** it means that you trust the app source files. They will be saved on your computer and the app will run. Your choice will be remembered, and the next time you web launch this app you will not have to accept the files again.

  If, for some reason you want to revoke your acceptance of the downloaded files, you can select the profile in the Web Applications Manager and click the **Clear Authorization** button.

- **If you click Reject** the files required to run the app will be deleted.

  You will also see a list of files you just rejected and be given the chance to change your mind. To revoke your choice:

  1. Click the **Reset DLL Authorization** button.
  2. Click **OK** to close the dialog window.
  3. Download the files again by clicking the green **Run** button in the Web Application Manager.

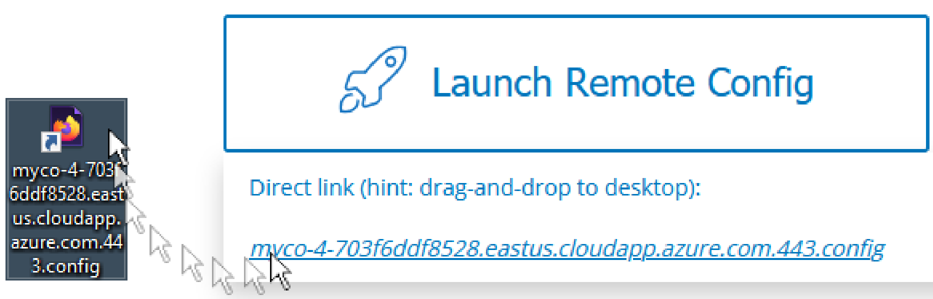
6. Proceed using the application as applicable for Cogent DataHub software, the Cogent DataHub service, or the WebView application.

Once you have downloaded an application, next time clicking the **Launch** button or using the desktop shortcut will immediately launch it, without requiring you to download the files again.

Create a Shortcut

Here are two ways to make a shortcut to quickly start the Remote Config program.

1. While the Remote Config instance is running, you can pin the program to your task bar, creating a short cut.
2. From the launch page you can drag the direct link onto your desktop.



With either of these shortcuts you can start a Remote Config instance with one click; no need to visit the launch page.

Remote Config

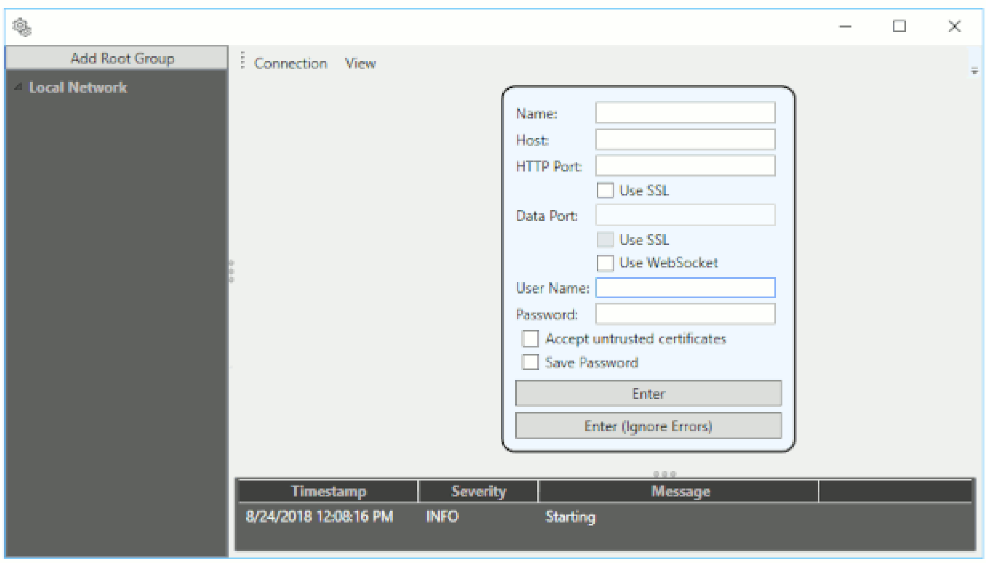
The Remote Config application is used to access DataHub applications for configuration and monitoring connections. Because it connects over TCP, it is especially useful for the Cogent DataHub service for Azure. It is also used with the Cogent DataHub program when it is running as a service, or to access it remotely.

Getting Started

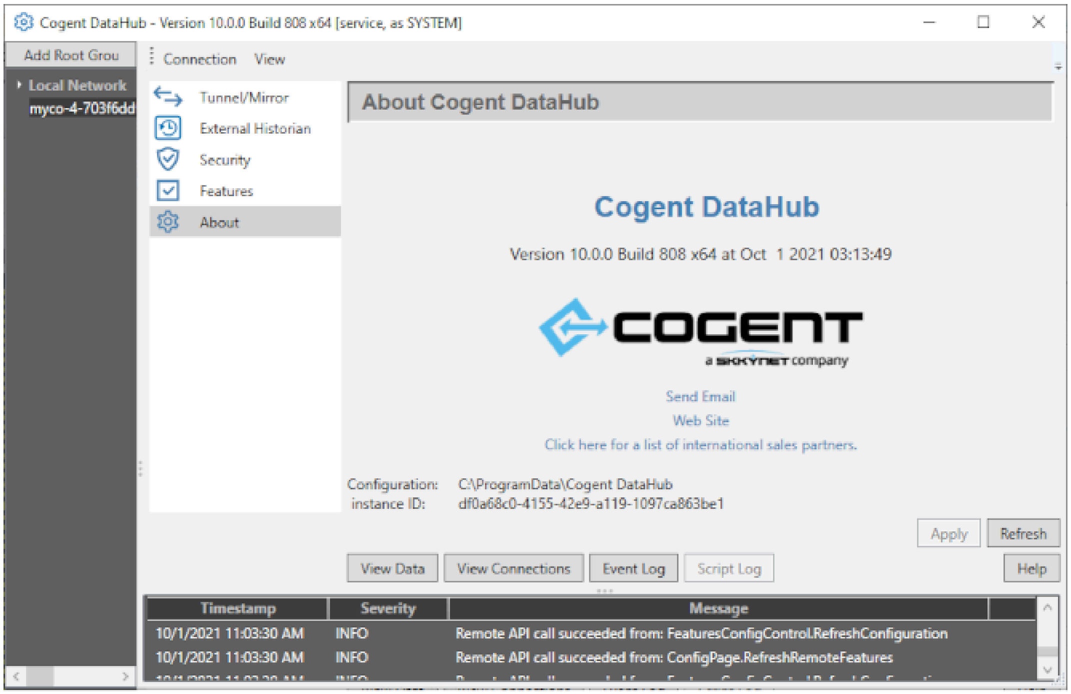
- **For the Cogent DataHub service for Azure** use the Web Application Manager to launch the Remote Config application. The log-in window will be pre-entered.

  When running on Windows 7, Remote Config can only connect to a local DataHub instance. Connections to the Cogent DataHub service require WebSocket support, and so must be done from Windows 8 or higher.

- **For the DataHub program** (or for a detailed explanation of the configuration options) please see Configuring a Local DataHub Instance.



After logging in, you will have access to the available DataHub features and their configuration options.



The panel on the left lists all of the DataHub connections you have configured. The bottom panel displays the application log for the connection to the DataHub instance. The center column displays all of the DataHub features of the DataHub Properties window that you have licensed or enabled, with the options for each feature appearing in the main, right-hand panel.

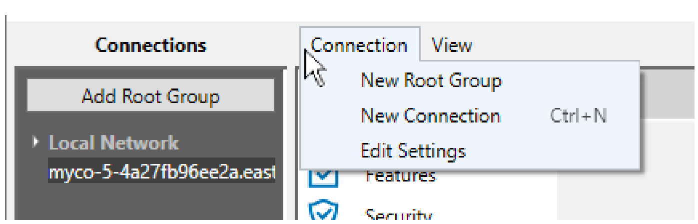
The buttons at the bottom of that panel open other DataHub windows for the Data Browser, Connection Viewer, and Event Log. If you are connecting to a Cogent DataHub instance, the Script Log button is also available.

Pressing the **Enter (Ignore Errors)** button instead of the **Enter** button when you first log in will allow you to open the Data Browser, and possibly the Event Log, Connections, and Script Log windows, but you will not be able to see or change any configuration.

Menu Options

These two menus contain the following options.

Connection



New Root Group

Lets you add a new root group, which you can use to help organize a large number of connections. This is the same as clicking the **Add Root Group** button.

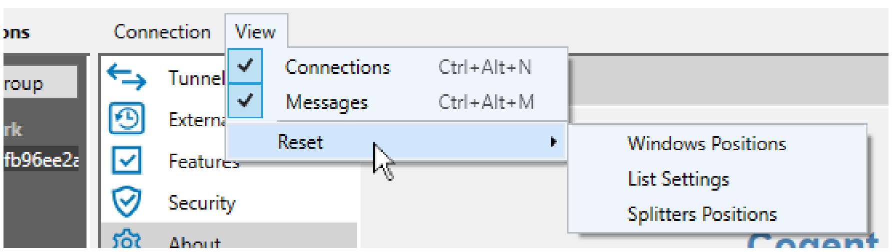
New Connection

Lets you add a new connection. For the Cogent DataHub program, please see Configuring a Local DataHub Instance for more information on making a connection. For the Cogent DataHub service, when you use the Web Application Manager to launch the Remote Config application, the connection is configured automatically, so this option is not usually necessary.

Edit Settings

Opens the Application Settings window, where you can set the HTTP timeout. The default setting of 100 seconds (100,000 ms) is typically sufficient, but you can change it here if necessary.

View



Connections

Hides or displays the **Connections** panel on the left-hand side.

Messages

Hides or displays the **Message** panel at the bottom.

Reset

Each of these three menu options deletes the corresponding saved state for the Remote Config user interface. The next time a window or dialog is opened, that state will revert to its defaults.

Window Positions

Resets all window and dialog screen positions to the defaults when reopened. This is useful if you think the saved window positions are causing problems, for example if a window is being drawn off-screen.

List Settings

Restores the order of columns in lists. For any lists in the main window, such as the lists of OPC client connections, you will need to restart the Remote Config program to see the result.

Splitter Positions

Some dialogs allow you to reposition the splitters between different dialog panes. This option restores the default sizing.

Status Icon

This feature is currently only available for the Cogent DataHub service.

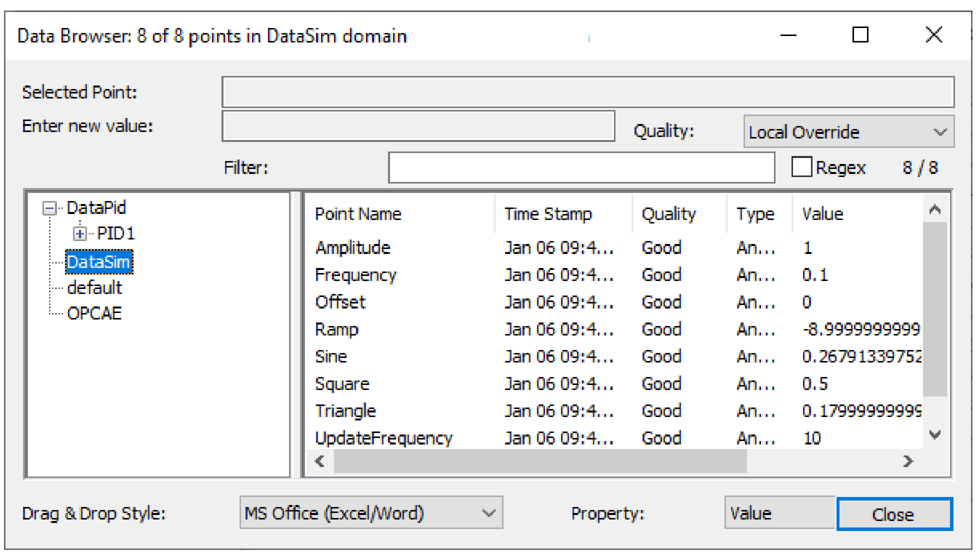
This icon shows the communication status with the DataHub instance. Remote Config connects to the DataHub data engine for data communications, while non-data related information comes via HTTP, from the DataHub Web Server.

- **No color:** Both HTTP and data communications are connected.
- **Yellow:** HTTP communications are disconnected, while data communications are connected.
- **Red** Both HTTP and data communications are disconnected.

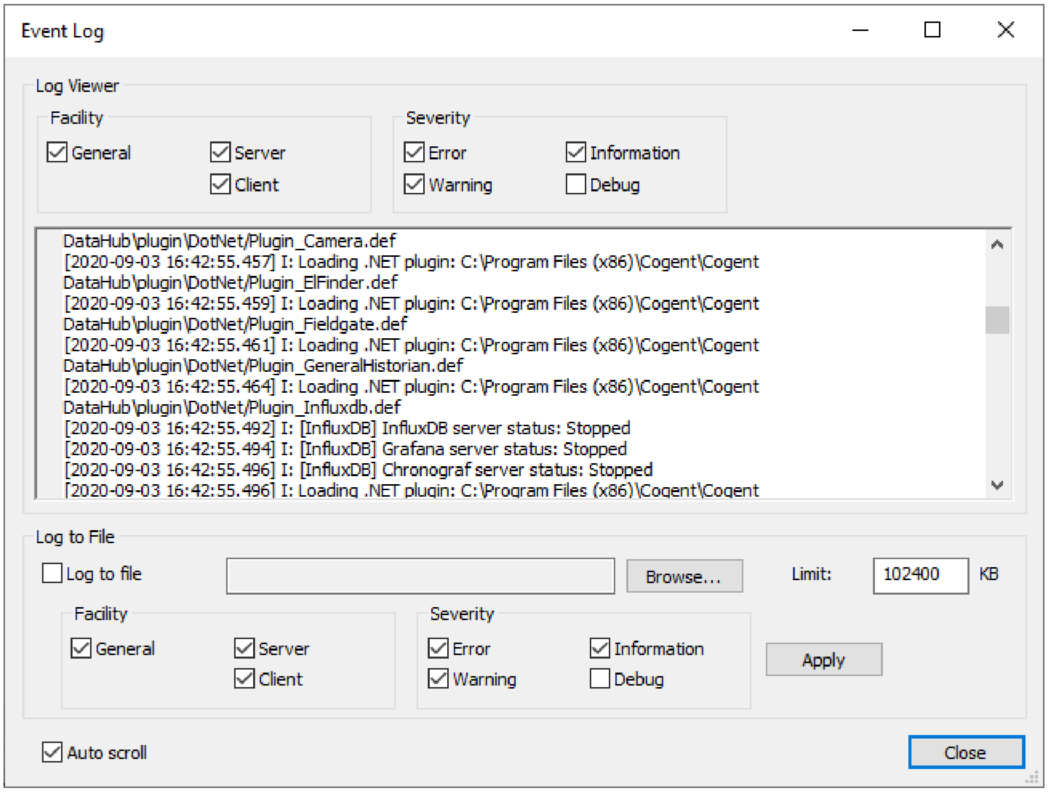
Monitoring Tools

There are three helpful monitoring tools accessible from the Remote Config application.

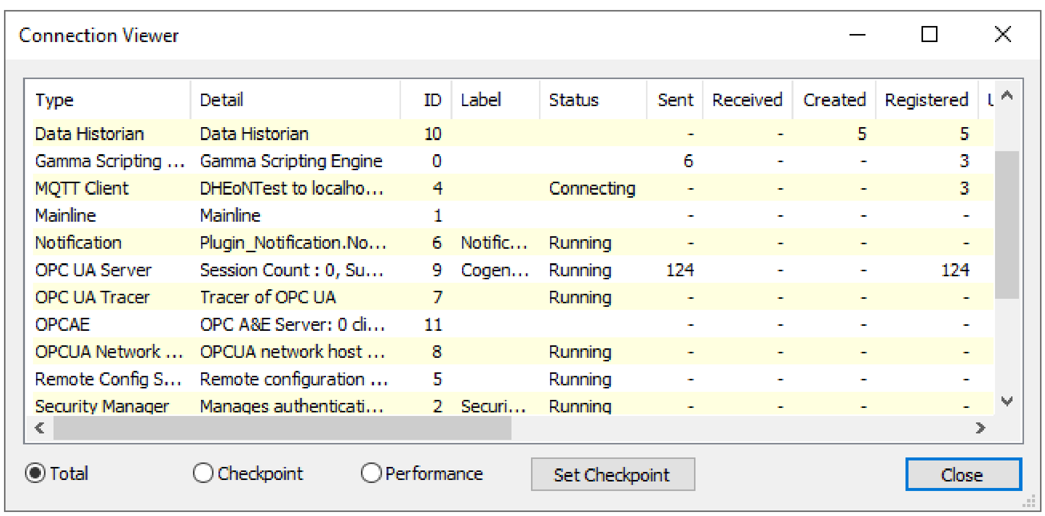
1. You can get a view into the data in your system using the **View Data** button to open the Data Browser.



2. To see more details of what is taking place, use the Event Log.



3. To track connections, use the Connection Viewer.



The Script Log button in the Remote Config application is only enabled when accessing the Cogent DataHub program, .

Importing and Exporting Configuration

This is only available in the Remote Config application, not in the DataHub Properties window.

The Remote Config application allows you to import and export configuration from CSV files. Each of the Remote Config interfaces for OPC DA, OPC UA, Bridging, MQTT Client, Modbus, and Historian has an **Import CSV** and an **Export CSV** button in its client configuration window that allows you to import configuration from CSV files in bulk, as well as export it to CSV files.

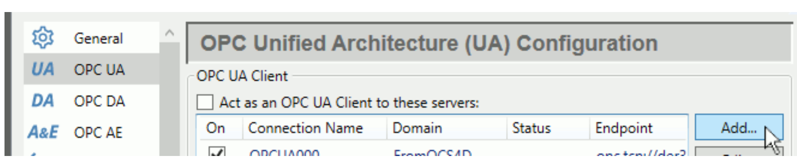
1. Locate the **Import CSV** or **Export CSV** button for the feature you need, as listed below: OPC DA, OPC UA, Bridging, MQTT Client, Modbus, External Historian, Historian.
2. To import, use the **Import CSV** button to open the Import Items window, as explained in Configuring.
3. To export, click the **Export CSV** button, enter a file name in the directory of your choice, and click the **Open** button.
4. Use the Property Lists to see which properties are available for each feature.

Accessing the Import and Export features

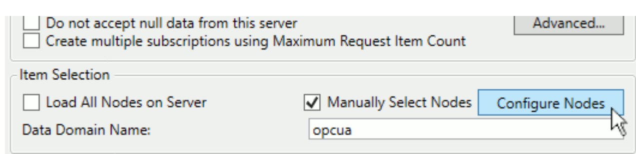
The **Import CSV** and **Export CSV** buttons are located as shown for each feature.

OPC UA

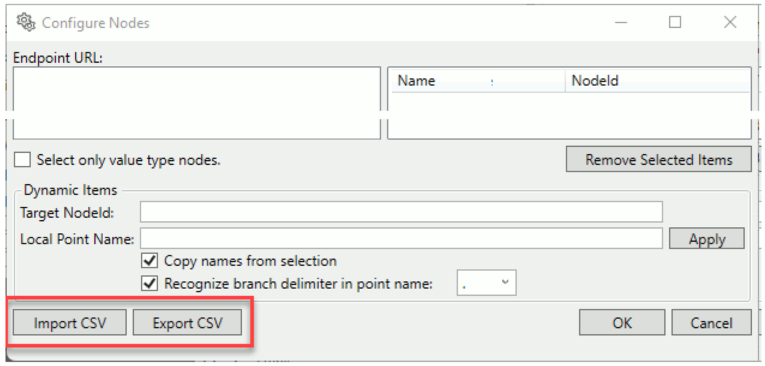
In the OPC UA option, click the **Add** button.



In the Configure OPC UA Data Access Server dialog, check the **Manually Select Nodes** box and click the **Configure Nodes** button.

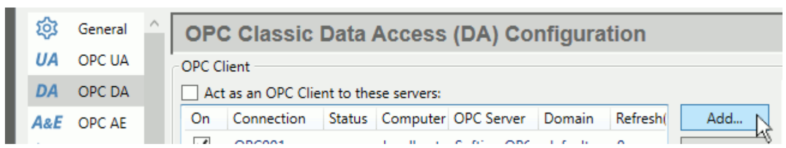


The **Import CSV** and **Export CSV** buttons are near the bottom of the Configure Nodes dialog.

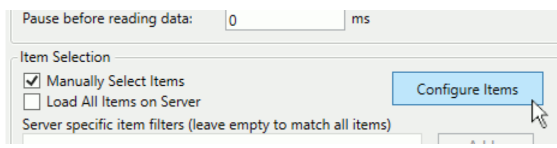


OPC DA

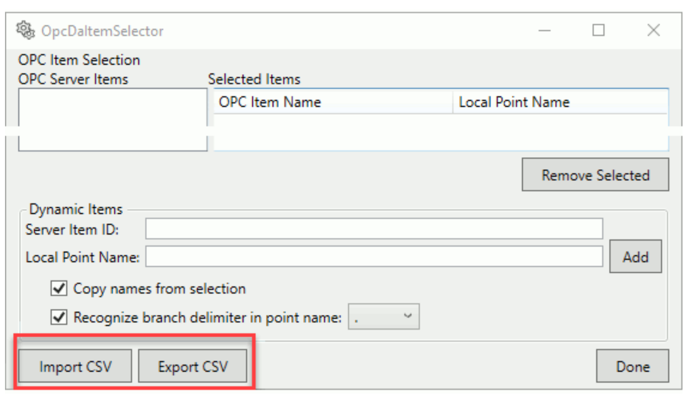
In the OPC DA option, click the **Add** button.



In the Configure OPC DA Server Connection dialog, check the **Manually Select Items** box and click the **Configure Items** button.

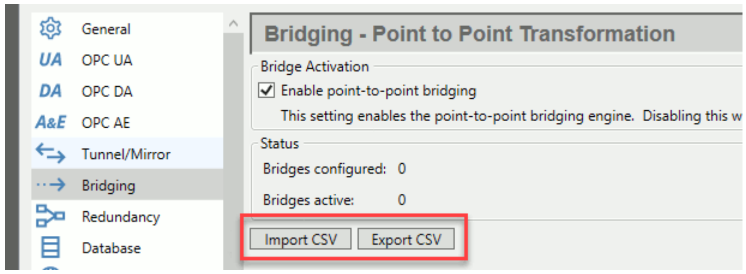


The **Import CSV** and **Export CSV** buttons are near the bottom of the OpcDaItemSelector dialog.



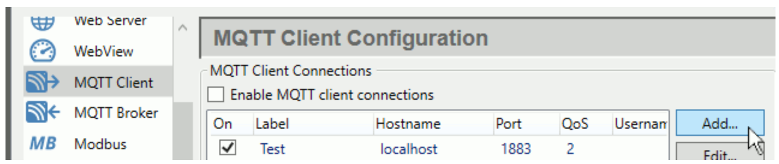
Bridging

The **Import CSV** and **Export CSV** buttons are at the bottom of the Bridging options.

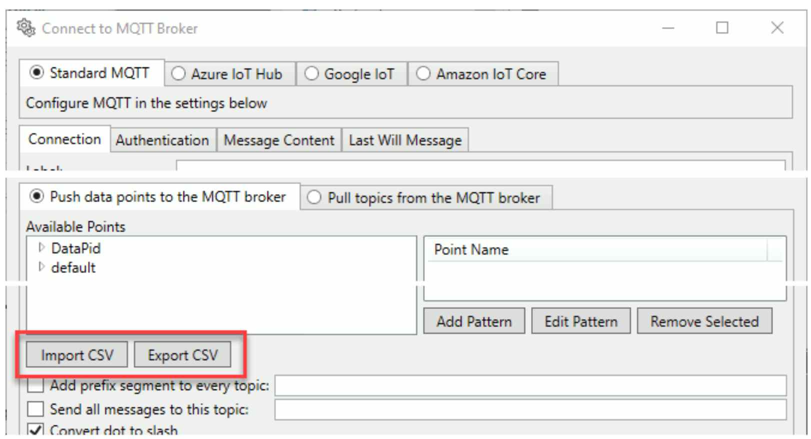


MQTT Client

In the MQTT Client option, click the **Add** button.

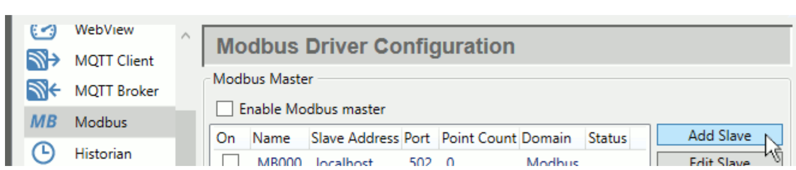


In the Connect to MQTT Broker dialog, the **Import CSV** and **Export CSV** buttons are in the **Push data points to the MQTT broker** section.

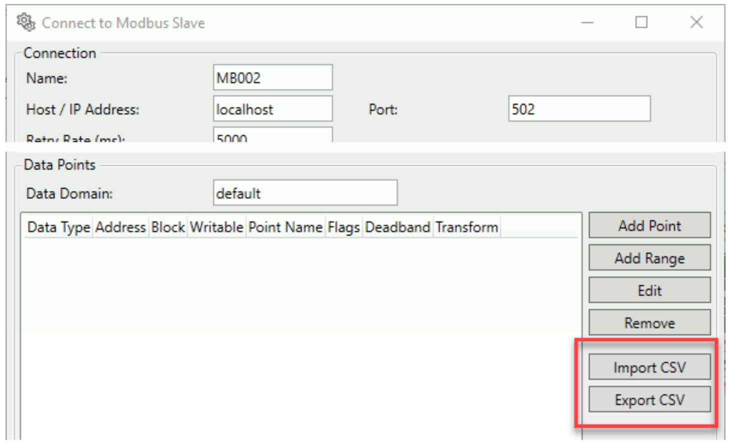


Modbus

In the Modbus option, click the **Add Slave** button.

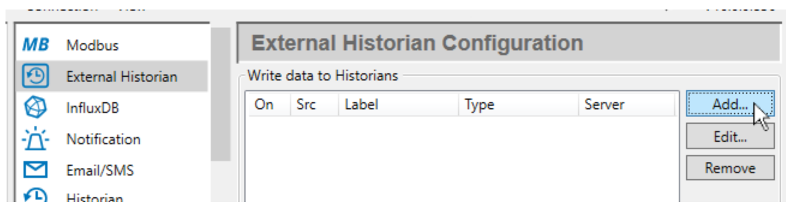


In the Connect to Modbus Slave dialog, the **Import CSV** and **Export CSV** buttons are in the **Data Points** section.

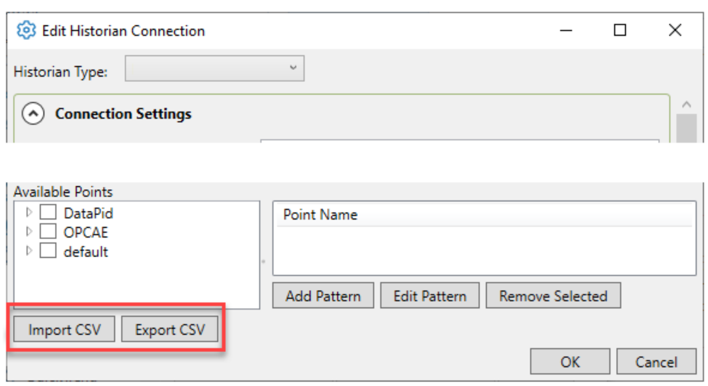


External Historian

In the External Historian option, click the **Add** button.

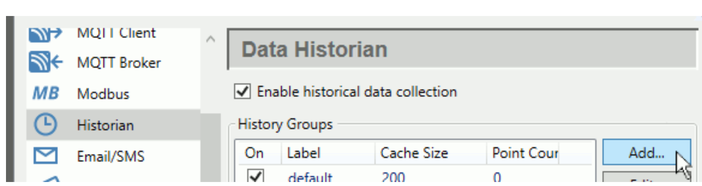


In the Edit Historian Connection dialog, the **Import CSV** and **Export CSV** buttons are at the bottom of the point selection options.

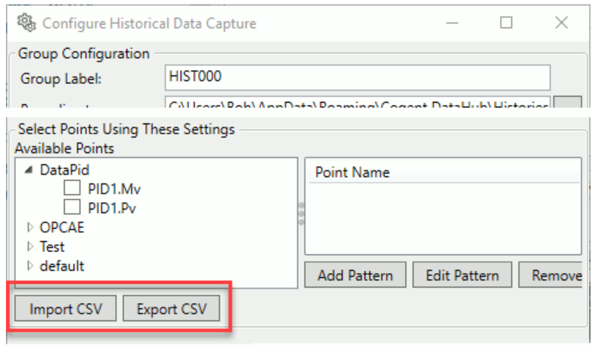


DataHub Historian

In the Historian option, click the **Add** button.

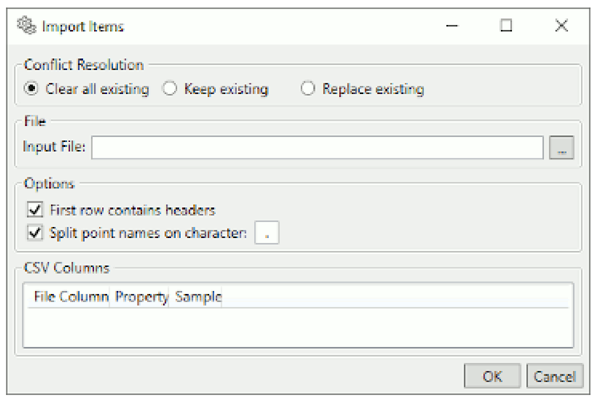


In the Configure Historical Data Capture dialog, the **Import CSV** and **Export CSV** buttons are at the bottom of the point selection options.



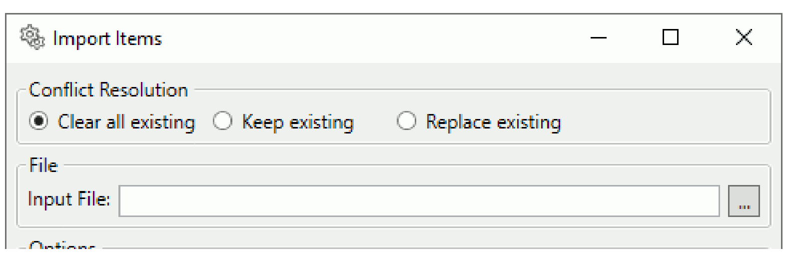
Configuring

The **Import CSV** button opens the Import Items window:



Conflict Resolution

These options let you specify what happens to existing, configured points when new points get loaded from the CSV file.



Clear all existing

Removes all existing points, then import the points from the CSV file. The result will be that only the points in the CSV file will remain after the import.

Keep existing

Keeps all existing points, and does not replace any of them from points in the imported CSV file. The result will be a combination of any existing points and the points from the CSV file. Where the CSV file contains the same points, the existing points will take precedence.

Replace existing

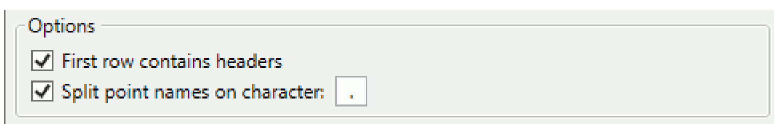
Replaces any existing point that has a corresponding point in the imported CSV file. The result will be a combination of the existing points and the points from the CSV file. Where the CSV file contains the same points, the values from the CSV file will take precedence.

File

In the **Input File** field, choose or enter the file name of the CSV file you plan to import.

Options

There are a few options for the import process.



First row contains headers

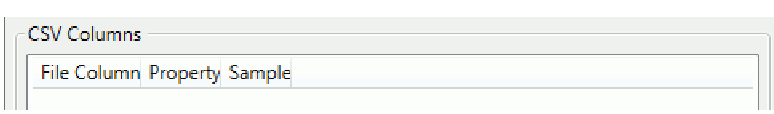
When checked, the system will treat the first row of your CSV file as a header with titles for each column. If this is not checked then the sample data will be presented with generic column names.

Split point names on character

When processing a point name, the import can optionally split the point name into path components using the specified character. This allows some interfaces (e.g., OPC DA) to produce a point hierarchy from the point name. In some cases you may have an OPC item name, for example, that provides a multi-level path split on another character (e.g., a / character). Specifying an alternate split character allows you import those items while constructing hierarchy.

CSV Columns

Each of the different features (OPC DA, OPC UA, Bridging, MQTT Client, Modbus, and Historian) that offers the Import CSV option must be configured according to its unique properties. When you specify the CSV file, the first two rows are loaded and processed. The first row is treated as the headers, and the second row is treated as a sample value. These will then be presented in the CSV Columns list.



You must choose which column in the file corresponds to the properties that the import requires. You may find it convenient to specify the columns in the CSV file in the same order as the properties are displayed when the file is processed.

File Column

A column title. If you have checked the **First row contains headers** button (above), then the contents of the first row will appear here. Otherwise, the system will create a title for the column.

Property

The property of this column. The interface program will provide a drop-down list to choose from. Each feature has different options, explained in Property Lists. You must associate each property with a column in your CSV file. Your CSV file may have extra columns that are not used, so long as it provides all of the columns necessary for the import. For easy configuration, you can use the property names as column headers in your CSV file.

Sample

Displays the values from the first data row of the file to help with associating the CSV file columns to the properties.

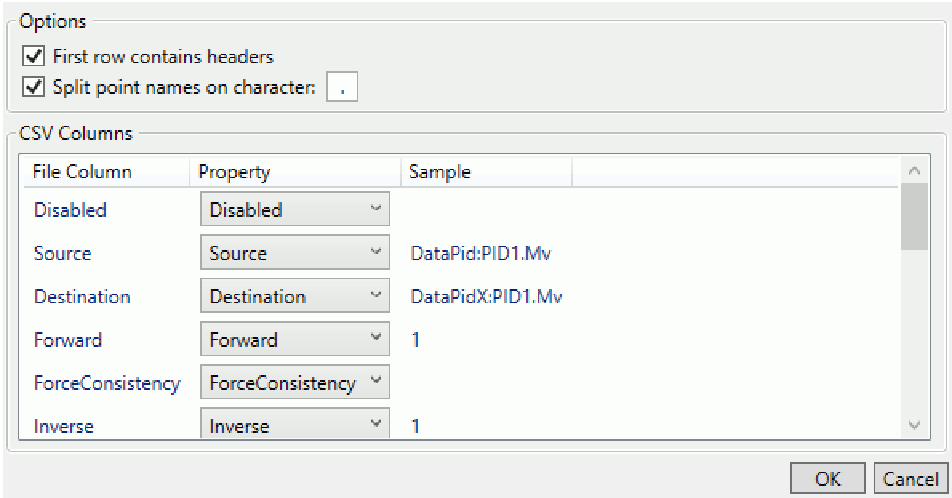
Clicking the **OK** button in the Import Items window closes it, and populates the configuration dialog with the CSV file contents.

Example

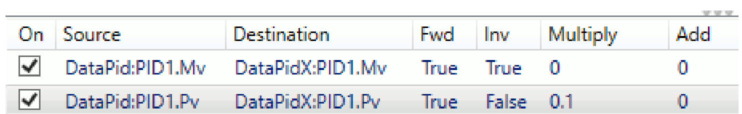
The first few rows of a CSV file for a Bridging configuration might look like this:

A	B	C	D	E	F	G	H	I	J	
Disabled	Source	Destination	Forward	ForceCons	Inverse	DirectCop	LinearTrar	Multiply	Add	Line
	DataPid:PID1.Mv	DataPidX:PID1.Mv	1		1	1				
	DataPid:PID1.Pv	DataPidX:PID1.Pv	1				1	0.1	0	

The Import Items configuration would look like this:



Clicking the **OK** button would close the Import Items window and populate the DataHub Bridging Configuration window like this:



Available Properties

Property Lists

Here are lists of the properties available for each of the protocols.

OPC UA

Property	Type	Range	Description
NodeId	string	any	The NodeId as provided by the OPC UA server.
PointName	string	unqualified point	The data point name in the DataHub to create for that NodeId.

OPC DA

Property	Type	Range	Description
ItemID	string	any	The ItemID as provided by the OPC DA server.
PointName	string	unqualified point	The data point name in the DataHub to

Property	Type	Range	Description
			create for that ItemID.

Bridging

Property	Type	Range	Description
Disabled	boolean	`0` or `1`	Set to `1` to indicate that this bridge is disabled.
Source	string	qualified point	The fully qualified name of the source point.
Destination	string	qualified point	The fully qualified name of the destination point.
Forward	boolean	`0` or `1`	Set to `1` to bridge in the forward direction.
ForceConsistency	boolean	`0` or `1`	Set to `1` to force consistency in the forward direction.
Inverse	boolean	`0` or `1`	Set to `1` to bridge in the inverse direction. Cannot be 1 if ForceConsistency is 1.
DirectCopy	boolean	`0` or `1`	Set to `1` for a direct copy without transformation.
LinearTransform	boolean	`0` or `1`	Set to `1` for a linear transformation.
Multiply	double	number	The multiplier for a linear transformation.
Add	double	number	The adder for a linear transformation.
LinearRangeMap	boolean	`0` or `1`	Set to `1` for a linear range map transformation.
SrcMin	double	number	The source minimum value for a linear range map transformation.
SrcMax	double	number	The source maximum value for a linear range map transformation.
DstMin	double	number	The destination minimum value for a linear range map transformation.
DstMax	double	number	The destination maximum value for a linear range map transformation.
ClampMin	boolean	`0` or `1`	Set to `1` to clamp the destination value at the minimum for a linear range map transformation.
ClampMax	boolean	`0` or `1`	Set to `1` to clamp the destination value at the maximum for a linear range map

Property	Type	Range	Description
			transformation.

MQTT Client

Property	Type	Range	Description
PointName	string	qualified point	The fully qualified point name to push to the MQTT server.

Modbus

Property	Type	Range	Description
Point or Range	string	point, range	Either point or range indicating whether this entry is for a single point or a range of points.
Point Name	string	unqualified point	An unqualified point name or point expression.
Block	string	`MB_AI`, `MB_AO`, `MB_DI`, `MB_DO`	The I/O block for this address.
Address	string	address expression	The numeric address of this item as an offset into the Block.
Type	string	type expression	Data type and flags (see pointType in ModbusSlaveAddPoint).
OneBasedAddress	boolean	`0` or `1`	`1` if the address is 1-based, otherwise `0`.
OneBasedBitAddress	boolean	`0` or `1`	`1` if bit numbers within a word are 1-based, otherwise `0`.
Allow Write	boolean	`0` or `1`	`1` if the DataHub can write to this address, otherwise `0`
Deadband	double	any	An absolute deadband applied to the transformed value. Changes below this deadband are ignored.
Transform	string	Direct, Linear, Range	The type of transformation to apply.
Multiply	double	number	The multiplier for a linear transformation.
Add	double	number	The adder for a linear transformation.
Modbus Min	double	number	The Modbus minimum value for a linear range map transformation.
Modbus Max	double	number	The Modbus maximum value for a linear

Property	Type	Range	Description
			range map transformation.
Point Min	double	number	The point minimum value for a linear range map transformation.
Point Max	double	number	The point maximum value for a linear range map transformation.
Clamp Min	boolean	`0` or `1`	Set to `1` to clamp the Modbus value at the minimum for a linear range map transformation.
Clamp Max	boolean	`0` or `1`	Set to `1` to clamp the Modbus value at the maximum for a linear range map transformation.
Convert	boolean	`0` or `1`	Set to `1` if the point type should be different from the Modbus type (e.g., convert Modbus integer to double point).
Converted Type	string	type expression	A data type without flags (e.g., `I2` or `R8`).
Range Count	integer	`> 0`	The number of items when **Point or Range** is set to `range`.
Range Offset	integer	`>= 0`	The starting item number when **Point or Range** is set to `range`.

External Historian

Property	Type	Range	Description
NodeId	string	qualified point	The fully qualified name of a point.

Historian

Property	Type	Range	Description
NodeId	string	qualified point	The fully qualified name of a point.

Differences between Remote Config and the native DataHub Properties windows

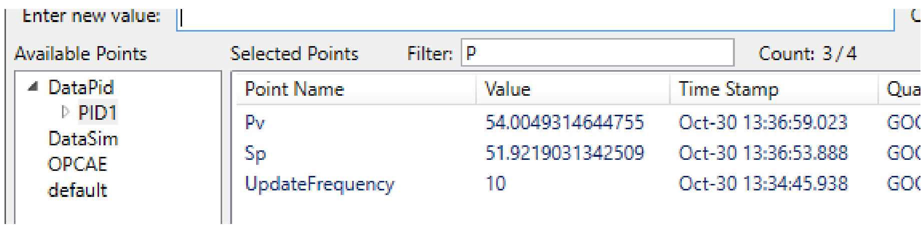
The Remote Config program is very similar to the native DataHub Properties window, with the following exceptions;

- **Reduced feature set** Not all of the DataHub features are replicated in the Remote Config program. Some are absent for security reasons, and others may be added later.
- **Database table creation** You cannot create a database table through the Remote

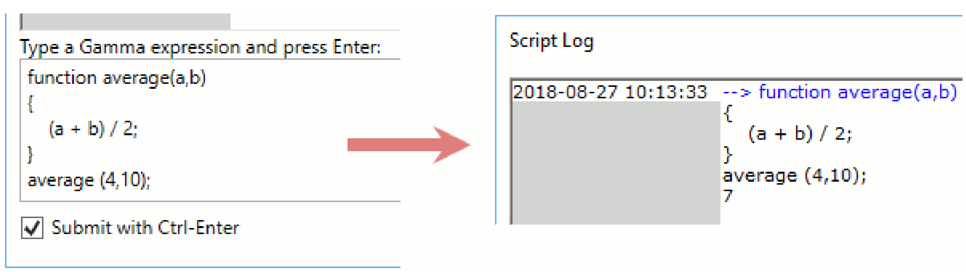
Config program as you can with Database in the native Properties window. Instead, create a table using the management tools that come with the target database, then assign points to the columns in the Remote Config program.

- **Apply button** The **Apply** button takes the place of both **OK** and **Apply** from the native Properties window. It applies changes only for the configuration panel that is currently visible.
- **Refresh button** The **Refresh** button takes the place of the **Cancel** button from the native Properties window, and does two things. It reloads the current configuration, and discards any changes that have not yet been applied.
- **About** is at the bottom of the list of DataHub options.
- **Data Browser** There is a 10 - 15 second delay for data domains to appear. Also, there is no **Drag and Drop** button.

  A point filter helps you find point(s) you are interested in within a selected domain.



- **View Connections** The statistics in this window run on a 5-second cycle, instead of a 1-second cycle like the native window.
- **Script Log** A panel on the left displays timestamps that get created whenever new output is printed to the screen. Checking the **Submit with Ctrl-Enter** box allows you to make multi-line entries.



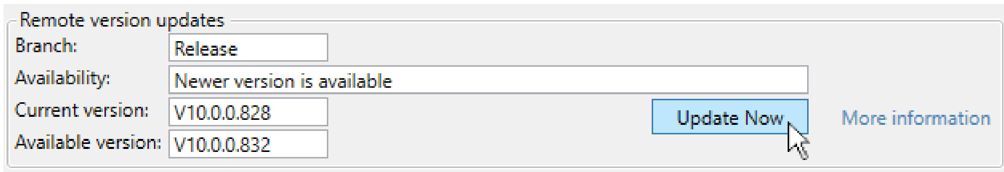
- **Connection status** When viewing connections in the Remote Config program (for example tunnel connections), the status of a connection only gets updated when you click the **Refresh** button.

Software Updates

This capability is currently only available for the Cogent DataHub service.

From time to time Skkynet updates the DataHub software with enhancements and bug fixes. You can re-install your DataHub instance at your convenience to take advantage of these updates.

1. In the **Features** option, click the **Update Now** button.



   The DataHub instance will shut down while the new software is installing. The Remote Config log will display one or more error messages related to the shutdown, and the Status Icon in the menu bar will indicate that HTTP and data connections have been lost. This whole process may take 5 minutes or longer.

   Both the DataHub software and the Remote Config installer will be updated, then Remote Config will automatically end the session.

2. Close Remote Config and then restart using the Web Application Manager.

The **Update Now** button will say **Re-install Now** if the current version and available version are the same, and **Revert Now** if for some reason the current version is newer than the available version.

Restarting the DataHub instance

This capability is currently only available for the Cogent DataHub service.

It is possible to restart the DataHub instance without re-installing it.

1. In the **Features** option, click the **Restart Now** button.

   The DataHub instance will take 15 to 30 seconds to restart. The Remote Config log will display one or more error messages related to the restart, and the Status Icon in the menu bar will turn red, then yellow, and finally back to normal, indicating that HTPP and data connections are working again.

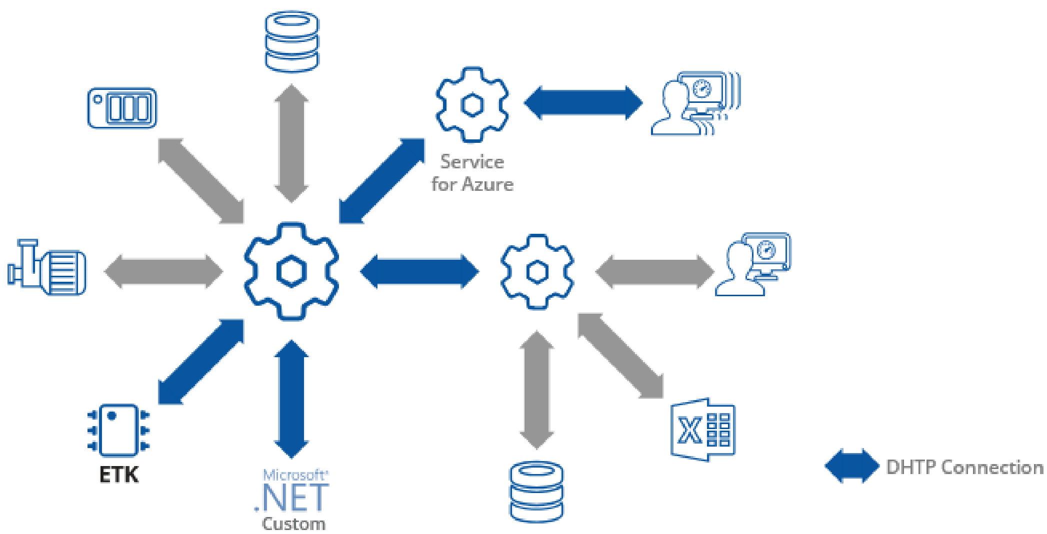
2. You can click the **Refresh** button to verify that the DataHub instance is running again.

Restarting the DataHub instance reloads all data points, which has the effect of removing all unused data points from the Data Browser.

DHTP - The DataHub Transfer Protocol

The DataHub Transfer Protocol (DHTP) is used by the DataHub Tunnel/Mirror feature, as well as the Cogent DataHub™ service for Azure service, ETK, and connected clients to send and receive data in real time over TCP across a LAN, WAN, or the Internet. Originally built upon HTTP, DHTP also supports SSL and WebSocket protocols. In continuous development for over 20 years, DHTP is open and documented in two parts, as the DataHub APIs and the DataHub Command Set.

Each DataHub instance connected by DHTP requires its own license. License verification is done between DataHub instances over the network. Occasionally a slow network may result in misleading "no license" errors. Please refer to TCPLicenseTimeoutSecs for more information.



Additionally, the DataHub program supports various protocols that are native to commonly used industrial applications, like ODBC, OPC, Modbus, etc. The ETK supports OPC UA and Modbus.

Examples

As shown in the above diagram, DHTP may be used for the following connection types:

- DataHub instance to DataHub instance for DMZs and tunnelling on LANs and WANs
- ETK to DataHub instance for on-premise connections and edge procsssing
- Custom programs to a DataHub instance, to integrate virtually any application

Applied DHTP Features

The DataHub program uses DHTP to provide these important Industrial IoT features:

- **Low Bandwidth & Low Latency:** Consumes minimal bandwidth, while functioning with the lowest possible latency

- **Ability to Scale:** Can support hundreds or thousands of interconnected data sources and users
- **Real-Time:** Adds virtually no latency to the data transmission
- **Intelligent Overload Handling:** A broker (DataHub instance or ETK) responds appropriately when a data user is unable to keep up with the incoming data rate
- Quality of Service: Guarantees consistency of data, preserved through multiple hops

DHTP Protocol Features

DHTP communications between and among DataHub instances, ETK, and their clients meet the following criteria for secure, robust industrial and IIoT data communications:

- **Closed Firewalls:** Keeps all firewall ports closed for both data sources and data users
- **Interoperable Data Format:** Encodes the data so that clients and servers do not need to know each others' protocols
- **Can Daisy Chain Servers:** Multiple instances of brokers (DataHub instances or ETK) can be connected to support a wide range of collection and distribution architectures
- **Propagation of Failure Notifications:** Each client application can know with certainty if and when a connection anywhere along the data path has been lost, and when it recovers
- **Simple:** Message syntax is simple enough to be implemented even on resource-constrained devices
- **Streamable:** Messages can be concatenated and streamed without requiring intervening acknowledgements. This allows clients and servers to communicate asynchronously, reducing latency and significantly improving throughput

DataHub™ Add-in for Microsoft Excel

Version 1.0

Connects Microsoft Excel spreadsheets to Cogent DataHub™-based programs and services.

Table of Contents

User's Guide

Getting Started

Overview

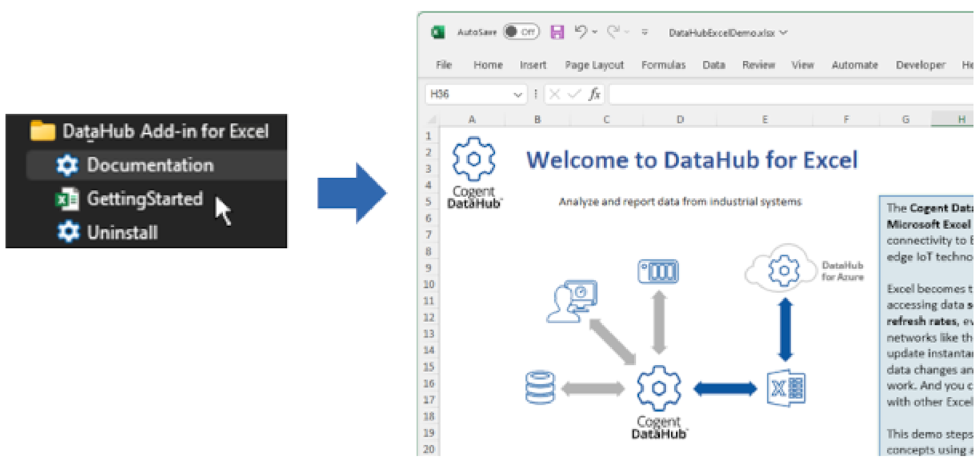
DataHub™ Add-in for Microsoft Excel connects Excel 2010, 2013, 2016, 2019, 2021, or Office 365 (desktop version) to Cogent DataHub software or the Cogent DataHub service for Microsoft Azure. This manual assumes that you have installed Cogent DataHub software, or that you have access to a Cogent DataHub service for Azure account.

Installation

To install the DataHub Add-in simply download the program archive, double-click on it, and follow the instructions. You will need to close Excel for the installation.

Demo Workbook

The DataHub Add-in installation includes a demo workbook that provides a step-by-step, hands-on demonstration of the most-used features. We encourage first-time users to go through that first, and refer to this documentation as a secondary resource.



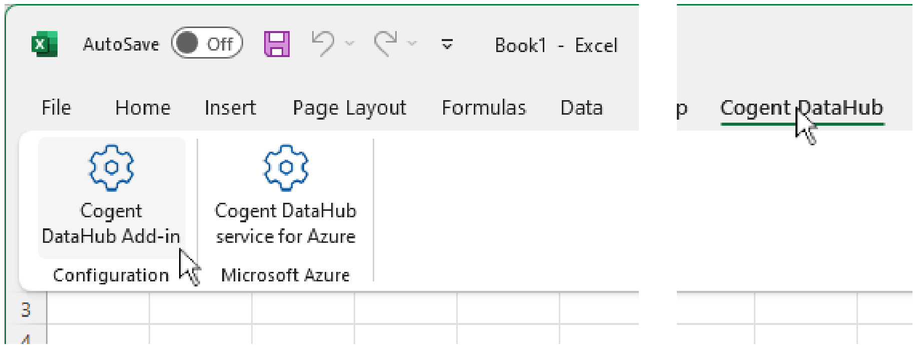
Video

Here is a video that shows how to connect the DataHub Add-in to a DataHub instance. This video uses an earlier product name, "Vine", but the funciionality is the same.

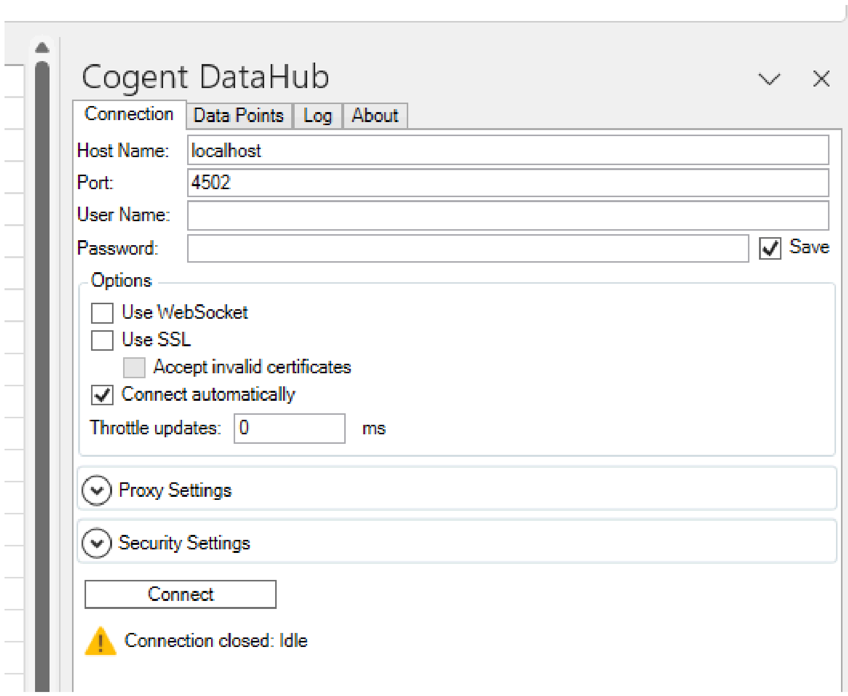
Making a Connection

Once the DataHub Add-in is installed, you are ready to make a connection.

1. In Excel, select **Cogent DataHub** from the ribbon menu, and then click the **Configuration** button.



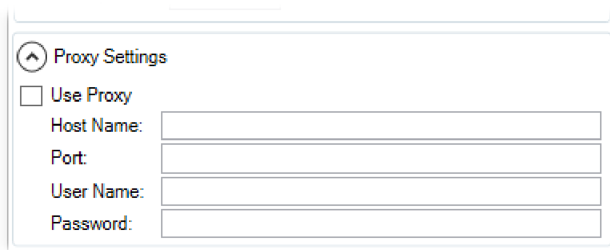
This opens the configuration panel:



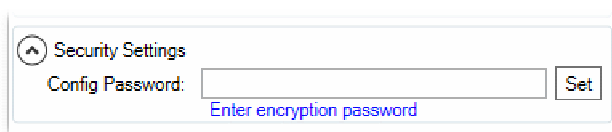
2. In the **Connection** tab you can configure a connection to the Cogent DataHub program or Cogent DataHub service for Azure.
3. Enter the **Host Name** or IP address and the **Port** number for the host computer for your DataHub instance, or the IP address for your Cogent DataHub service for Azure account. For a **WebSocket** connection, the port number is typically `80`, and for **SSL** (with or without WebSocket), it's typically `443`. Connections to the DataHub for Azure must use WebSocket and SSL on port `443`.
4. Enter your **User Name** and **Password** for the DataHub program or DataHub for Azure account. You can check the **Save** box to save your password with this worksheet.
5. Checking the **Connect automatically** box tells the DataHub Add-in to make the connection to the data source as soon as the worksheet is opened. To activate this option, you need to check the **Save** box for the Password entry, even if you have not

entered a password.

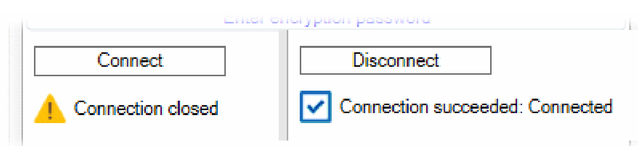
6. You can configure **Throttle updates** to control the rate (in milliseconds) at which updates come into Excel over this connection. This is helpful for reducing bandwith or system resource use. The default (`0`) allows updates as fast as possible.
7. You will need to configure **Proxy Settings** if there is a proxy between you and your DataHub program or DataHub for Azure. Enter the **Host Name**, **Port**, **User Name** and **Password** for the proxy here.



8. See Security Settings in Reference.



9. When you are ready to connect, click the **Connect** button. The status should evenatually change to **Connection succeeded: Connected**.



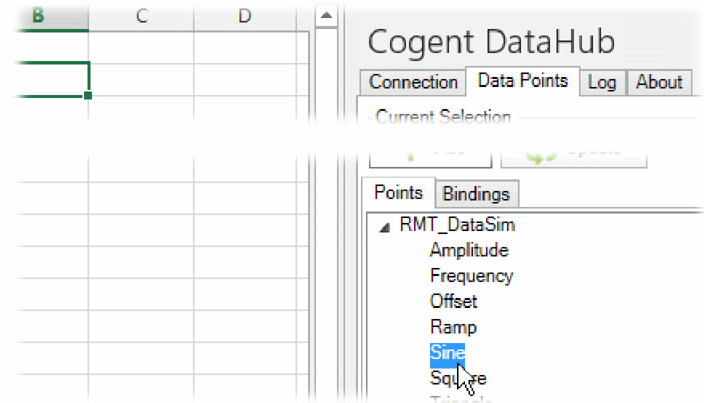
If the connect attempt fails, you can check the **Log** to see what the connection steps were, and get an indication of what might have gone wrong.

Once your connection is established, you are ready to add some data points.

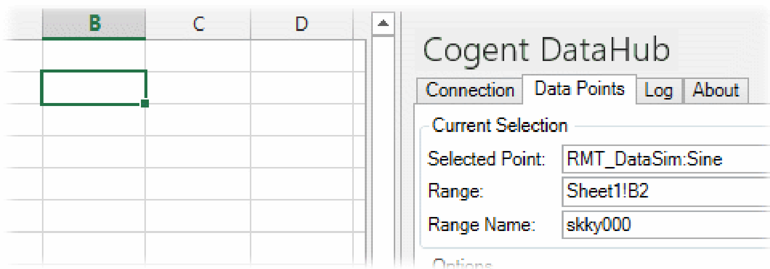
Adding Data Points

When you are connected to the DataHub program or DataHub for Azure, you can start adding data points.

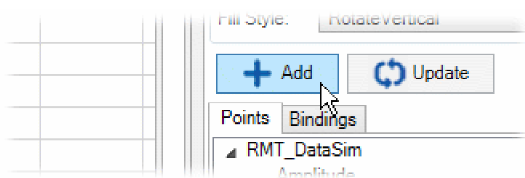
1. In the **Data Points** tab, select a point from the **Points** list in the lower frame.



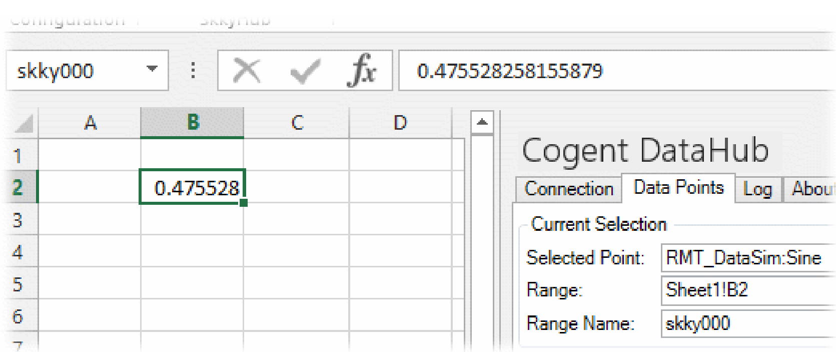
2. Notice that the DataHub Add-in automatically fills in the **Selected Point** and **Range** fields, and automatically generates a **Range Name**. You can choose a different cell to change the range, and you can edit the range name, if desired.



3. When you are ready to add the point, click the **Add** button...

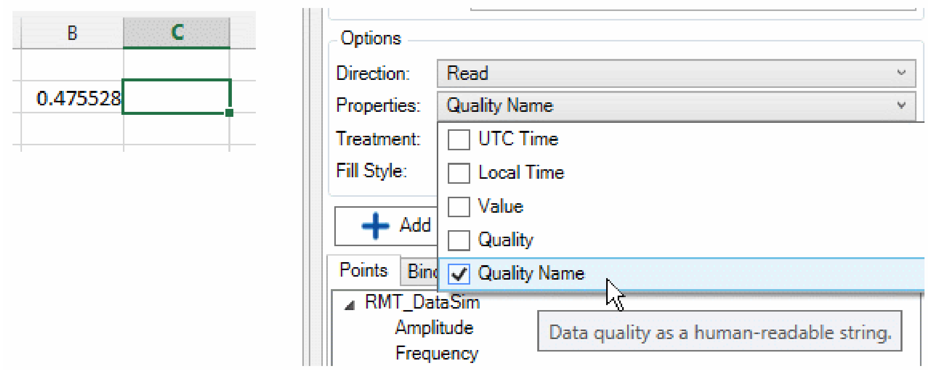


...and the point will be added.

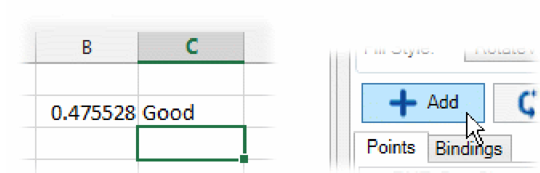


At any time you can change the entered parameters for an existing point, and then click the **Update** button to have your changes take effect.

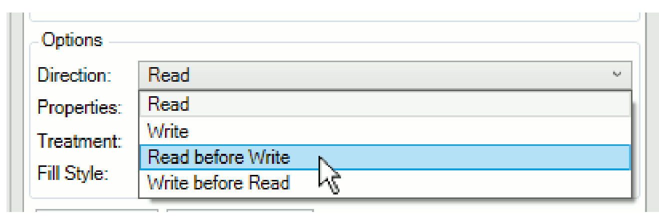
4. You can also add information about a point other than its value, using the Properties drop-down box. For example, go to another cell and then select **Quality Name** for the same point from the Properties list.



5. Click the **Add** button, and the quality name will get entered.

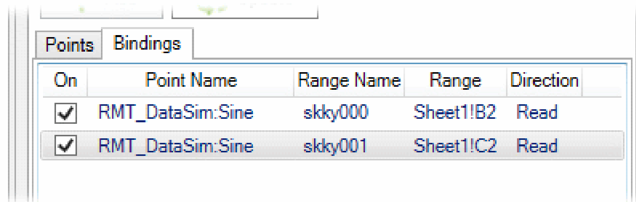


6. To add a point that writes back to the DataHub instance or DataHub for Azure, you can use the **Direction** option to change the direction to **Read** or **Write** for one-way data flow.



For bidirectional data flow, **Read before Write** always takes the value from the DataHub instance or DataHub for Azure initially when this worksheet is first opened. **Write before Read**, on the other hand, updates the DataHub instance or DataHub for Azure as an initial value. In either case, once the connection is made, the data is subsequently updated by the latest values from either side.

7. To see a list of the points you have added, click the **Bindings** tab.



Here you can enable or disable any data point bindings you have made, or remove them.

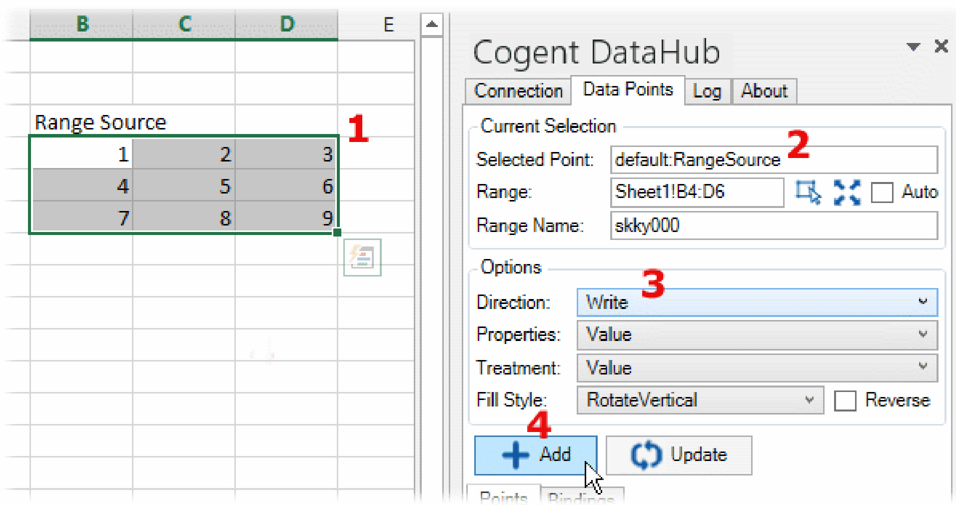
Now that you are familiar with adding individual points, you are ready to work with ranges. For more details adding points, please refer to the section called “Data Points”.

Working with Ranges

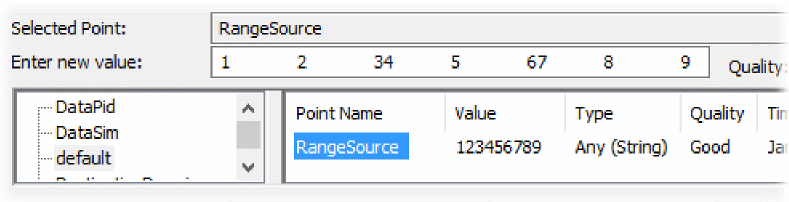
Demo

In addition to binding an individual cell to a DataHub point, you can also bind a range of cells. Here is a brief demo of how to work with ranges:

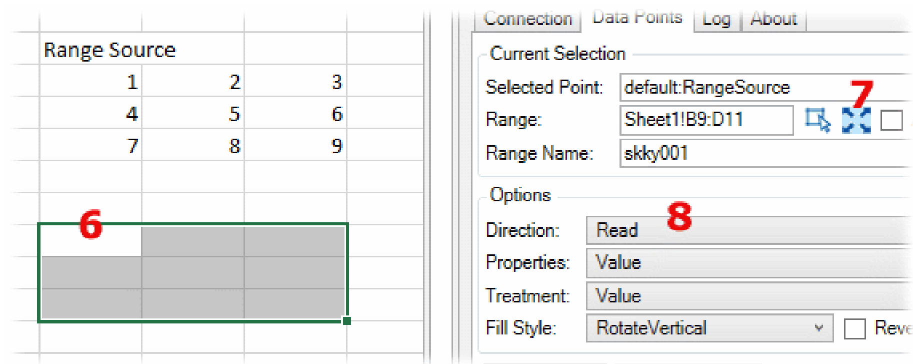
1. Select a range and enter some data into it.



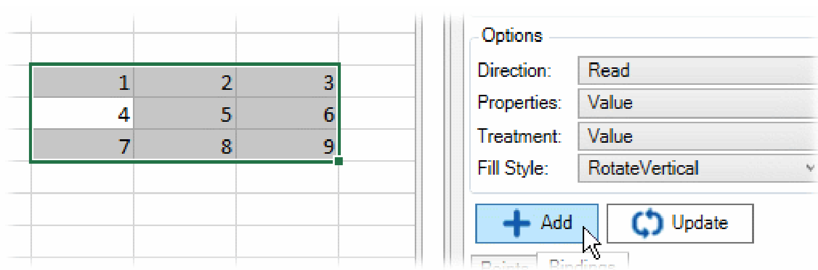
2. In the **Data Points** tab, select or enter a DataHub point name. For the purposes of this demo, this should be a data point that you can write to.
3. In the **Direction** option, choose **Write**.
4. Click the **Add** button to create the binding. This will act as your data source.
5. You can check your DataHub Data Browser to see that the point exists, that it is bound, and that it is a range.



6. Now you can create a second range to receive the data. Ensure that you still have the same **Selected Point**, and then in the worksheet select a single cell.

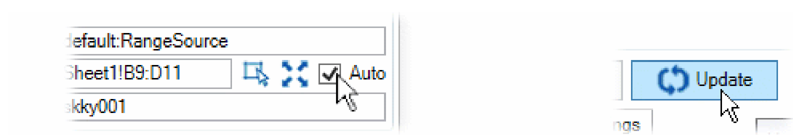


7. Click the the range size icon. The one-cell selection should expand to the size of the bound range.
8. In the **Direction** option, choose **Read**.
9. Click the **Add** button.

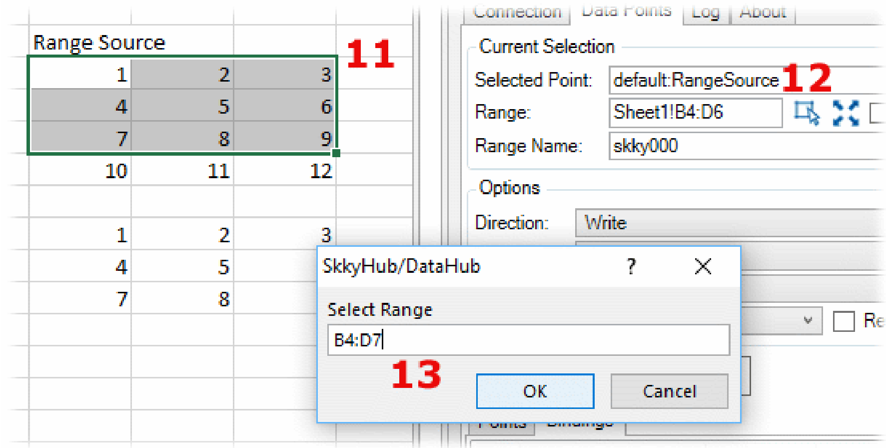


The range should fill with the data from the data source range. Now, whenever any value in data source range changes, this range will update with the same values.

10. What happens if the size of the source range gets changed? You can configure this target range to automatically change as well. While the target range is still selected, check the **Auto** box, and then click **Update**.

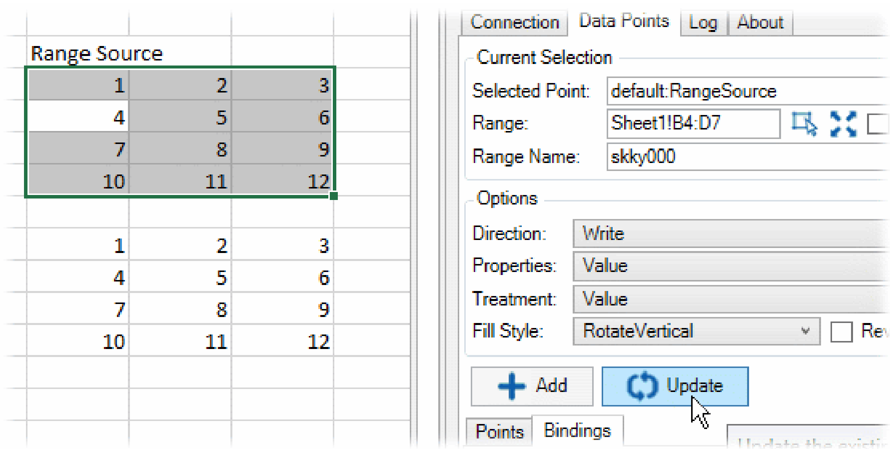


11. Now change the size of the source range, say by adding an extra row. First, select the source range.



An easy way to select a range is from the **Bindings** tab.

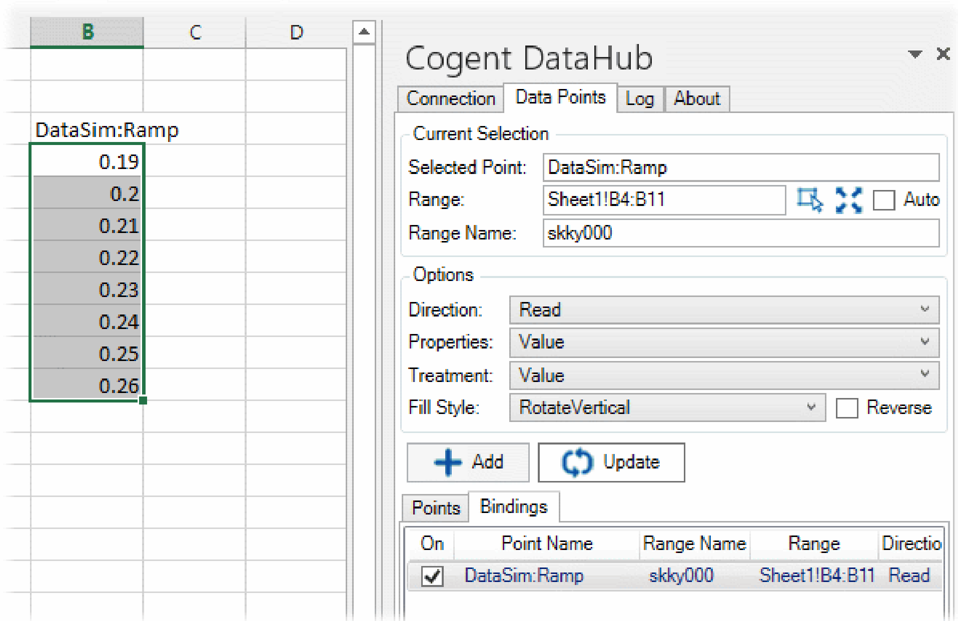
12. With the source range selected, click the new range icon .
13. Enter the coordinates for the new range, click **OK**.
14. Click **Update**.



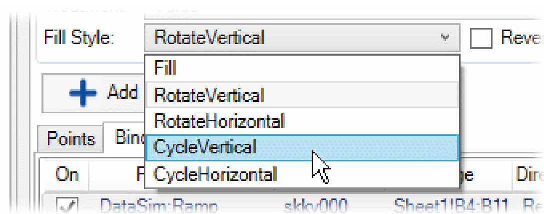
The target range should update as well.

Rotate or Cycle

A multi-cell range can be used to create a rotating or cycling series of updates through the range. The range must be either a single row or a single column, and it must be bound to a point with a single vaue.



For example, using the DataSim program, you can bind a vertical range to the `DataSim:Ramp` point. As the point value increases, the latest value appears at the bottom of the column, and each older value is pushed up one cell. You can check the **Fill Style**'s **Reverse** box to change directions, and have the latest value appear at the top.

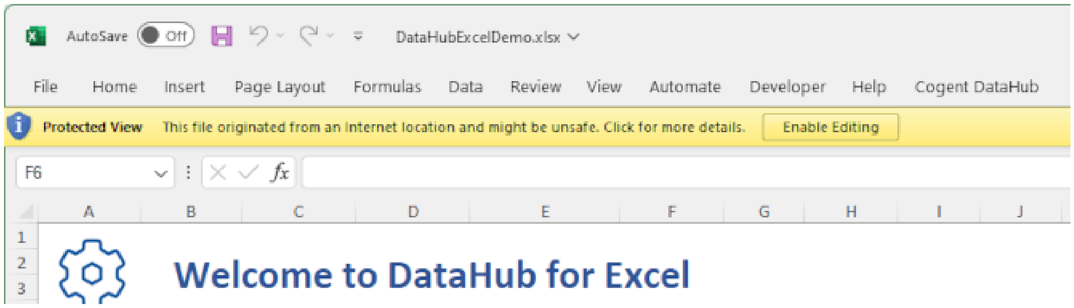


The **Fill Style** options let you specify **Vertical** or **Horizontal** directions for columns or rows, respectively. Also, you can choose between **Rotate** and **Cycle**. The **Cycle** option cycles the latest value through the different positions in the range, creating a wave of updates. Again, checking the **Reverse** box changes the direction.

Troubleshooting

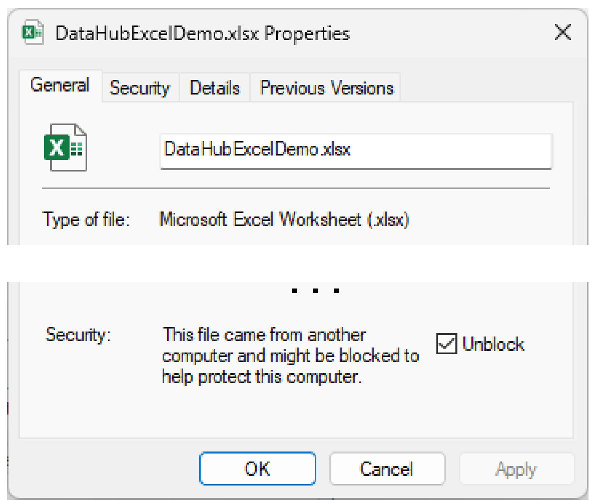
Protected View messages

Under certain circumstances, such as when you download a workbook from the Internet, or copy it from another computer on your network, you may see the following message when trying to open the file. This will prevent your data from updating.



Clicking the **Enable Editing** button will close the message, but your data may still not update. You will need to close and reopen the file in order for the data to start updating.

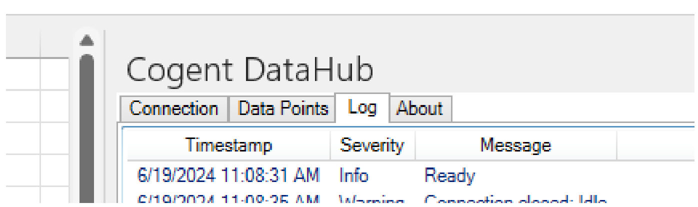
If you still can't see the date, then you may need to close the workbook and open its Properties window in the file browser. At the bottom of the **General** tab, check to see if there is a **Security** option, with an **Unblock** box checked.



If that box is checked, uncheck it, and then click **OK**. When you reopen the workbook, your data should start updating.

What to do if you can't connect

1. Open the DataHub configuration panel and look in the **Log** tab.



If you see messages that look like this:

```
Connection failed - retrying: One or more errors occurred.
```

```
Unable to connect to the remote server:
The remote name could not be resolved: 'demo.skkynet.com'
```

This means your computer could not connect to the cloud server. Typically, if you can connect to a web site from your computer, then you should be able to reach the `demo.skkynet.com` demo site.

2. The `DataHubExcelDemo.xslx` workbook tries to make a WebSocket connection to DataHub for Azure to read and write data. If you are using Windows 7 you will find the connection will not succeed because the WebSocket implementation used by DataHub Add-in is not supported in this OS. Please try the demo on a Windows 8 or later system, or you can connect to a local instance of the DataHub program to stream data across your network.

Other information

- Streaming live data disables Excel's Undo feature. To enable the Undo feature again, you will need to disconnect from the data stream.

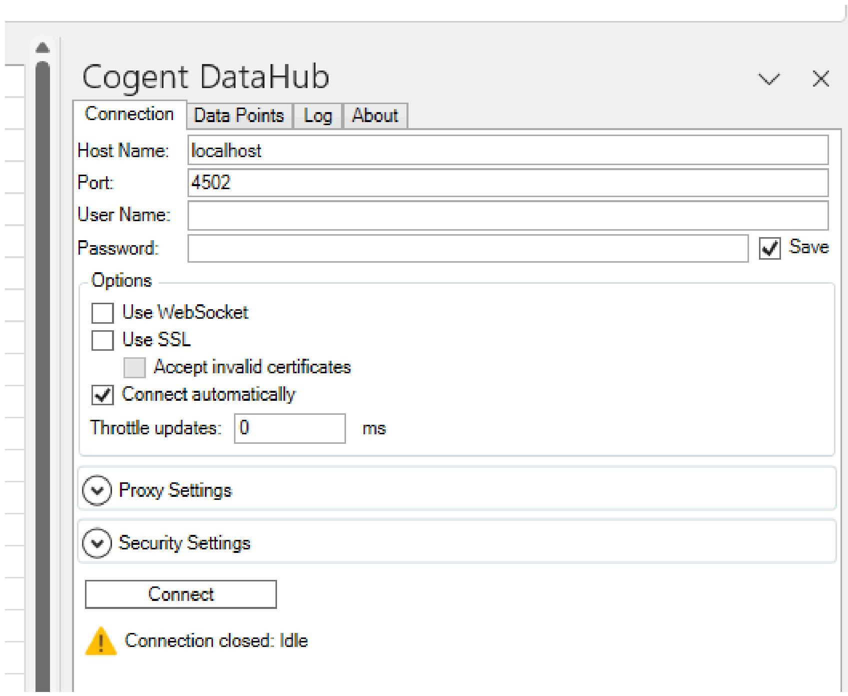
Contact Support

If none of the above suggestions solve your problem, you can send an email to support@skkynet.com and we will respond as soon as possible. Go to Options

Reference

Connection

These are the required and optional parameters for making a connection to a DataHub instance or DataHub for Azure.



Host Name

The name or IP address of the host computer for the DataHub instance, or the IP address for DataHub for Azure.

Port

The port number on the host computer or `443` for DataHub for Azure accounts. Port `80` is standard for WebSocket connections, and `443` for SSL (see below).

User Name

The user name for the DataHub instance or DataHub for Azure.

Password

The corresponding password. The **Save** button allows you to save the password with this worksheet.

Options

Use WebSocket

This is required for connections to DataHub for Azure, and optional for a DataHub instance. It ensures that the connection is outbound-only from the DataHub Add-in.

Port `80` (see above) is standard for this option when used without SSL.

Use SSL

Provides the option of using SSL. Port `443` (see above) is standard for this option, when used alone or with the WebSocket option, such as with DataHub for Azure.

Accept invalid certificates

Allows the SSL connection to be made even if the security certificate is invalid.

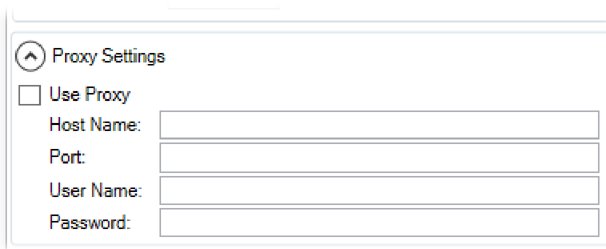
Connect automatically

Causes the workbook to attempt a connection when it is opened.

Throttle updates

Lets you control the rate (in milliseconds) at which updates come into Excel over this connection. This is helpful for reducing bandwith or system resource use. The default (`0`) allows updates as fast as possible.

Proxy Settings



Host Name

The name or IP address of the host computer for the proxy server.

Port

The port number on the host computer for the proxy server.

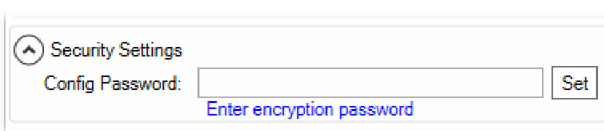
User Name

The user name required by the proxy server, if any.

Password

The corresponding password.

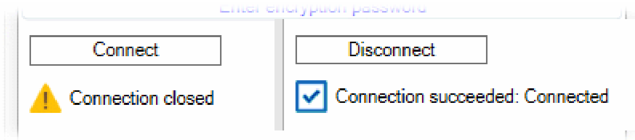
Security Settings



Config Password

Entering a password here and saving the worksheet will encrypt the DataHub Add-in configuration stored within the worksheet. Once a password is set, any user opening the worksheet would need to open this configuration panel and enter the password to establish the data connection.

For all connections

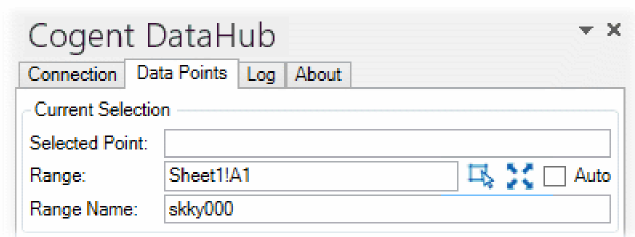


Connect button
: Sends a request for a connection (or disconnect) according to the current configuration.

Status messages
: Displays the status of the connection. These all get logged, and can be viewed in the Log tab.

Data Points

Here you can select and configure the data points to which you want to connect.

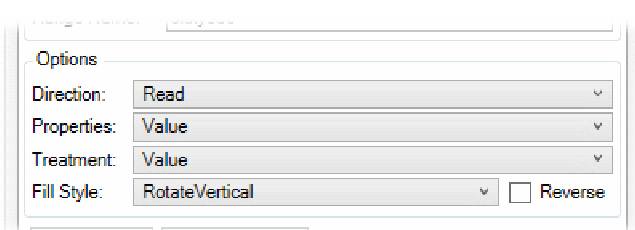


Selected Point
: Enter the point name manually, or select it from the list in **Points** or **Bindings** below.

Range
: The range selected in the worksheet will appear here. You can change this with the new range icon, or modify it to match the size of the range with the range size icon. You can also check the **Auto** box to automatically adjust the range when the range in the data point changes size. These changes will take effect when you click the **Update** button (below).

Range Name
: The system provides a default range name, which you can change. This range name can be used in formulas in other cells.

Options



Direction

There are four options for the direction of the data flow:

- **Read** the data from the server (DataHub instance or DataHub for Azure) into Excel.
- **Write** the data from Excel to the server. Use this to publish a value or formula result back to the server.
- **Read before Write** creates a bidirectional connection that always *takes the value from the server* initially, when this worksheet is first opened. Once the connection is made, the data is sequentially updated by the latest values from either side.
- **Write before Read** creates a bidirectional connection that always *updates the server* from this worksheet when it is first opened. Once the connection is made, the data is sequentially updated by the latest values from either side.

Properties

Lets you select which properties of the data will appear in consecutive cells in a range (**UTC Time**, **Local Time**, **Value**, **Quality**, and **Quality Name**). They will be added to the range in that order. You need to ensure that you have selected the correct number of cells to accommodate all of the ones you select.

Treatment

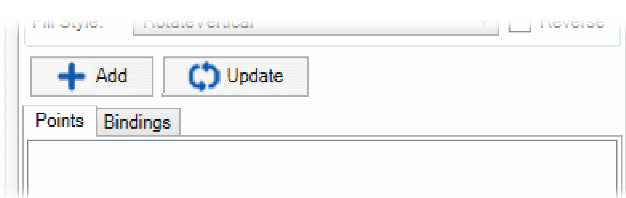
Lets you specify how the data is treated. **Value** preserves the point's data type and value. **Formula** treats strings that start with = as formulas; all others are treated the same as **Value**.

Fill Style

When you select a range of cells, the **Fill Style** determines how **Read** values will fill the cell:

- **Fill** updates all cells in the range with the same value.
- **RotateVertical** adds new values to the last cell in the range, pushing all previous values upward within the range.
- **RotateHorizontal** adds new values to the last cell in the range, pushing all previous values to the left.
- **CycleVertical** adds new values to the range from top to bottom. When the last cell in the range is filled, new values begin to to fill in from the top again.
- **CycleHorizontal** adds new values to the range from left to right. When the last cell in the range is filled, new values begin to to fill in from the left again.
- **Reverse** changes the direction of any **Rotate** or **Cycle** option above (e.g. bottom to top, right to left, etc.).

For all selections



Add button

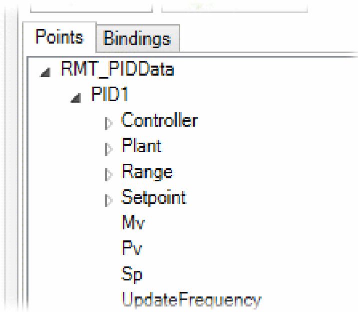
Adds the current selection.

Update button

Applies any configuration changes made to the current selection.

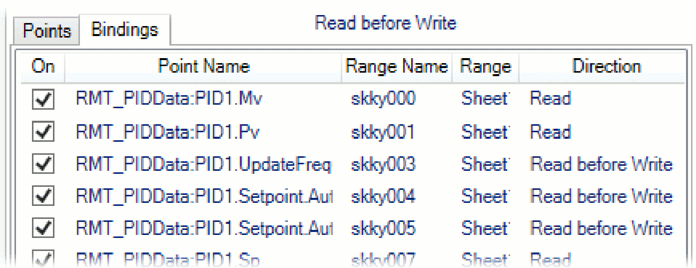
Points

Displays all the points that are available on the server.



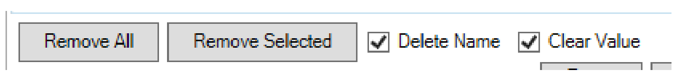
Bindings

Displays all the saved bindings of points to ranges.



Remove All or **Remove Selected**

These buttons remove all bindings, or the one selected.



When removing, the **Delete Name** option lets you remove or keep the range or cell name. The **Clear Value** option lets you remove or keep the values in the range or cell.

Export and **Import** buttons

These allow you to export or import bindings.

To export

1. Open a blank sheet and select a cell where you want the list of exported bindings to start.
2. Press the **Export** button. All the binding information will be written as an eleven-column list, with one binding per line.

3. You can save the sheet or its contents to a file.

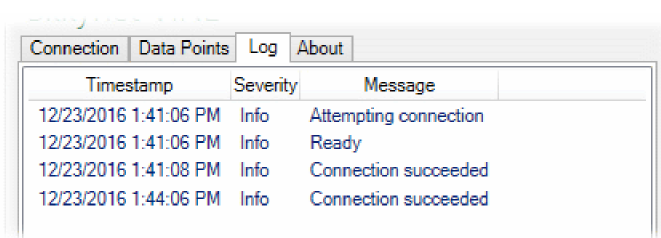
To import

1. In the target workbook, open a blank sheet and select a cell where you want to start the list of bindings.
2. Put the whole binding information list, including headers, into the sheet. You can do this by copy/paste or by reading a CSV file into the sheet.
3. You can now modify the contents of the list, add rows, remove rows, etc. to customize the import, if you wish.
4. Select the entire range, including the column headers.
5. Press the **Import** button.

   The bindings should appear in the **Bindings** window and be fully operational.
6. You can now delete the sheet with the bindings list you created.

Log

Each status message for the connection is logged, and can be viewed here.



DataHub™ WebView™ HMI

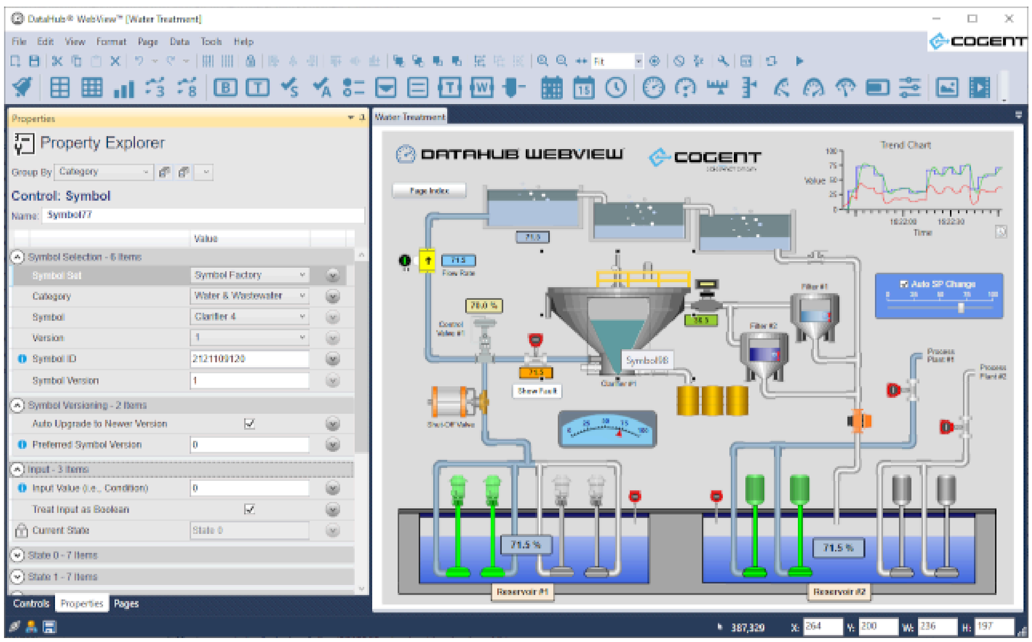
Version 2.0

A powerful HMI application fully integrated with Cogent DataHub™ software.

Table of Contents

Introduction

The DataHub WebView program is a state-of-the-art, rich internet application for designing and delivering high-quality, real-time displays in Windows Desktop or Internet Explorer. All page creation and editing is done using a built-in editor, and page updates can be automatically published as soon as changes are saved. Page designers have access to standard controls, gauges, and 4,000 industry-standard symbols, each of which can be easily configured to recognize condition states and to graphically notify operators of process status and anomalies. All controls feature powerful, "anything-to-anything" data binding.



Advantages of the DataHub WebView application

- **Edit screens anywhere** Just open your web browser, type the address of your DataHub Web Server, log in to the system and, based on your access permissions, you can build, edit and view WebView screens from anywhere with network/Internet access.
- **No coding required** Build all your screens using the powerful built-in graphical environment. Complete point and click freedom, with no code in sight.
- **No development system required** You do not need to install a development system on your computer in order to build WebView screens. The development interface is provided to you, in your browser, by the web server. No compiler necessary.
- **No deployment required** Because the screens you build in the WebView application are saved on the web server, you never have to deploy your changes to other users. When you are editing a page and you want to show your colleagues, you simply save your changes, and tell your team to reload the page in their browser. No deployment, no complicated file updates.

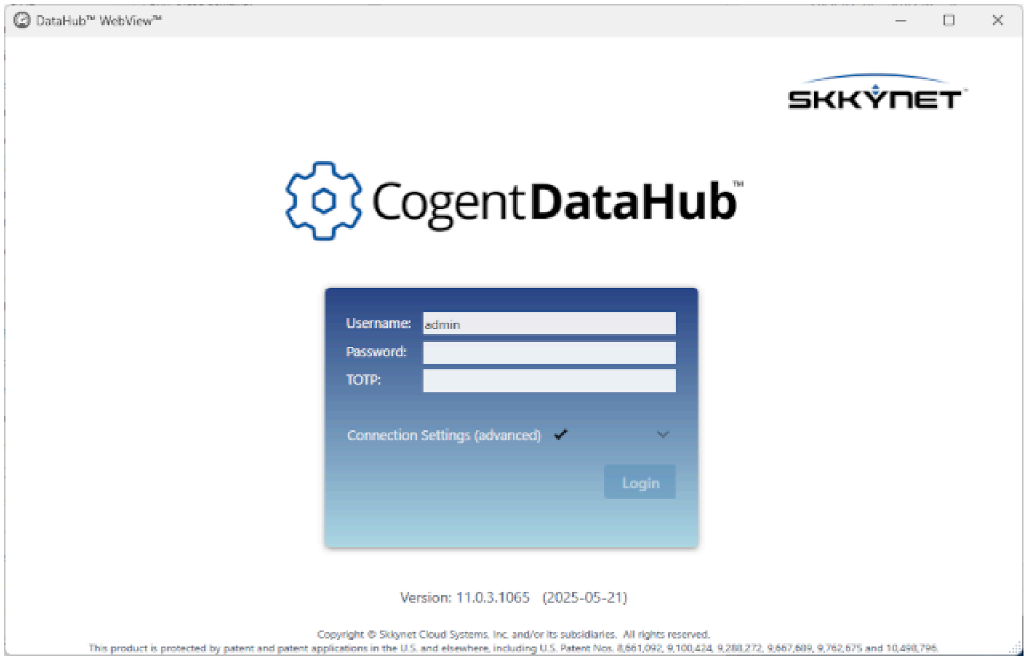
- **Collaborate on development** With no limit to the number of users accessing the system, you can have a team of developers building pages at the same time. Depending on the permissions you give to your team members you can have them edit everyone's pages, or restrict access so they can only edit the pages they build.
- **Build entire multi-page HMI applications** with hyperlinks between pages, just like a web site or standard HMI system.
- **Security at every level** The permissions based security model allows you to define very precise privileges to each user. You can define certain users to have read only access, while other can view and make changes but not access the development interface. In the WebView application, the security model was one of the fundamental primary requirements, not an afterthought.
- **Specify sophisticated graphical interactions between controls** using the WebView application's powerful property binding feature. Property binding allows you to associate the input values for one control, with the properties of other controls. Simpler to do than to describe, this saves you time and adds significant power to your WebView screen.
- **Comes with a standard set of built-in controls** such as trends, gauges and sliders. In addition, the WebView application also ships with a complete set of Symbol Factory[1] symbols, which offer thousands of industry standard symbols for a variety of industries. The WebView application is able to provide these and other future third party symbols.

Run Locally

1. To run the WebView application on your local computer, from the Start menu go to the Cogent programs and select the WebView program.

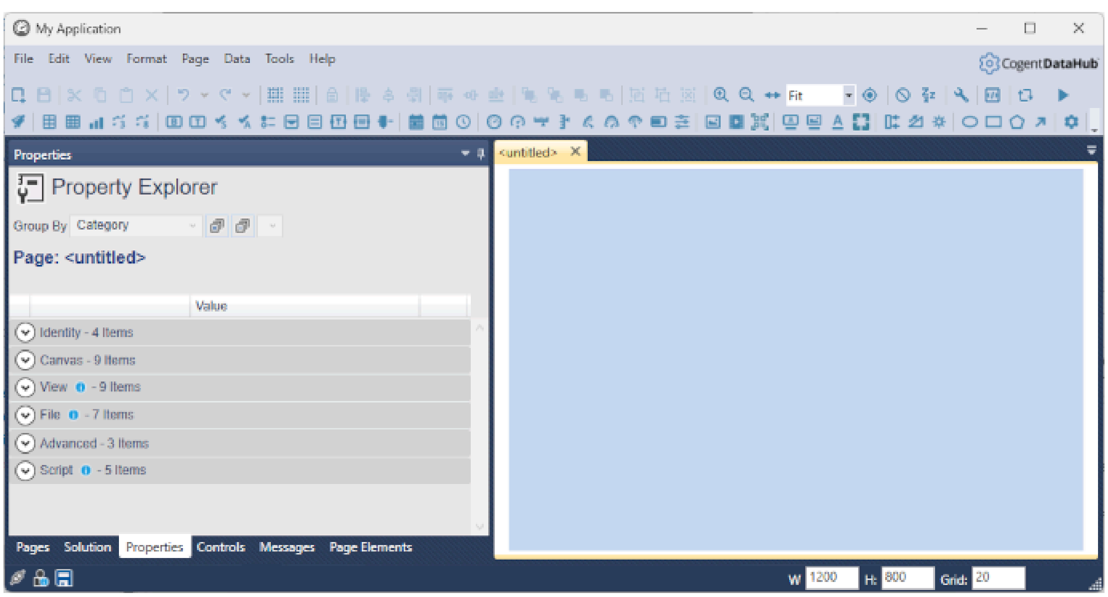
   This will open the WebView log-in screen:

[1]Symbol Factory# is a trademark of Reichard Software Corporation. Symbol Factory graphics are included with the WebView application under license from Software Toolbox and Reichard Software Corporation.



2. To log in, enter **`Local`**, **`admin`**, **`admin`** for **Organization**, **Username** and **Password**, respectively. To change user name or password, please refer to DataHub Security. For details about connection options, please see Advanced Launch Options. And for DataHub configuration options, please see DataHub Configuration.

   Logging in will open the WebView interface:



You are now ready to start creating pages.

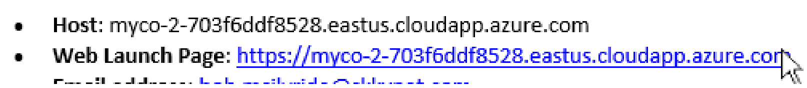
Web Launch

To access WebView remotely—to use with the Cogent DataHub service for Microsoft Azure or a remote Cogent DataHub instance—you can launch it using the Skkynet Web Application Manager. This special program helps you securely manage the launch process and application files.

1. Access the Skkynet Web Application Manager in one of these two ways, depending on your program or service:

   Cogent DataHub service for Azure:

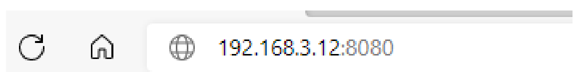
   Click the Web Launch Page link in the email you received from Skkynet.

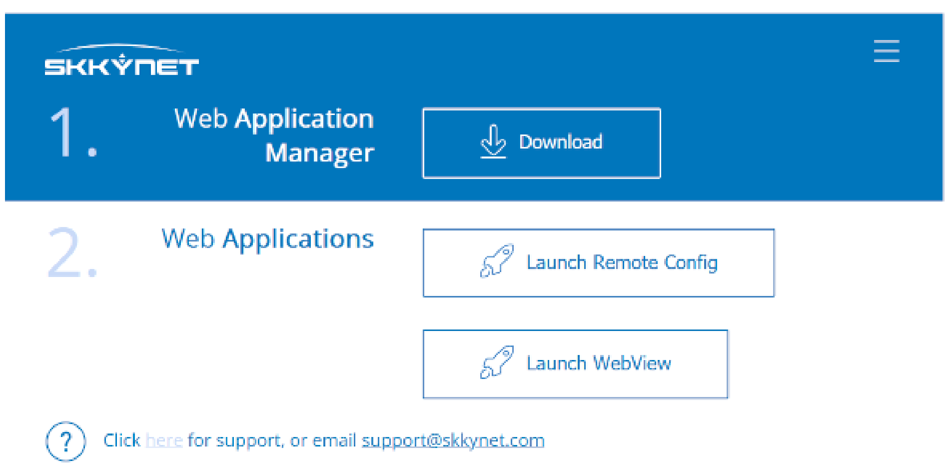
   A remote Cogent DataHub instance:

   a. Ensure that the remote DataHub instance is running, and that its Web Server feature is enabled.

   b. Open a web browser and type in the IP address or network name for the DataHub computer. If the Web Server feature on that DataHub instance is configured to use a port other than the default port `80`, include that port number in the network address. For example, if the remote DataHub instance is at `192.168.3.12` and its Web Server is configured to use port `8080`, then the network address would be `192.168.3.12:8080`.

   Any of these approaches opens the launch page for the Skkynet Web Application Manager:

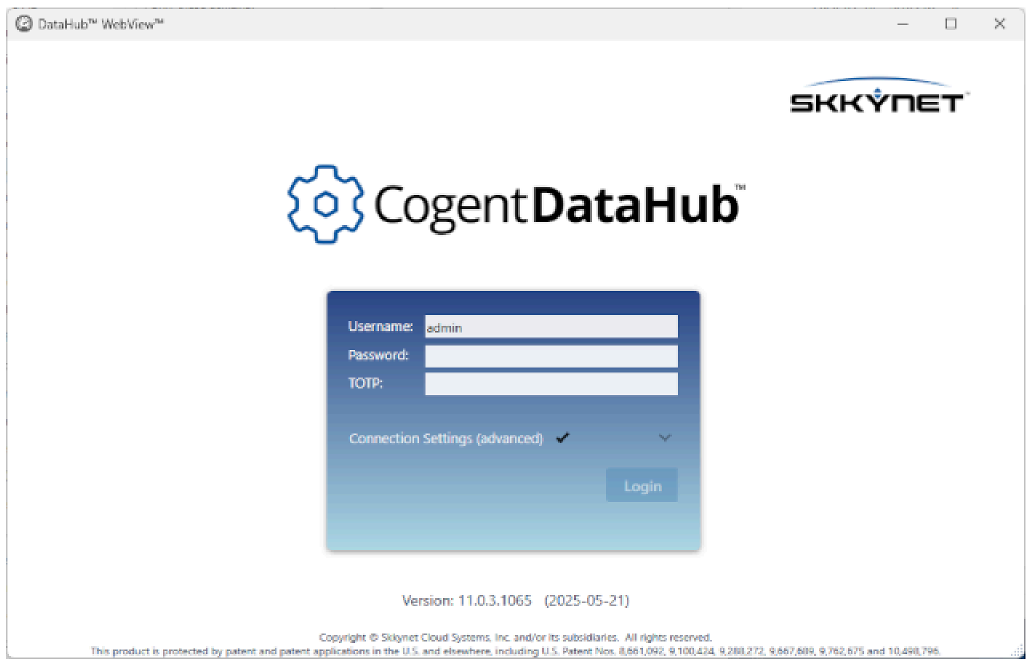
   

2. Click the **Download** button to download and install the Web Application Manager.

3. In the Web Application Manager, click the **Launch WebView** button.

If this is the first time that a remote launch of the WebView application has been done on this computer, you will be prompted to securely download the necessary files to run it. Please see Launching Applications for additional information.

4. As soon as the WebView application files have been accepted, the WebView application will run:



5. To log in, enter the appropriate credentials. If accessing a remote DataHub instance that has not yet been configured for security, you can enter **`Local`**, **`admin`**, **`admin`** for **Organization**, **Username** and **Password**, respectively. To change user name or password, please refer to DataHub Security. For details about connection options, please see Advanced Launch Options. And for DataHub configuration options, please see DataHub Configuration.

6. The first time the WebView app is used, it will download a set of WebView controls and support files which enable you to design and build WebView pages. These files are also certificate signed, so you will see a second list of files you need to accept or reject, as explained in Launching Applications. If you reject the files, you will not be able to place or see controls in your WebView screens.

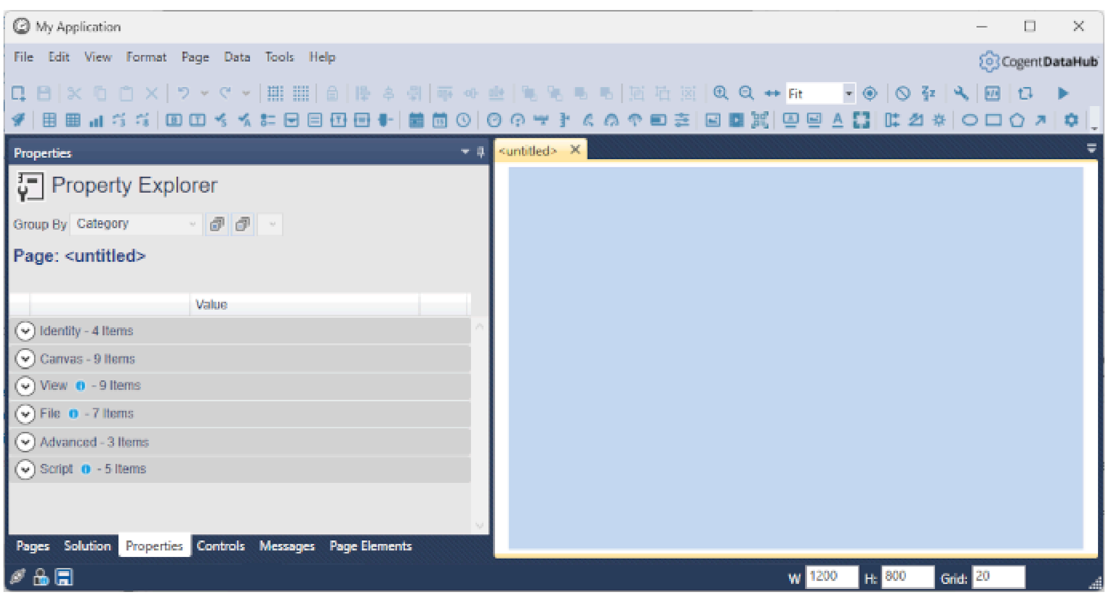
The WebView application allows you to create and deliver custom controls to your users. These custom controls are delivered to the client as DLLs that contain executable code. If you have created a custom control, or are using somebody else's custom control, it must be signed with a code signing certificate. If the certificate is not valid the dialog background will be red, and the certificate status will be Invalid. You may still accept the controls if you know they are from a trusted source. Never accept controls that are delivered from the Internet, including from Skkynet, that are not signed with a valid certificate.

Click **Accept** to download the necessary files and continue. Your choice will be remembered, so you will not see this again the next time you run the app.

It is highly unlikely, but if for some reason you want to revoke your acceptance of the downloaded WebView controls and support files, then you will need to navigate to the following location and delete the `settings.xml` file.

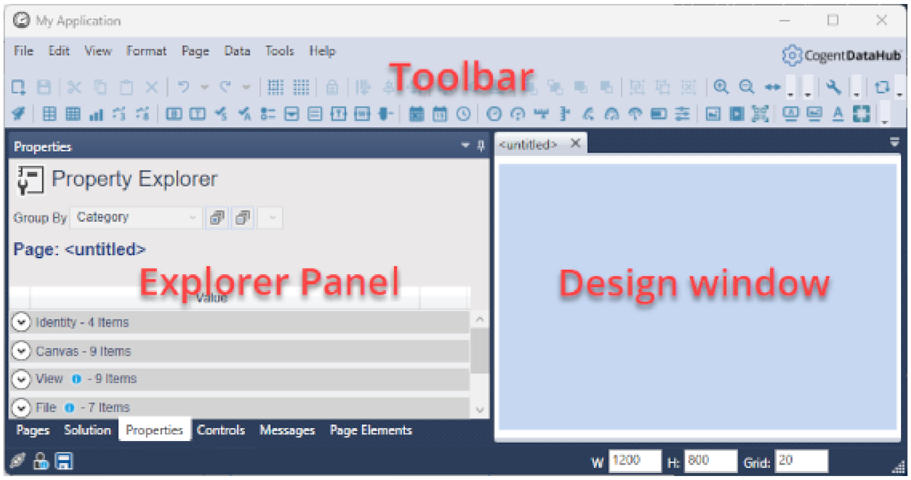
`C:\Users\`*`user name`*`\AppData\Roaming\Skkynet\Cache\`*`your IP address`*`_80\ControlAssemblies`

You are now ready to start creating pages.



User Interface

The WebView user interface is made up of 3 main areas: the Toolbar, the Explorer Panel, and the Design window.



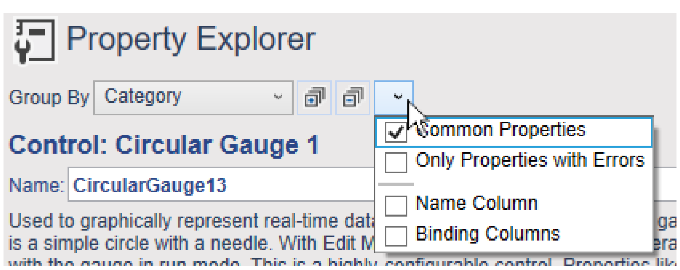
The Toolbar contains all the tools and controls used for building pages.

Pages and controls are described in more detail in the Pages and Controls sections.

The Design window is where you build pages and place controls.

The Explorer Panel has several tabs for displaying details about the pages, controls, and other elements of your WebView project. Here is a brief description of all Explorer Panel tabs available in v11:

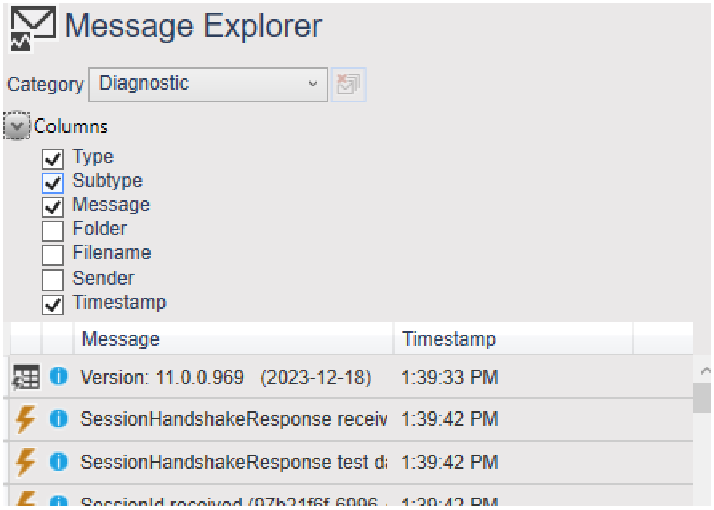
- **Pages** lists pages grouped by the page owner, as well as Solutions that contain multiple pages.
- **Solution** provides a way to configure page management settings for a solution, a group of pages held in memory to allow quick switching between them. (See Solutions for details).
- **Properties** gives access to all of the properties of the selected item in the Design window, typically a control or a page.



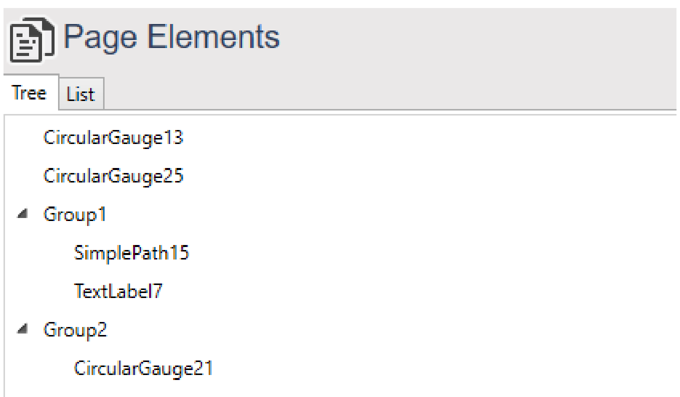
  There are options for grouping and sorting properties, as well as for hiding or displaying certain properties or additional columns of information.

- **Controls** lists all WebView controls by category, with descriptions and activation buttons.
- **Messages** displays the system message logs, and offers several column and sorting

options.

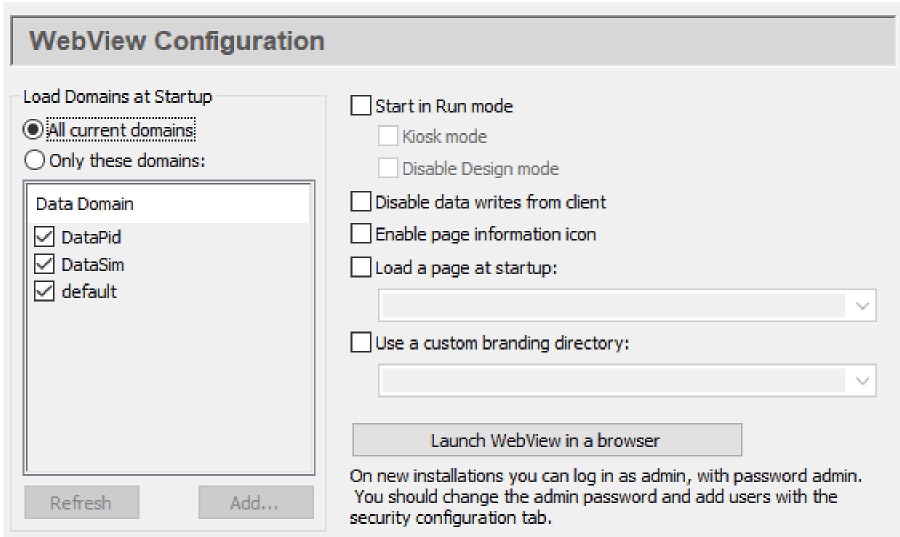


- **Page Elements** lists all the elements on a page, in either tree or list view. This is helpful for managing pages with large numbers of controls.



DataHub Configuration

Certain parameters of the WebView application can be configured from within the DataHub Properties window:



All current domains

This option initializes all DataHub data domains when the WebView application starts. This is helpful in Design mode for selecting data points to bind to controls, by using auto-fill-in.

Only these domains

This option initializes all points in the selected domains when the WebView application starts. Data points in the unchecked domains will be loaded only when requested by a WebView client. Unchecking domains that contain large numbers of points can significantly improve page load times for users during Run mode.

Start in Run mode

Allows you to start in Run mode, rather than Design mode, with these options:

Kiosk mode

Presents just the working screen of the web browser, with no border, menus, URL entry field, etc. To escape from Kiosk mode (and close the browser), press **Alt** + **F4**.

Disable Design mode

Prohibits any switch from Run mode to Design mode, whether running in Kiosk mode or normally.

Disable data writes from client

Prevents the web client from accessing DataHub point values.

Show page information icon

Shows or hides the page information icon.

Load a page at startup

Allows you to specify a page that will automatically load when the WebView application starts.

Use a custom branding folder

Allows you to specify a folder for holding custom branding information. For details, please refer to Customizing.

Launch WebView in a browser

Provides a convenient way to start the WebView application to check this configuration.

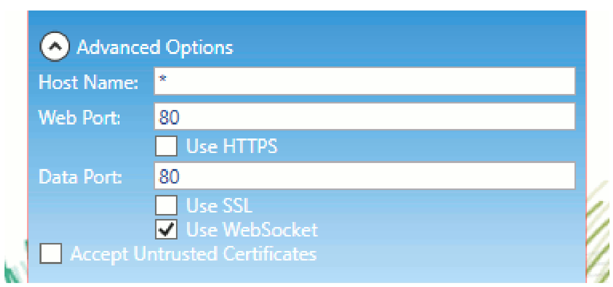
The WebView application requires the DataHub instance to be configured as a tunnelling master. Please refer to Tunnel/Mirror Master in the Cogent DataHub manual for details.

DataHub Security

For Cogent DataHub program users, once you have tested the WebView application with the default username and password (`admin`, `admin`), you may want to change the `admin` password or add other users with different access permissions. This is explained in the WVUser example of the Using Security chapter of the Cogent DataHub book.

Advanced Launch Options

The following advanced options are available.



Host Name

The name or IP address of the computer on which the DataHub instance is running.

Web Port

The HTTP port number on which the DataHub Web Server is listening. The default `80`.

Use HTTPS

Enables the HTTPS protocol, and changes the **Web Port** default to `443`.

Data Port

The number of the port used to connect to the DataHub data feed. The default is `4502`.

Use SSL

Enables SSL, and changes the **Data Port** default to `4503`, or `443` when combined with **Use WebSocket**.

Use WebSocket

Enables the WebSocket protocol, and changes the **Data Port** default to `80`, or `443` when combined with **Use SSL**.

Accept Untrusted Certificates
Ignores security certificate warnings.

Working With the WebView Application

Quick Start

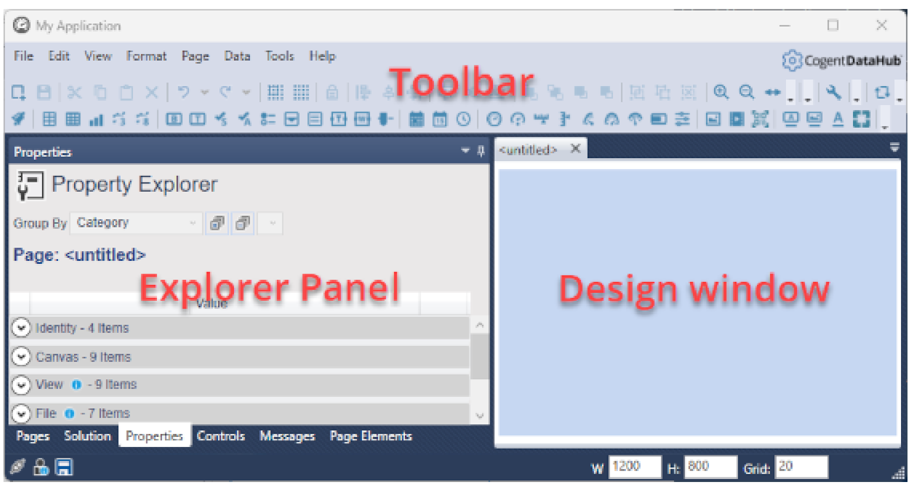
Here is a brief example of how to start the WebView application, add a control to a page, edit a property and animate the control with live data, and then save and view the resulting page.

Start the WebView Application

You have two options for starting the WebView application:

1. Run the WebView application locally.
2. Web launch the WebView application.

The WebView user interface is made up of 3 main areas: the Toolbar, the Explorer Panel, and the Design window.



The Toolbar contains all the tools and controls used for building pages.

The Design window is where you build pages and place controls.

The Explorer Panel has several tabs for displaying details about the pages, controls, and other elements of your WebView project.

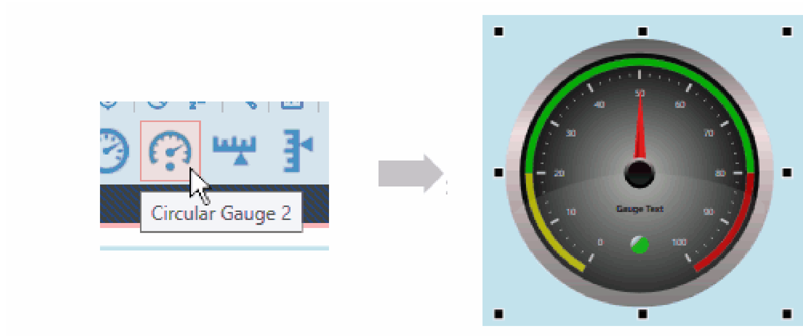
Please see User Interface for more information on these.

Add and Modify a Control

You are ready to begin building pages.

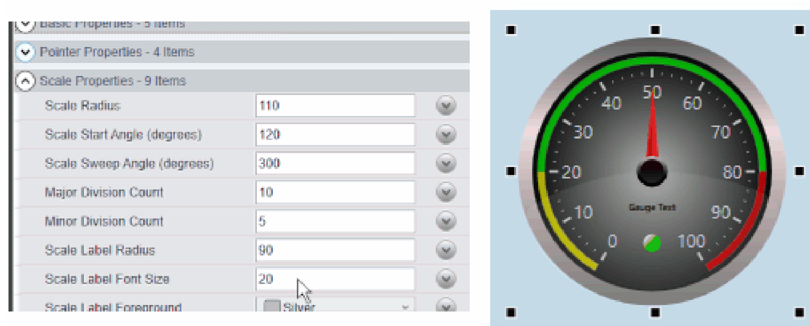
1. Find the Circular Gauge 2 control button among the controls in the Toolbar, and click

it.



A copy of the Circular Gauge 2 control will appear in the blank page.

2. Now let's adjust a property of the gauge. In the Properties list in the Explorer Panel, find the **Scale Properties**, expand the list, and in the **Scale Label Font Size**, enter **`20`**.



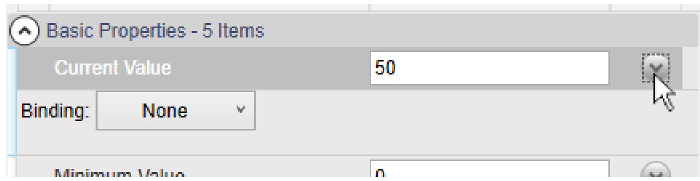
Press **Enter**, and the font size of the numbers on the gauge will expand to 20 points.

See also the section called "Control Properties" for more details about working with control properties.

Bind a Control to a Data Point

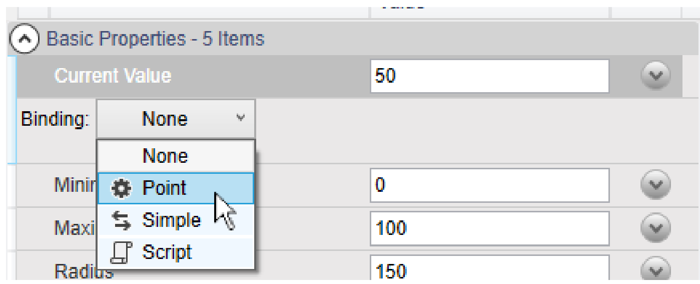
Many of the WebView controls can be bound to certain variables, so that whenever the variable changes, the value or appearance of the control changes as well. For example, a gauge or meter can be bound to a DataHub point to display changes to the point in real time. In this example we bind the gauge we created above to display the value of the DataPid point Pv.

1. Start the DataPid program that is included in your Cogent DataHub archive to generate some test data.
2. Open the **Basic Properties** of your gauge, and click the arrow button on the right side of the **Current Value** row.



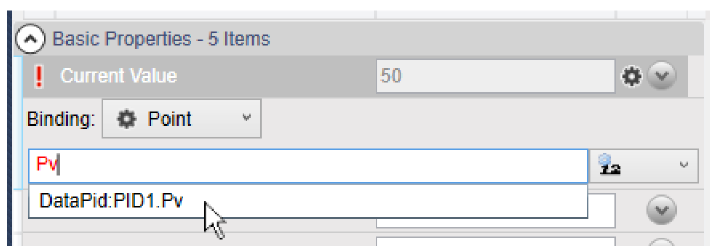
A **Binding** selection box will appear.

3. In the **Binding** selection box, click the down arrow to open the list, and select **Point**.



This will activate the point selection entry field.

4. We want to connect to the DataPid point **DataPid:PID1:Pv**, so enter just **Pv**. All the points that have "Pv" in their names will appear.

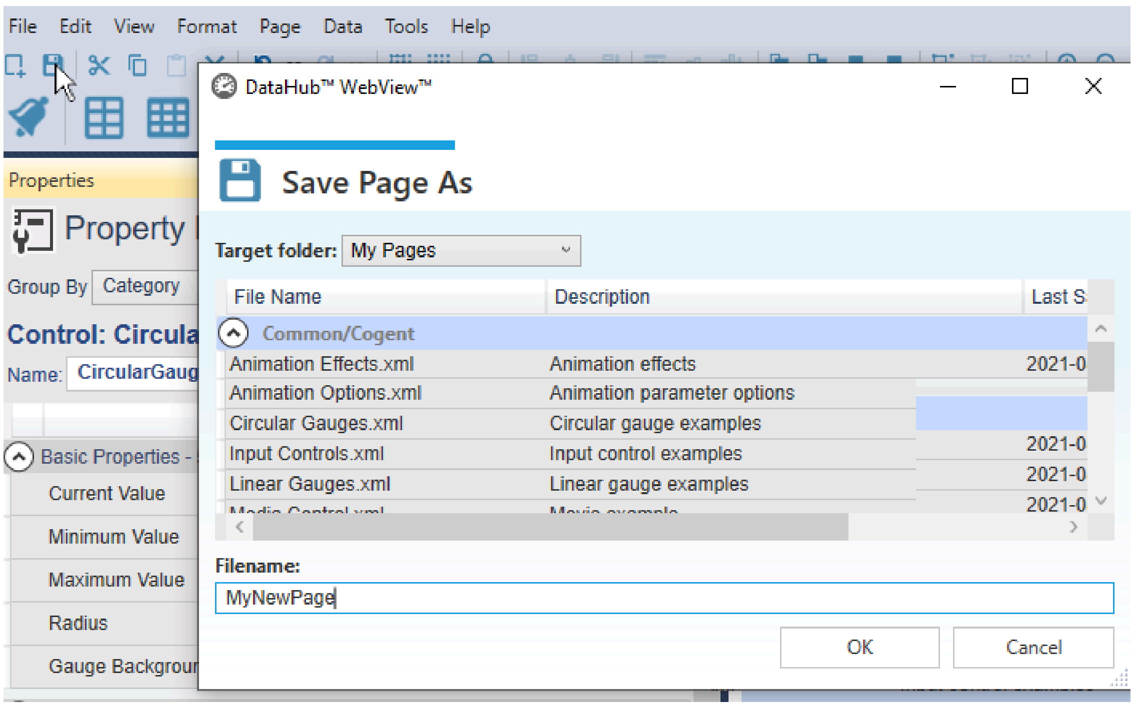


Select the point **DataPid:PID1:Pv**. Once selected, the data will start updating in the value entry, and the gauge needle will start to move.

See also the section called “Controls” for more details about using controls, or the section called “Property Binding” for binding data them to DataHub points.

Save and View a Page

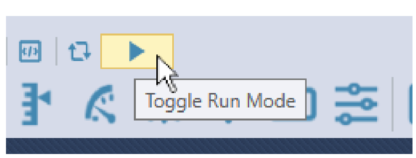
1. To save the page, you can click the Save button , or choose **Save** from the **File** menu, or press **Ctrl** + **Shift** + **S**.



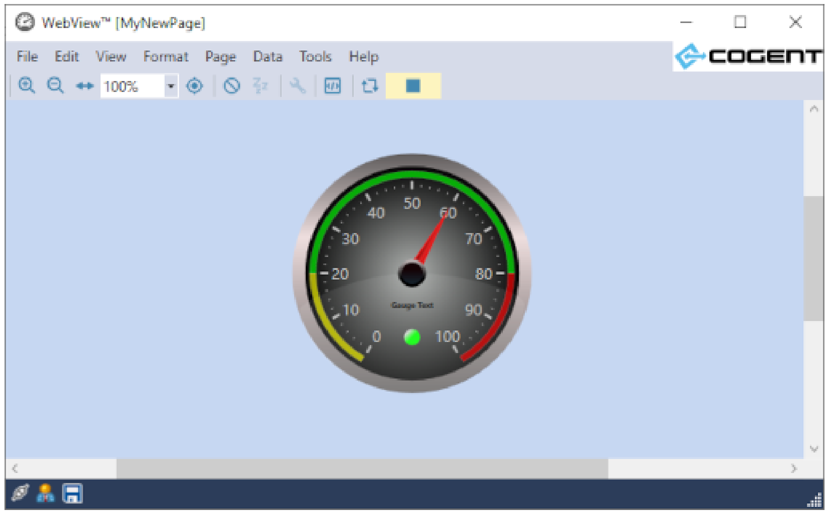
Specify a file name for the page.

> Any page created in WebView version 1.4 and earlier (that was distributed with DataHub version 7.x) gets upgraded to the current version of the WebView application as soon as it is opened. If you save this page, the conversion is permanent, and you will be unable to load the page in the older version of the WebView application. If you expect to revert to the older version, you should create a backup of your page before saving it in the latest version of the DataHub program.

2. To enter Run mode and view your page, click on the **Enter Run Mode** button or press **Ctrl** + **Shift** + **R**.



Your page will appear in the web browser as a user would see it, with all the controls fully animated and functional.

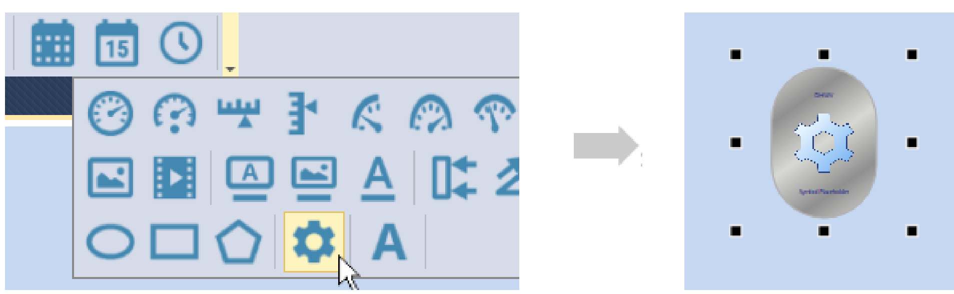


To exit Run mode and return to Design mode, click on the **Exit Run Mode** button  or press **Ctrl** + **Shift** + **R**.

See also the section called “Pages” for more details about saving and viewing pages.

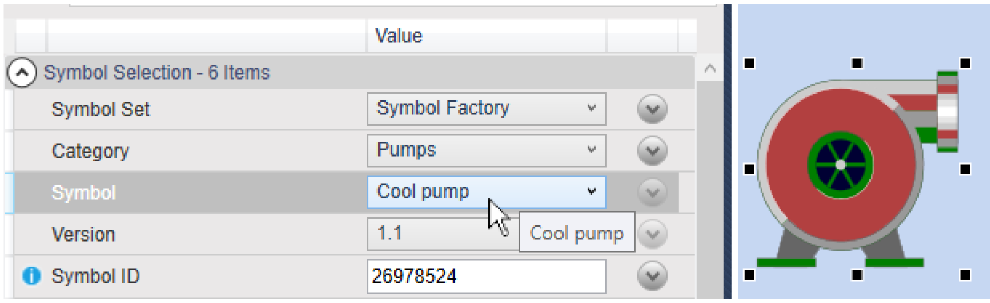
Add a Symbol

1. Find the Symbol control button near the end of the list of controls, possibly in a drop-down list. and click it.



A copy of the Symbol control will appear in the page. This one control can be used to represent any symbol in the symbol library, which contains thousands of different symbols.

2. In the Properties list, for the **Symbol Set**, choose **Symbol Factory**. For **Category** choose **Pumps**, and for **Symbol**, choose **Cool pump**.

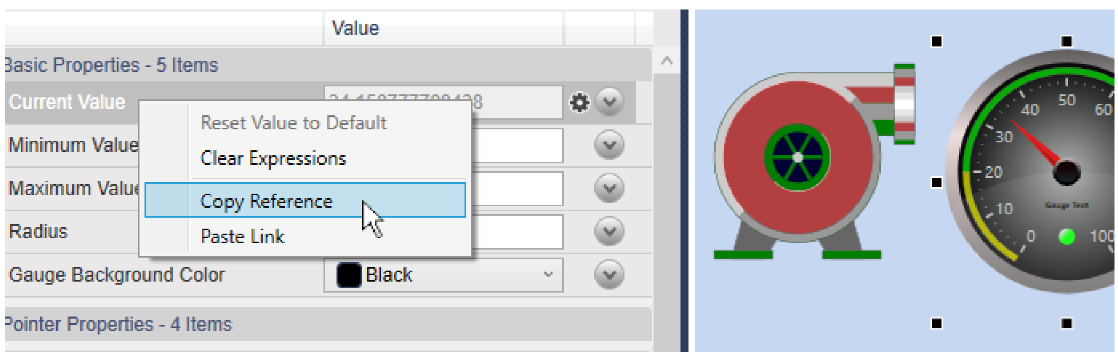


The generic symbol icon should change into a symbol of a pump.

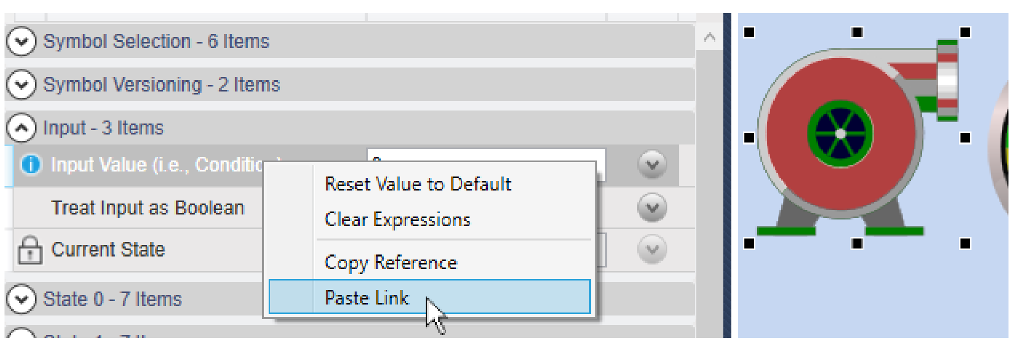
Bind a Control to another Control

Most controls can bind their properties to other controls, so that when the first control is modified, the bound control gets modified automatically. Here's an example, binding the value of the pump we just created to the value of the gauge.

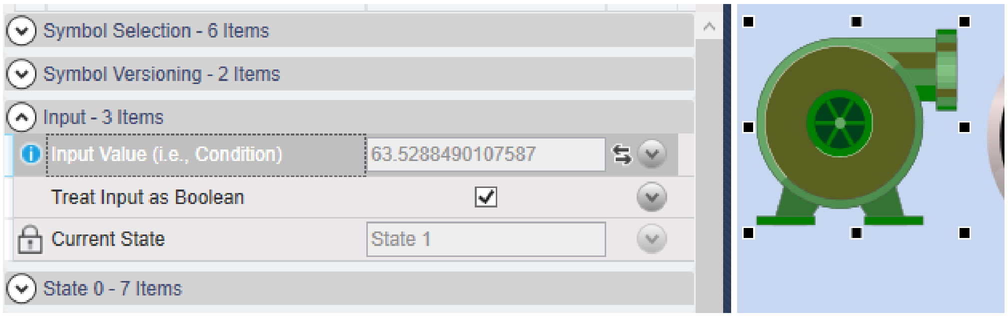
1. Click the gauge, and in the **Basic** properties, right-click the **Current Value** row, and select **Copy Reference**.



2. Click the pump, and in the **Input** properties, right-click the **Input Value** row, and select **Paste Link**.



The pump will take the same values as the gauge, and turn green, the default non-zero color for this symbol.



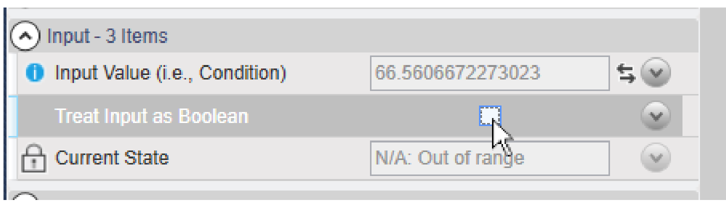
Notice that the **Current State** is **State 1**, for `True`. This default can be changed, as explained below.

See also the section called “Property Binding” for more details about binding control properties.

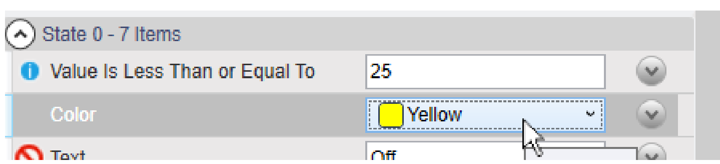
Set Symbol States

Most symbols can be set as booleans, to show on/off states, and many can also display multiple states. Here we'll change the default boolean settings and colors of the pump to display three different states.

1. Click on the pump, and uncheck the **Treat as Boolean** box.



2. In the **State 0** properties, for **Value Is Less Than or Equal** enter a value of `25`. Then change the **Color** to **Yellow**.



3. In the **State 1** properties, enter a value of `80` and change the **Color** to **MediumSeaGreen**.
4. In the **State 2** properties, enter a value of `100` and change the **Color** to **Red**.

Now, whenever the gauge value is between `0` and `25`, the pump highlight color will be yellow, `26` to `80` medium sea green, and `81` to `100` red. Notice that for each state you enter the maximum value, while the minimum value is controlled by the previous state.

Pages

Create, Open, Save, and Delete Pages

To create a page click on the **Pages** tab and then click on the New button in the Toolbar. You can also create a page from the **Edit** menu, or by pressing **Ctrl** + **Shift** + **N**.

To open a page click on the **Pages** tab and then click on the Open button next to the name of the page. You can also open a page by double-clicking on the name of the page in the Pages tab.

To save a page simply click on the Save button. You can also save a page from the **Edit** menu, or by pressing **Ctrl** + **Shift** + **S**.

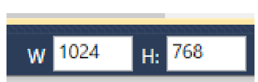
Any page created in WebView version 1.4 and earlier (that was distributed with DataHub version 7.x) gets upgraded to the current version of the WebView application as soon as it is opened. If you save this page, the conversion is permanent, and you will be unable to load the page in the older version of the WebView application. If you expect to revert to the older version, you should create a backup of your page before saving it in the latest version of the DataHub program.

To remove a page from the **Pages** tab, you will need to manually delete the page from the DataHub WebView installation directory. Please see File Locations for more information.

View: Size, Grid, Zoom, Elements

Page Size

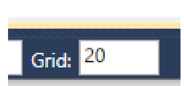
To change page size enter a number of pixels for the width and height of the W: and H: entry fields at the bottom right corner of the editing window.



The Grid

To show gridlines click the **Show gridlines** button, or type **True** in the **Tools** menu, **Options** dialog, **Design Mode** list, **Show gridlines** entry.

To change the grid size enter a number of pixels in the **Grid** entry field at the bottom right corner of the editing window.



To snap controls to the grid click the **Snap to grid** button, or type **True** in the **Tools** menu, **Options** dialog, **Design Mode** list, **Snap to grid** entry.

Zoom

To view the page at a specific size, click the Page Zoom button Fit, which opens a list of zoom levels, and choose the level you need. There are several other ways to zoom in and out, to make resizing the page convenient.

To fit the page into the window, click the Fit button, use the **View**/**Zoom** menu, or press **Ctrl** + **Shift** + **Z**.

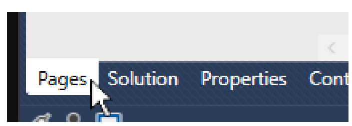
To zoom in and out click the Zoom In or Zoom Out buttons, use the **View** menu, or press **Ctrl** + **Shift** and spin the mouse wheel up or down.

To focus your zoom on a specific location in the page, click the Set Zoom Focal Point button, or click that option in the **View**/**Zoom** menu. Then click the page where you want to focus your zoom.

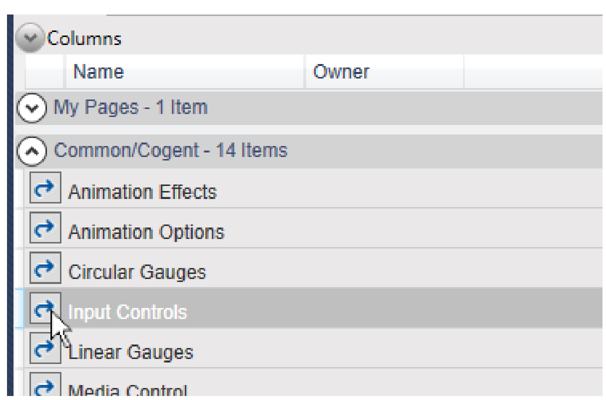
To zoom on a control click the control, and then from the **View**/**Zoom** menu check the **Zoom on Selected Control** option.

Multiple pages

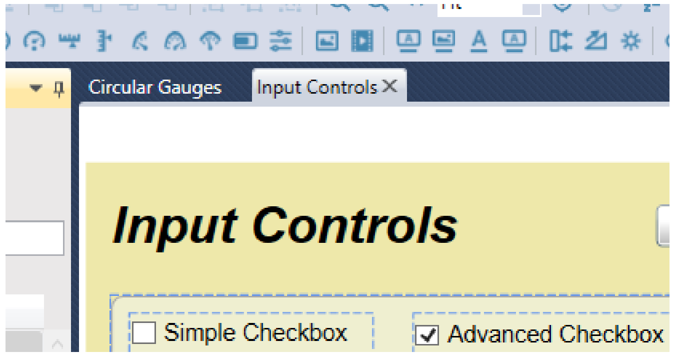
To open multiple pages in Design mode, start WebView, and open the Pages tab.



Find a page to display and double-click the arrow icon to display it.



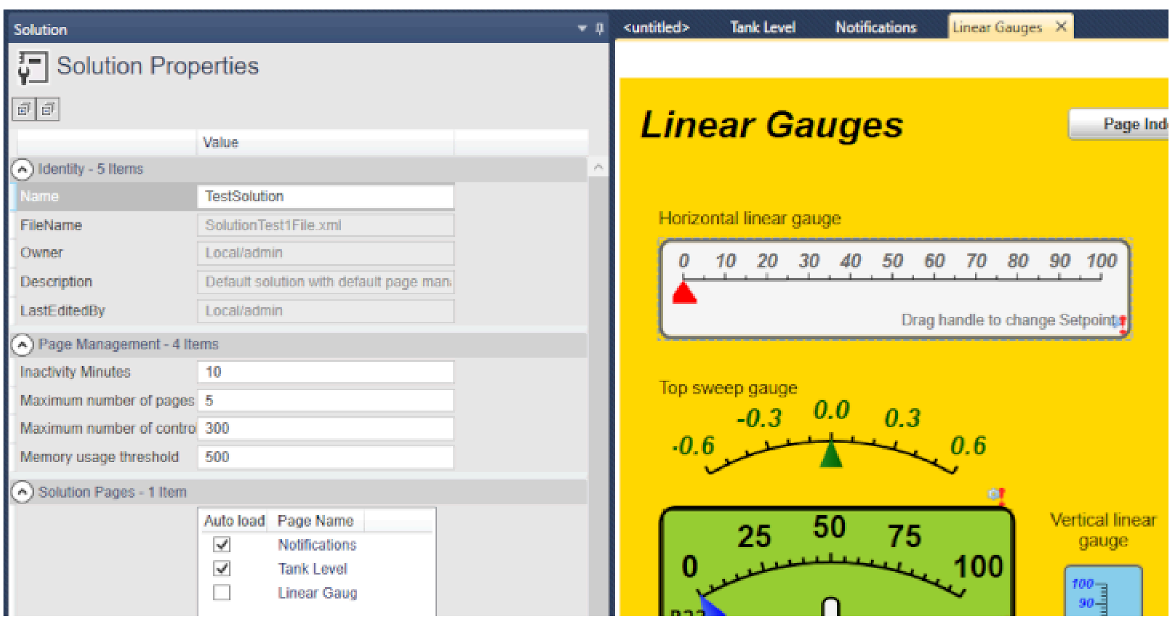
Keep adding pages as needed.



You will find that you can quickly switch between the tabbed pages. Please keep in mind that the tabs are only visible in Design mode.

Solutions

A WebView solution is a group of pages that can be opened and worked on together. All open WebView pages are held in memory to allow quick switching between them, and the solution provides a way to configure page management settings for all its pages simultaneously.

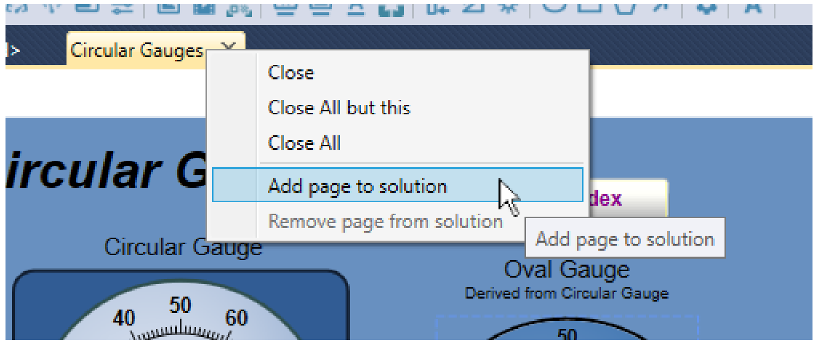


An empty solution is created by default when starting WebView with a default set of page management settings. Those settings can be changed, and pages can be added to the solution from the Solution Properties tab.

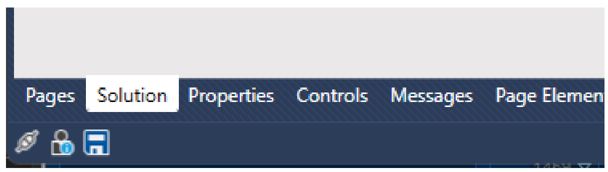
To add pages to a solution:

1. On an open WebView page, or from the **Pages** tab, right click on the page's title to

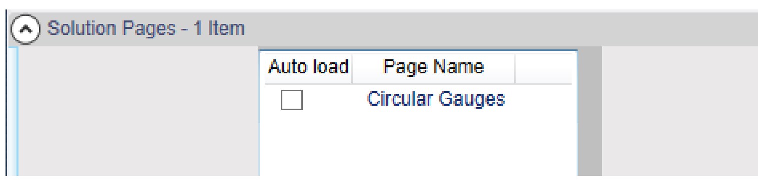
open the page context menu, and select **Add page to solution**.



2. Go to the **Solution** tab.

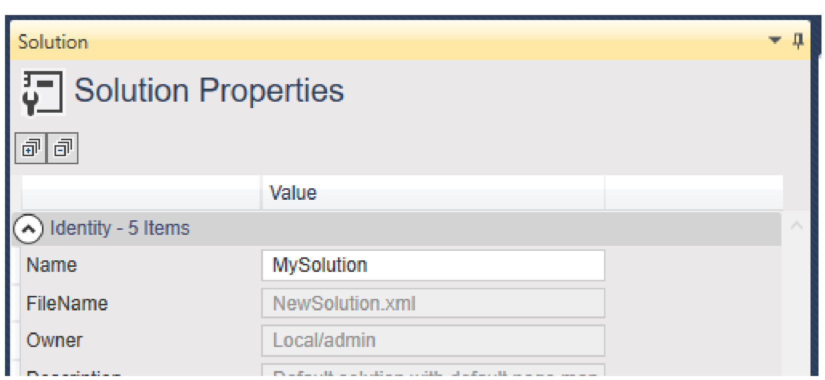


You should see the page in the list.

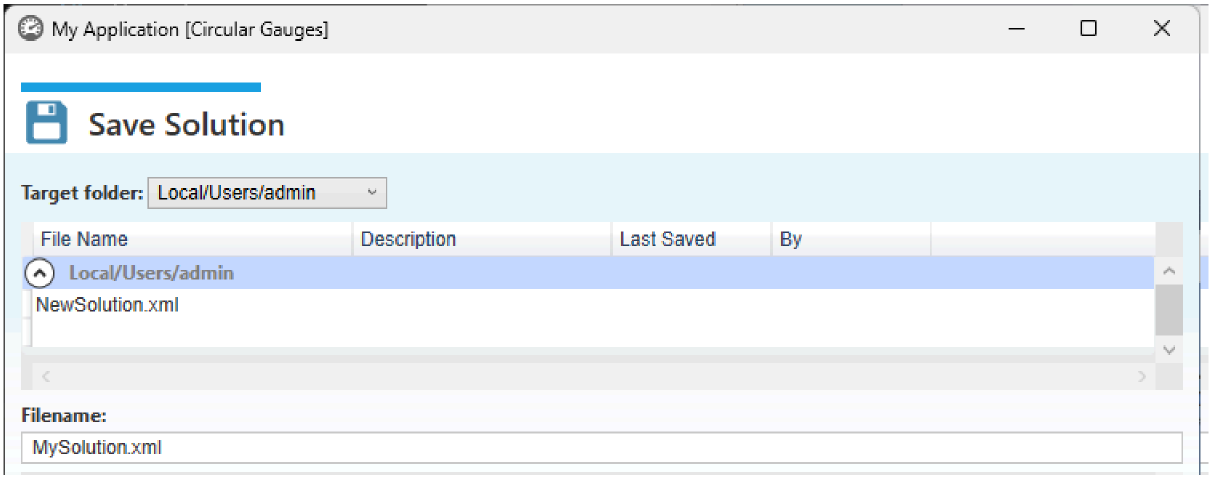


You can check the **Auto load** button for the page to have it load automatically when you open the solution.

3. To save the solution, first expand the **Identity** properties in the **Solution** tab and enter a unique name.

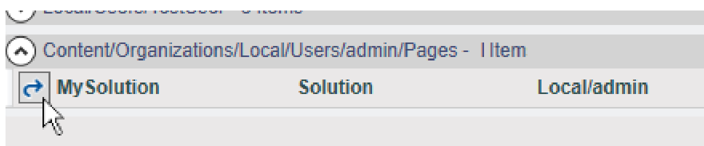


4. Then from the **File** menu choose **Save Solution**. The file will saved with an `.xml` file extension.

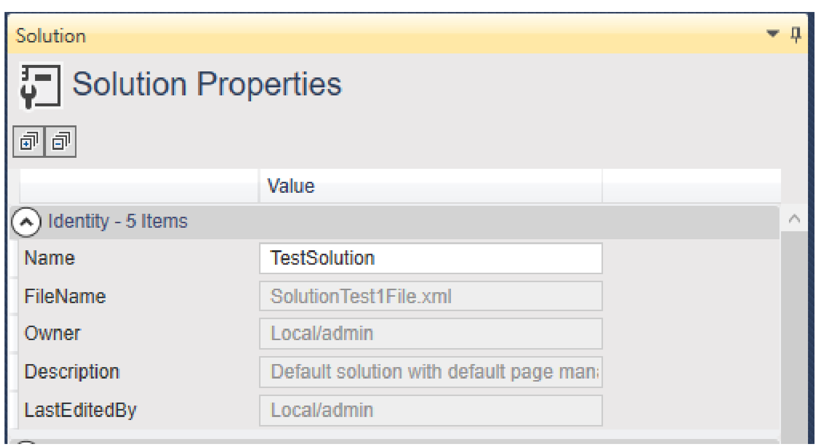


Once you have saved your solution, its file name will appear in the list whenever this dialog is reopened.

5. To open a saved solution, from the **Pages** tab, choose the relevant ***`path/username/`*** **Pages** drop-down, and double-click on the arrow icon of the solution you need to open.



The available properties in the **Solution** tab are as follows:



Identity

Name

The name of the solution, as a text string.

FileName

The name of the XML file that contains the solution configuration data.

Owner

The WebView user that created the solution.

Description

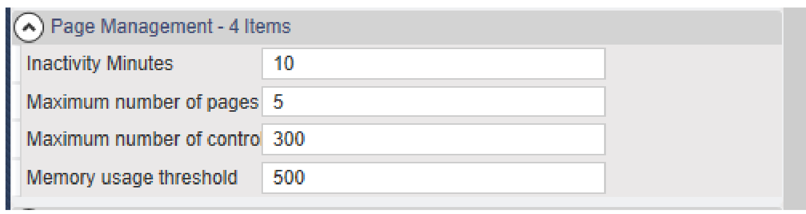
A text description of the solution.

LastEditedBy

The most recent user to have edited the solution.

Page Management

The properties in this section are used to manage memory. Each active page consumes memory. Setting limits on the maximum number of active pages, number of controls, and memory usage threshold ensures that the application continues to perform well.



Inactivity Minutes

The number of minutes to keep pages in memory when they are active. A page that has been inactive for a longer time than this number of minutes will be silently unloaded. Revisiting the page tab will reload the page. A page that has changes will not be retired until after it is saved.

Maximum number of pages

The maximum number of pages that can be loaded in memory at the same time. When the number of open pages exceeds this number, pages will start getting retired.

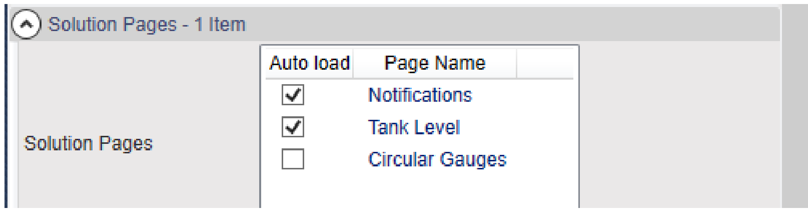
Maximum number of controls

The maximum number of controls a page can have to be considered eligible for retirement. A page containing a large number of controls will consume more memory and it will be retired earlier than other pages containing fewer controls.

Memory usage threshold

The number of kilobytes of memory allocated for use before pages start getting unloaded to free up memory resources.

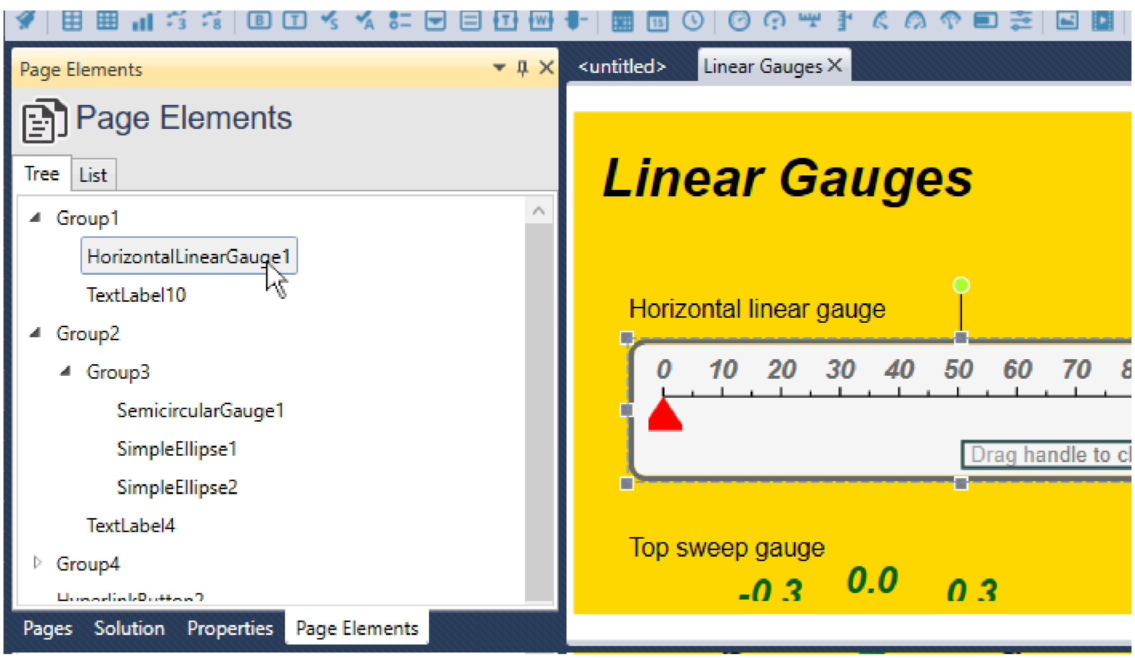
Solution Pages



A list of all pages in the solution. Checking the **Auto load** button for a page causes it to load automatically when the solution is opened. For example, when this solution is opened, two page tabs will be added: one for the **Notifications** page and one for the **Tank Level** page.

Page Elements

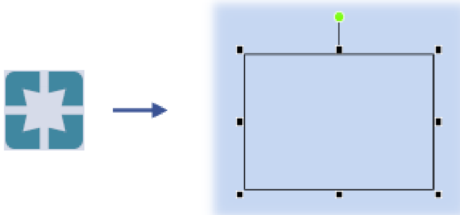
With any page selected, you can get a list or tree view of all of its elements, using the **Page Elements** tab.



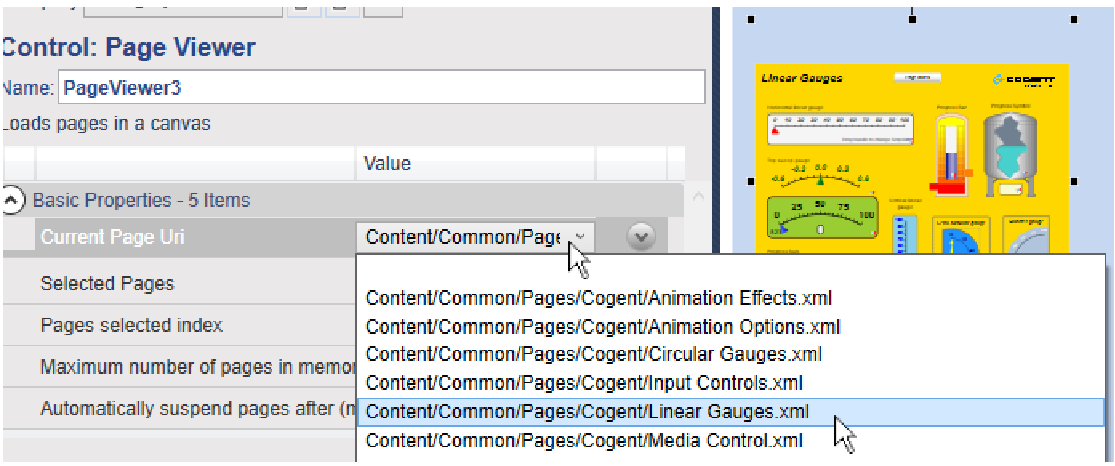
The list is searchable and can be sorted by control type or control name. Selecting a control from the tree or the list will also select it on the drawing canvas, and vice versa.

Page Viewer Control

The Page Viewer control allows you to display multiple pages side by side, or to allow the viewer to switch between pages displayed in one place. To use the control, in Design mode click the Page Viewer button.



To display a page, open the **Basic Properties**, and select a page name from the **Uri** dropdown list.

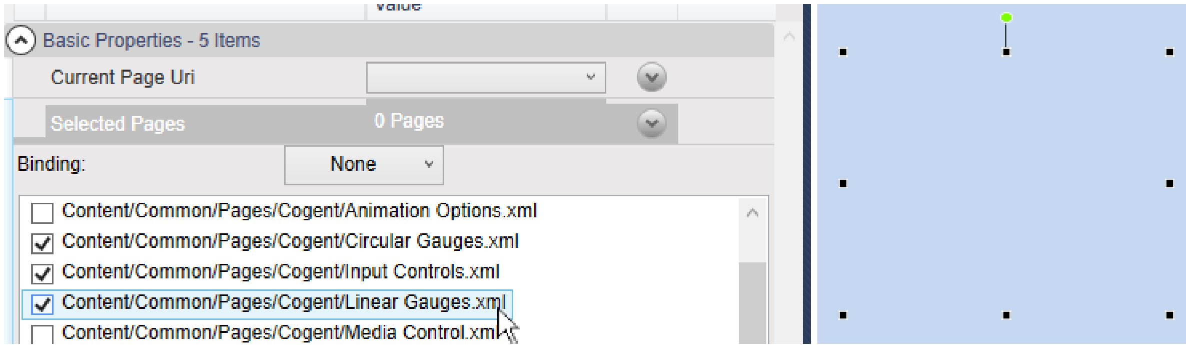


You can add multiple Page Viewer controls to see multiple pages on a single page.

With a Combo Box

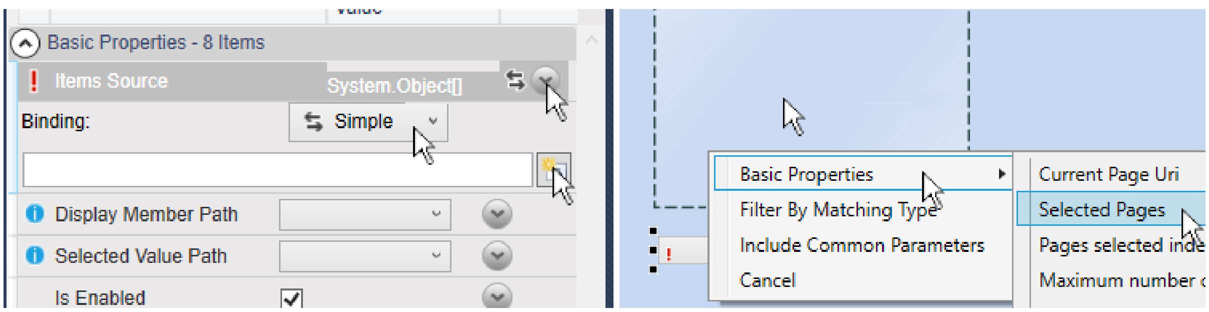
You can also use a Page Viewer control to display several pages in one place, using a Combo Box to choose which page is visible. Here's how:

1. Add a Page Viewer control to the page, and in the **Selected Pages** drop-down list, choose a few pages.



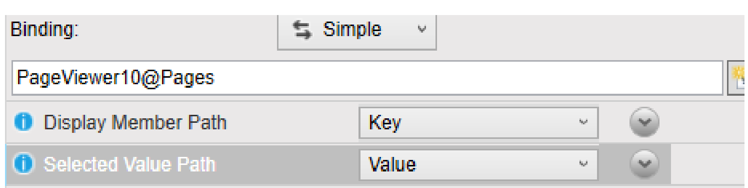
2. Add a ComboBox to the page.

3. In the Combo Box **Basic Properties**, for **Item Source** choose **Simple**. Then click the **Property Picker** icon, select the Page Viewer control, and from the pop-up menu choose **Basic Properties** and **Selected Pages**.

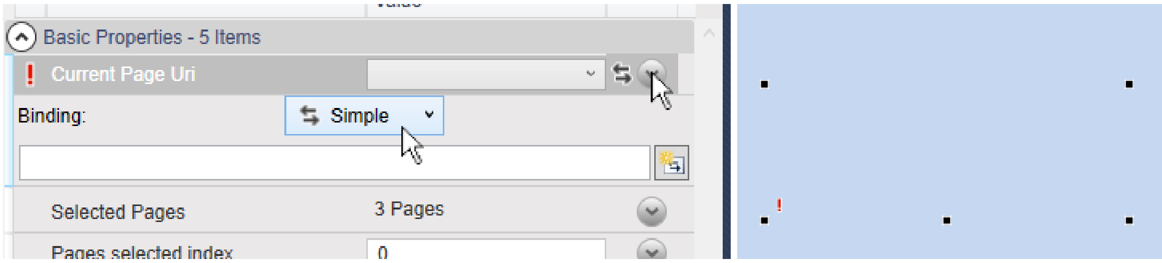


This tells the Combo Box to use the values that you have selected from the Page Viewer control.

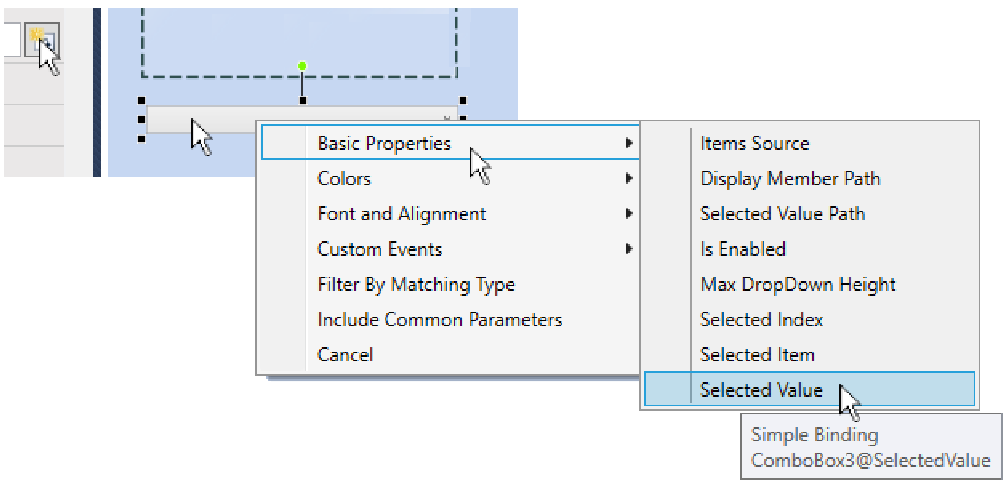
4. Still in the Combo Box properties, for **Display Member Path** choose **Key**, and for **Selected Value Path** choose **Value**.



5. Now you need to connect the Page Viewer to the Combo Box. Select the Page Viewer control, and in the **Basic Properties**, for the **Current Page Uri** select **Simple**.



6. Then click the **Property Picker** icon, select the Combo Box control, and from the pop-up menu choose **Basic Properties** and **Selected Value**.



7. Switch to Run mode, and you should now be able to choose between your pages.

Design and Run Modes

At log in the WebView application checks for user and editing permissions. If you log in with a user name that does not have editing permissions, then the WebView application will automatically open in Run mode and you will not be able to switch to Design mode. If you do have permissions to edit and create new pages, then the WebView application will open in Design mode.

To enter Run mode from Design mode, click on the **Enter Run Mode** button or press **Ctrl** + **Shift** + **R**.

To exit Run mode and return to Design mode, click on the **Exit Run Mode** button or press **Ctrl** + **Shift** + **R**.

To display the Kiosk View which removes the toolbars in Run mode, go to Design mode, and from the **Edit** menu, select **Run Mode Options** and check **Use Kiosk View**.

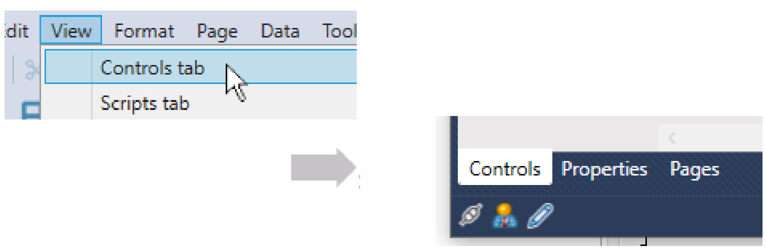
If you have configured Run mode to display in Kiosk View, there will be no toolbar at the top of the page, so you will need to use **Ctrl** + **Shift** + **R** to exit Run mode.

Controls

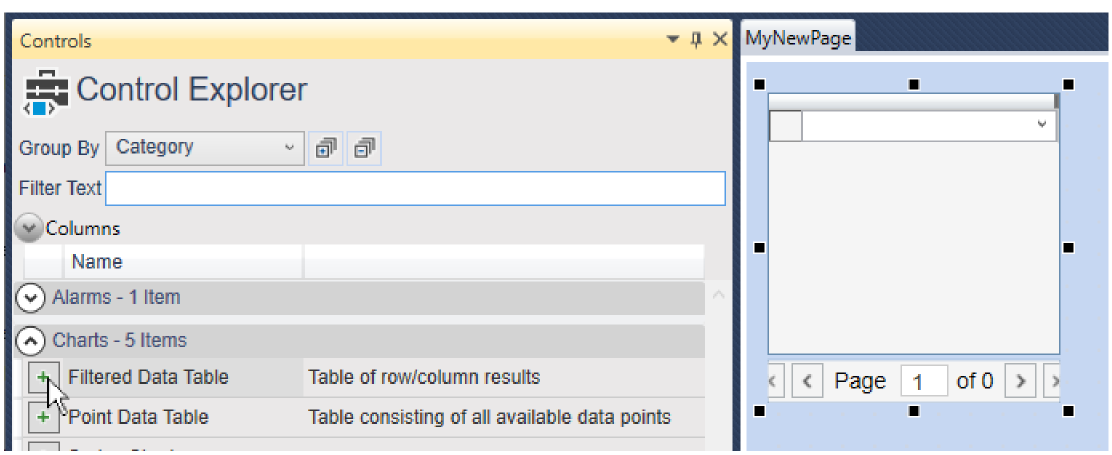
Add and Manipulate Controls

To add a new control to your page, you have two options:

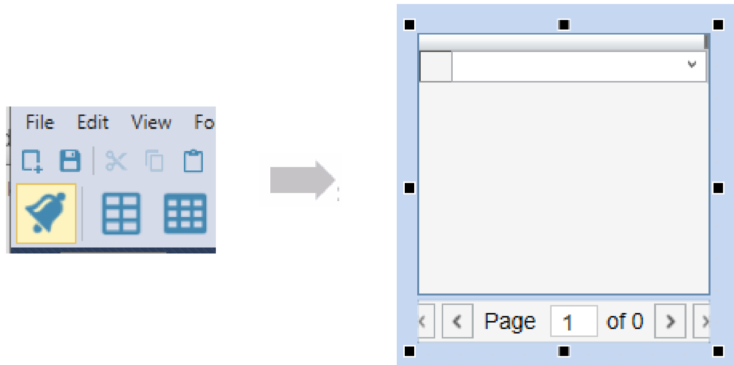
1. From the **View** menu, select **Controls tab** to open the Control Explorer.



In the Control Explorer, find the control in its appropriate group and click the Add button .



2. Alternatively, you can click that control's button in the Control Toolbar at the top of the page to put the control in the center of the page.

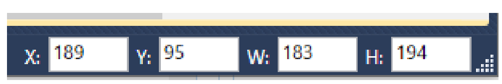


Pressing the **Shift** key while you click on the control button lets you manually position the control on the page. While positioning the control, pressing **Ctrl** + **Shift** and turning the mouse wheel allows you to zoom in and out.

To copy a control select it, and from the **Edit** menu choose **Copy**, or press **Ctrl** + **Shift** + **C**.

To paste a control select it, and from the **Edit** menu choose **Paste**, or press **Ctrl** + **Shift** + **V**.

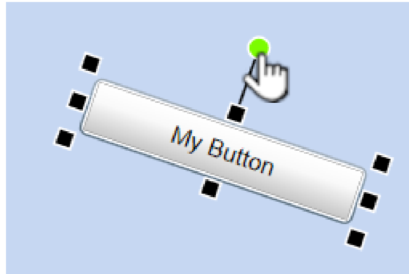
To resize a control select it and resize it with one of the black resize handles. Or, enter a width and height in the **W:** and **H:** entry fields at the bottom right corner of the editing window.



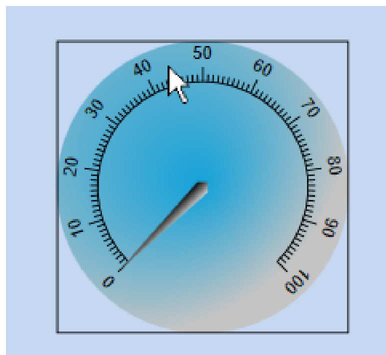
To move a control select it, and move it with the mouse. For precise movements, you can show gridlines, and snap controls to the grid. Or, enter X and Y coordinates (distance from the top-left corner) in the **X:** and **Y:** entry fields at the bottom right corner of the editing window. Alternatively, you can use the cursor keys as follows:

- move by 1 pixel: **Ctrl** + arrow keys
- move by 10 pixels: arrow keys
- move by 100 pixels: **Ctrl** + **Shift** + arrow keys

To rotate a control use the rotation handle on the top of the control.

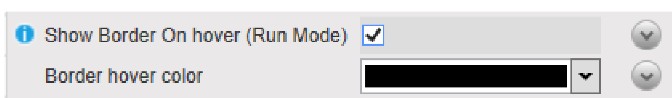


To add a hover border you can configure a one-pixel border of any color that appears around the control in Run mode when you hover your mouse over it.



To activate this feature:

1. Select a control.
2. In the **Property Explorer**, go to **Common Properties: Content Visibility and Appearance**.
3. Check the **Show Border on hover (Run Mode)** box.



The border will appear on hover for any opacity setting of the control (**Content Opacity** or **Opaque on hover**), but will not appear if the **Visible in Run Mode** box is not checked.

Grouping Controls

Controls can be grouped together, forming essentially a single large control.

To group controls click the controls that you want to be in the group, and then click the Group button . This is also available from the right-click pop-up menu.

To ungroup controls click the group that you want to ungroup, and then do choose one of the following:

- Click the Ungroup button to preserve the size and position changes you made while the controls were grouped. This is also available from the right-click pop-up menu.
- Click the Cancel Group button to discard all changes that you made to the group. This is also available from the right-click pop-up menu.

To access and change the properties of any control in a group

1. Hover your mouse over the control you want to select.
2. Tap the **Ctrl** key on your keyboard.
3. Click the control in the group that you need to access.

If you have a group within a group, you can access a single cell like this:

1. Hover your mouse over the outer group.
2. Tap the **Ctrl** key on your keyboard.
3. Hover your mouse over the inner group that you need to access.
4. Tap the **Ctrl** key *twice* on your keyboard.
5. Click the control that you need to access.

Control Properties

Each control has a number of properties associated with it. There are common properties (see below) shared with each control, as well as other properties unique to that particular control. When you click on a control, the **Properties** tab opens, listing the properties by groups, with the **Basic Properties** group viewable. The Basic Properties are the ones that you'll probably use most often. Below these are groups of other properties unique to the control, followed by the common properties.

To change the value of a property click the control and type in or select the value.

To bind the properties of a control to a DataHub point or another control, please refer to the section called “Property Binding”.

Common properties shared by all controls include:

Background, Border and Margin

Background
A color for the background of the control.

Border
A color for the border of the background of the control.

Border Thickness
The thickness of the background border, in pixels, for the left, top, right, and bottom borders, respectively. Adding to this thickness will reduce the visible size of the control.

Border Corner Radius

The radius of each corner of the background border, in pixels, for the top-left, top-right, bottom-right, and bottom-left corners, respectively.

Inner Border, Thickness, and Corner Radius

These are the same as for the Border, but for a separate inner border.

Content Margin

The width of the margins, in pixels, for the left, top, right, and bottom borders, respectively. Adding to this width will reduce the visible size of the control.

Background Image

Image File

A file to use for a background, selected from the drop-down list. To add images to the DataHub WebView library, you can copy your image files to the following directory:

```
[OrgLocal]\Images
```

Image Width

The width of the image, in pixels.

Image Height

The height of the image, in pixels.

Image Alignment

Aligns the background image with a corner, side, or middle of the control, or stretches it to fill the whole area.

Image Opacity

A number between 0 (transparent) and 1 (fully opaque).

Image Margin

The width of the margins, in pixels, for the left, top, right, and bottom sides of the image, respectively. Adding to this width will reduce the visible size of the image.

Image Rotation

A number of degrees to rotate the image to the right. The image is static unless this value is bound to a variable.

Flip X-Axis

Flip the image top-to-bottom.

Flip Y-Axis

Flip the image right-to-left.

Content Visibility and Appearance

Visible in Run Mode

Will this control be visible in Run mode?

Content Opacity

A number between 0 (transparent) and 1 (fully opaque).

Opaque on hover (Run mode)
: Causes the control to be visible when the mouse hovers over it in Run mode.

Static Rotation (degrees)
: A number of degrees to rotate the control to the right.

Maintain Uniform Size for Static Rotation
: Prevents the control from changing size to fit its container when rotated.

Clip Content
: Ensures that no part of the control renders outside its bounding rectangle, as when rotating a control or using a negative margin.

Flip X-Axis
: Flip the content of the control top-to-bottom.

Flip Y-Axis
: Flip the content of the control left-to-right.

Position and Size

Left
: A number of pixels specifying the distance of the top left corner of the control from the left side of the page.

Top
: A number of pixels specifying the distance of the top left corner of the control from the top of the page.

Width
: A number of pixels specifying the width of the control.

Height
: A number of pixels specifying the height of the control.

Locked
: Avoids inadvertently changing the size or position of the control.

Fit Page
: Have the control fill the page, behind the other controls.

Content Animation

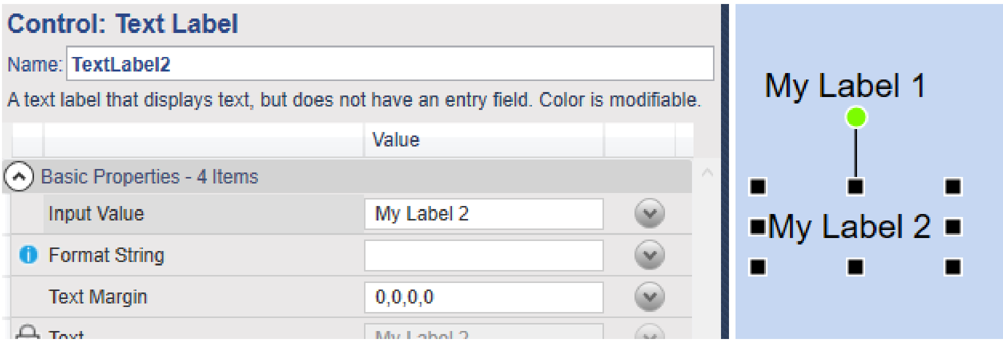
Is Content Rotating
: Specifies if the control content rotates.

Animated Rotation (rpm)
: Specifies the speed, in rotations per minute, of the control content.

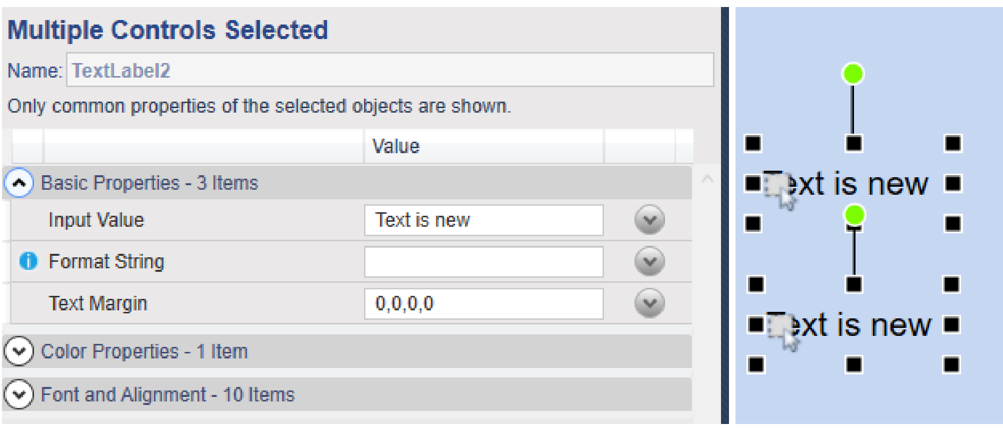
Multiple control editing

It is now possible to edit the properties of multiple controls simultaneously. This is useful if you have several controls on a page with common properties that you need to edit.

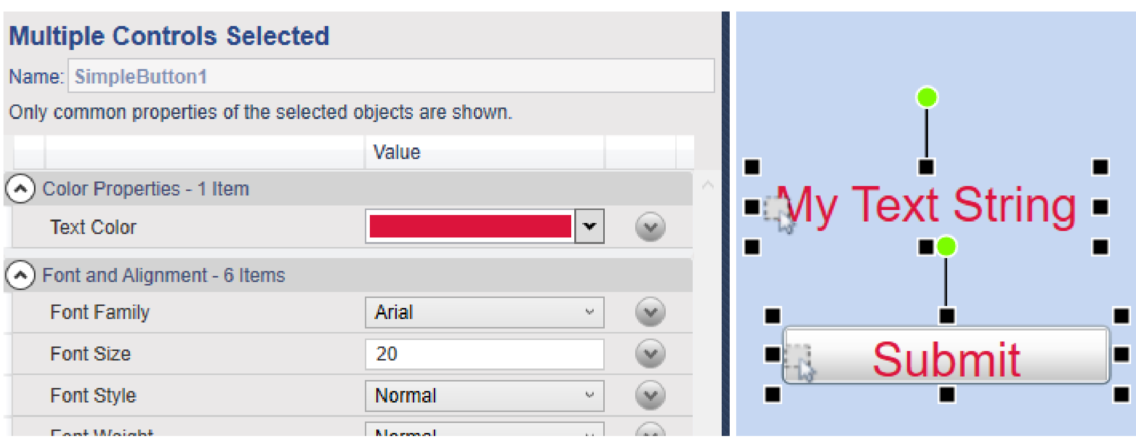
If the controls are identical, then all the properties are available.



You can test this by creating two Text Label controls, and give them different text. Then select them both, and when you edit any of the properties, you'll see that your edits are applied to both controls.

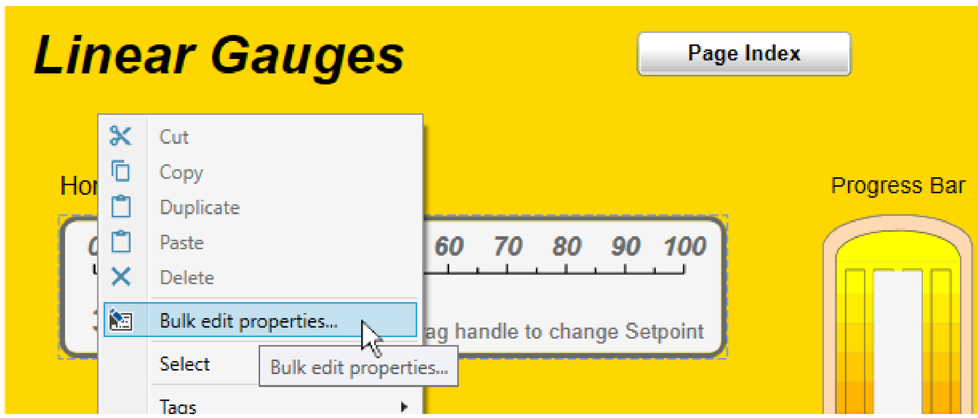


It is also possible to edit the common properties on dissimilar controls. For example, you can set the text color and font properties of a Text Label and Simple Button to be the same, with one edit.



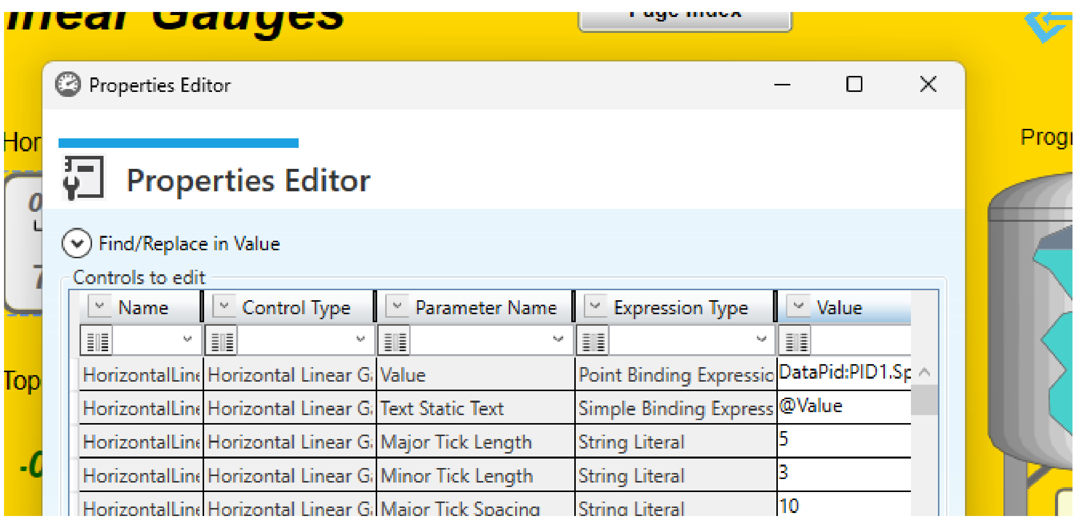
Properties Editor

For any page, you can now open a Properties Editor that gives you access to all the Point Binding Expressions, Symbol Binding Expressions, and String Literals (like font sizes and input values) of all the controls on the page. You can use this to edit properties of more than one control without having to select each one individually. This is particularly useful on pages with dozens or hundreds of controls.

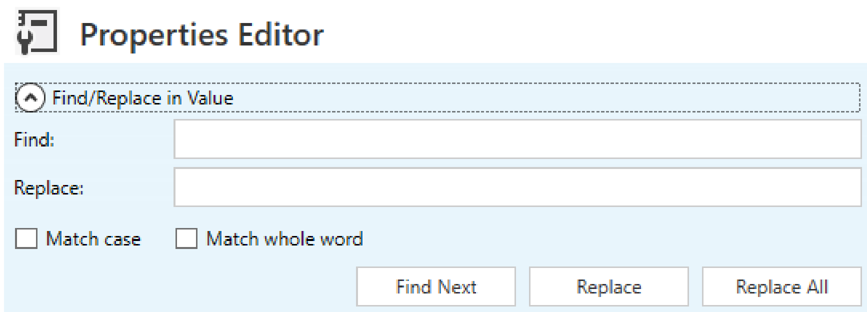


To open the Properties Editor, right-click on the page or open the the **View** menu, and choose **Bulk edit properties**.

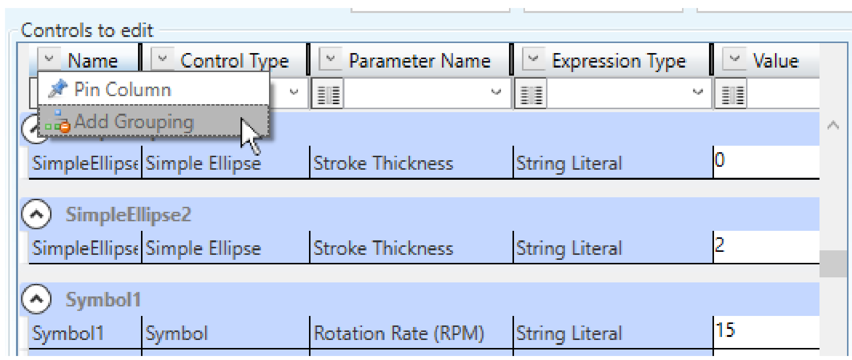
Each parameter of each control is listed by control name and type, along with the corresponding expression type and value. Entries in the **Value** column are editable, for making changes.



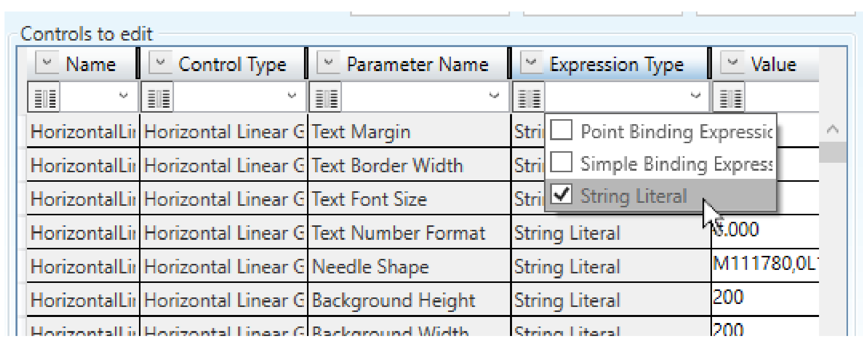
There is a Find and Replace feature to help navigate through and make bulk edits for large numbers of controls.



For each column, the **Pin Column** feature freezes the column for horizontal scrolling, and the **Add Grouping** option allows you to group by name, control type, etc.



A filtering feature on each column lets you limit the display to just the type or types of entries you need to work with.



Format Strings

Controls like text labels, gauges, and level indicators that can display text or numbers have a **Format String** property that allows you to format the text. This is particularly useful for numbers.

Standard Numeric

Standard numeric values use Windows Standard Numeric Format Strings.

Examples:

Input Value	Format String	Displayed
`0.1234`	**`E2`**	`1.23E-001`
`0.1234`	**`P2`**	`12.34%`

The following formats are supported:

Numeric type	**Format string**
Decimal	`D` or `d`
Exponential	`E` or `e`
Fixed	`F` or `f` point
General	`G` or `g`
Number	`N` or `n`
Percent	`P` or `p`
Round-trip	`R` or `r`
Hexadecimal	`X` or `x`
All digits	`@`

Applying format strings may cause precision to be lost if there is a long string of digits in the number. To preserve the entire string of digits, set the format string to `@`. This is specific to the WebView application, and not a Windows format string.

Custom Numeric

Custom numeric values use Windows Custom Numeric Format Strings, which typically consist of one or more instances of the custom numeric specifiers `0` and `#`. Two- and three-part custom numeric format strings are also valid, using semi-colons to delimit the parts.

Examples:

Input Value	Format String	Displayed
`5678`	**`#,##0.00`**	`5,678.00`
`5678`	**`My 0 data points.`**	`My 5678 data points.`
`123.456`	**`#.#;(####)`**	`123.5`
`-123.456`	**`#.#;(####)`**	`(123)`
`0`	**`#.#;(####);zero`**	`zero`

Text Values

You can build composite strings by using the `{0}` placeholder to insert a text value.

Examples:

Input Value	Format String	Displayed
OFF	**The alarm is {0}**	The alarm is OFF
High	**Tank level: {0}**	Tank level: High

Dates

Both standard and custom date format strings are supported, using Windows Standard or Custom Date and Time Format Strings, respectively.

Examples:

Input Value	Format String	Displayed
May 9, 2016, 3:58 PM	**d**	05/09/2016
May 9, 2016, 3:58 PM	**f**	Tuesday, 09 May, 2016 15:58
07/14/2016 08:15:25	**yyyy-MM-dd hh:mm tt**	2016-07-14 08:15 AM

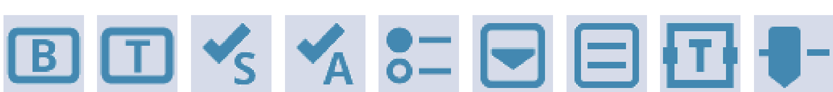
Controls Listed by Category

WebView controls are arranged in the following categories. You can click on the control icon for more information about the specific control.

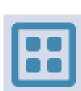
- **Alarms**

- **Charts**

- **Common Input Controls**



- **Configuration**



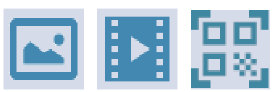
- **DateTime**

- **DTC: Palettes**

- **DTC: Program Blocks**

- **Gauges**

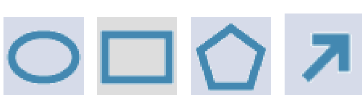
- **Media Controls**



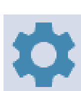
- **Navigation**

- **Notification**

- **Shapes**



- **Symbols**



- **Text Controls**

Property Binding

The WebView application provides extensive support for property binding, allowing the properties of one control to be bound to other controls, or to DataHub point values. These three binding options are available on many control properties:

- **None** allows you to enter a static value, not bound to anything.
- **Point** lets you bind a control property to the value of any DataHub point. When the point changes value, the property changes value with it. For example, you can bind the current value of a gauge to a DataHub point, animating the gauge indicator with live data.
- **Simple** lets you bind a property of a *reference* control to the property of a *linked* control. Whenever you change the value of the property on the reference control, the property will change on any linked controls. For example, if you bind the color and size of several buttons to a single, reference button, whenever you change the color or size of the reference button, all the other buttons will change too. Any control with bindable properties can be used as a reference control, a linked control, or both.

There are several features of property binding that facilitate page design, such as:

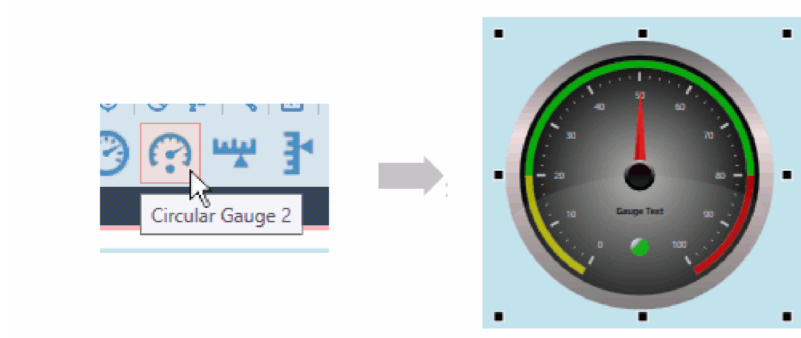
- **Simple bindings are universal** so that any control can be bound to any other control, as long as the bindings are compatible (eg. value-to-value, color-to-color, etc.).
- **The Property Picker shows compatible properties** for simple bindings.
- **For simple bindings, properties can be both references and links** which means that bindings can be chained, allowing controls to act simultaneously as a references to other controls or be linked to them, in any combination.
- **Simple and Point bindings can be combined** in a single control, which allows you to get your data from the DataHub program, and the control appearance from another control.
- **Copying a control** will copy all property bindings. So, if you need a number of similar controls to share certain properties, you can make a reference control and one linked control, and then copy the linked control as many times as needed.

DataHub Point Binding

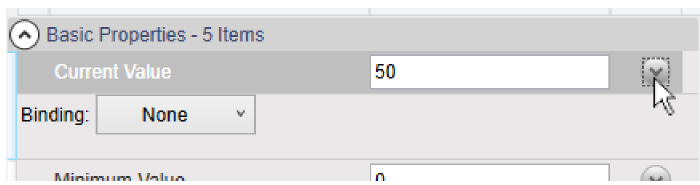
To create a **Point** binding you can follow this example, where we bind the indicator value of a gauge to a DataPid point:

1. Start the DataPid program that is included in your Cogent DataHub archive to generate some test data.

2. Open a blank page and add a Circular Gauge 2 control.

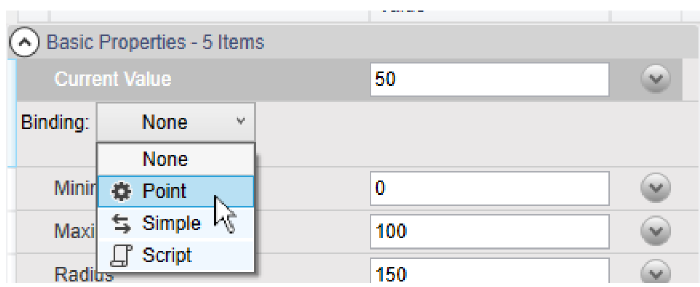


3. Open the **Basic Properties** of the gauge, and click the binding button on the right side of the **Current Value** row.



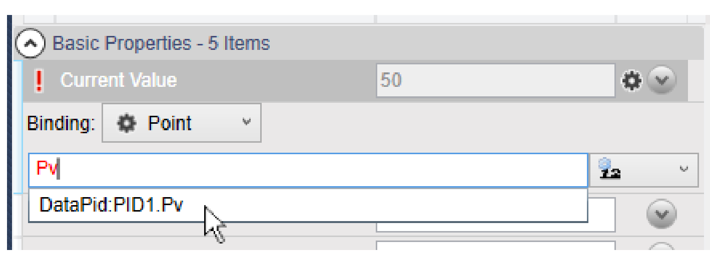
A **Binding** selection box will appear.

4. In the **Binding** selection box, click the down arrow to open the list, and select **Point**.



This will activate the point selection entry field.

5. To connect to the DataPid point **DataPid:PID1:Pv**, you can enter just **Pv**. All the points that have "Pv" in their names will appear.

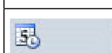


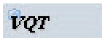
Select the point **DataPid:PID1:Pv**. Once selected, the data will start updating in the value entry, and the gauge needle will start to move.

Point Attribute Selection

When binding a point, the WebView application provides a choice of point attributes that are available for the control you are working with. These attributes may include, in various formats, the point name, the quality of the connection, the timestamp of the most recent value change, and the value of the point itself. These are chosen through right-clicking on the small arrow to the right of the text-entry field, and selecting from the drop-down menu that appears:

Here are the possible choices, availability depends on the control you are working with:

Menu Item	Point Attribute	Example
n.ab	The full point name, no domain.	`PID1.Pv`
ab	The abbreviated point name.	`Pv`
d.n.ab	The full point name, with domain name.	`DataPid:PID1.Pv`
Q	The point quality, in plain text.	`Good`
Q#	The code for the point quality.	`192`
	The full date and time.	`09/02/2011 13:09:15`
12	The point value.	`71.33489150492`

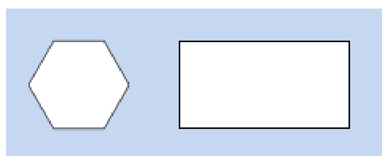
Menu Item	Point Attribute	Example
	The point value, quality, and timestamp.	`71.334 {Good,13:09:15.32}`

The point value (**12**) is the default, and used for most bindings, while the other options are available if necessary. Certain controls that need to reference timestamps, such as the Trend control, require using **VQT**.

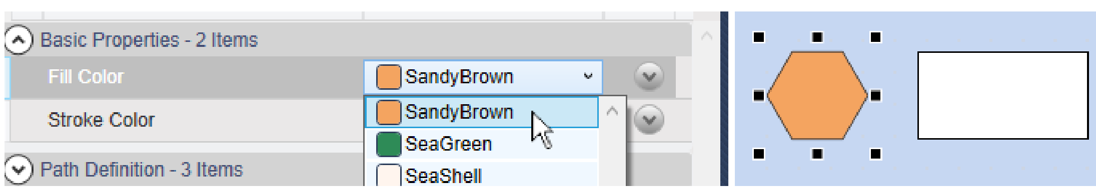
Simple Binding - Property Picker

There are two ways to create a simple binding, either with the Property Picker, or by copy and paste. The following example shows how to use the Property Picker. In this example, we use a hexagon as the reference control, and a rectangle as the linked control.

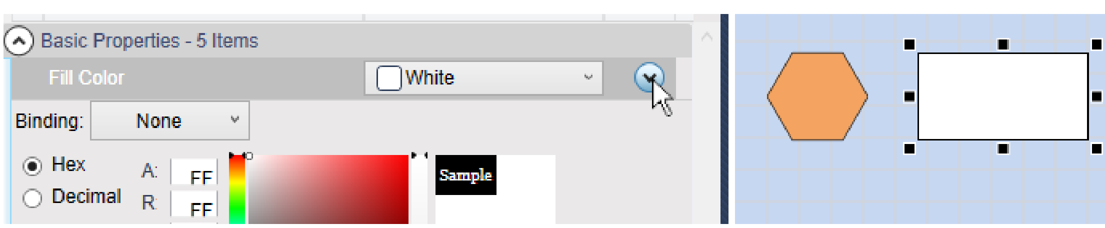
1. On a blank page, add one hexagon and one rectangle, using the **Simple Path** and **Simple Rectangle** controls.



2. Select the hexagon (the reference control), and in the **Basic Properties**, **Fill Color** choose a color other than **White**, such as **SandyBrown**.

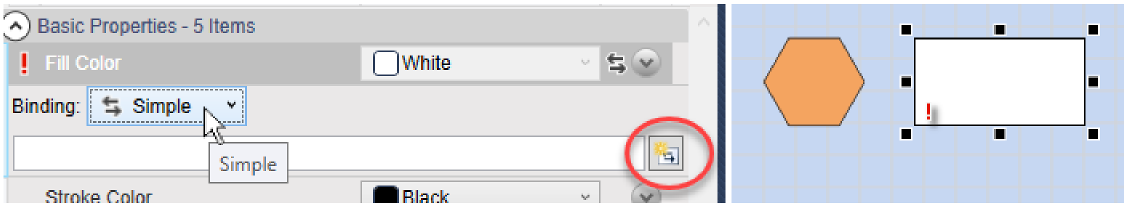


3. Select the rectangle (the linked control), and in the **Basic Properties** click the binding button on the right side of the **Fill Color** row.

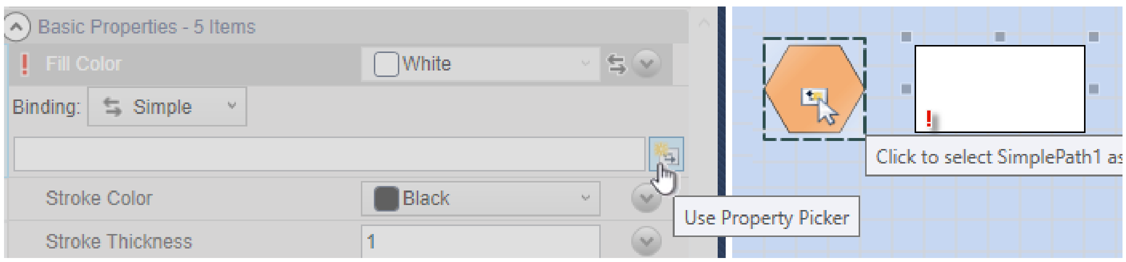


   A **Binding** selection box will appear, above the color selection dialog.

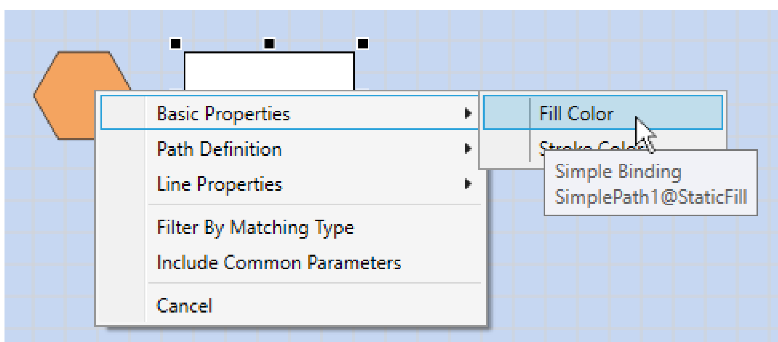
4. In the **Binding** box, select **Simple**. A text-entry box will appear, and to the right, the Property Picker icon.



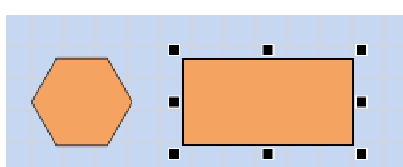
5. Click the Property Picker icon. The **Properties** area will turn gray, and when you move the mouse over the page, it will take the shape of the Property Picker.



6. Click the hexagon. This will open the Property Picker menu. From here you can choose which property of the hexagon you wish to give to the rectangle.
7. From the **Basic Properties** submenu, choose **Fill Color**.



The rectangle will change to **SandyBrown**. It is now bound to the color of the hexagon, and will change whenever that color gets changed.



There are two options on the Property Picker menu:

Filter by Matching Type

Reduces the list of properties in the reference control to only those that are also present in the linked control. This helps you quickly identify which properties you can actually bind to this particular control.

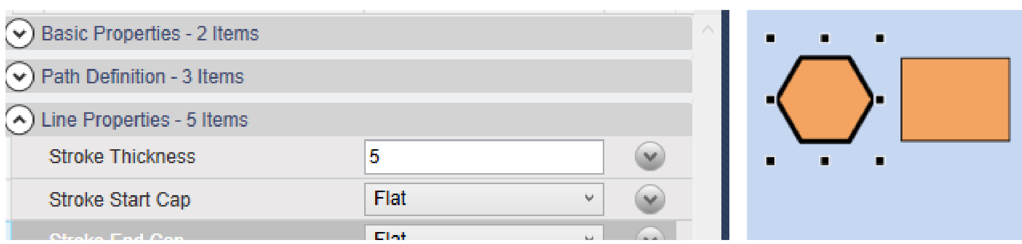
Include Common Properties

Hides or displays the Common Properties in the list.

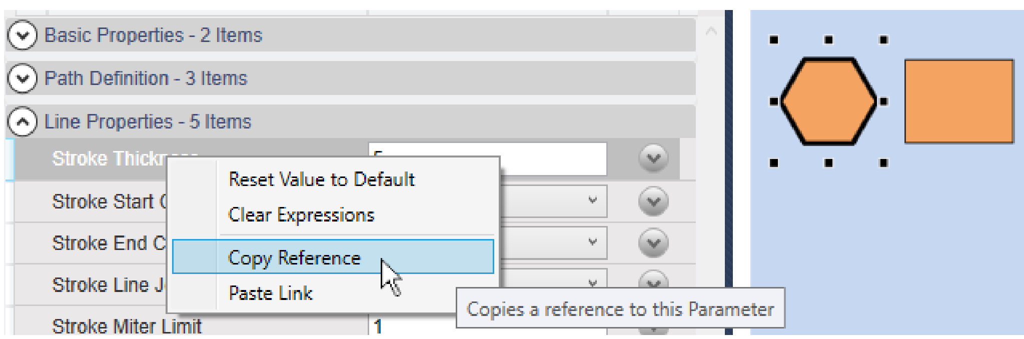
Simple Binding - Copy and Paste

Another way to create a simple binding is by copying a reference for a binding and then pasting the link. This is especially useful if you know what properties you need to bind, or if you need to link many controls to a single reference control. Below is an example, based on the controls created in the example above. In this example, the hexagon again is the reference control, and the rectangle is the linked control.

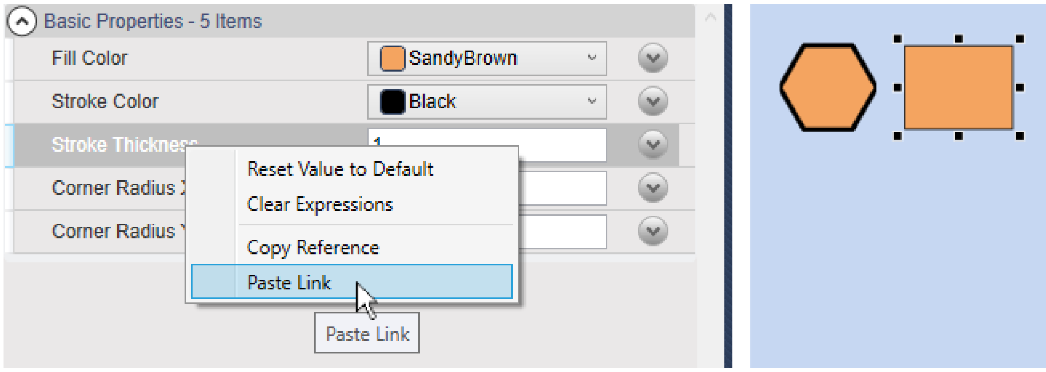
1. Select the hexagon (reference control), and in the **Line Properties**, change the **Stroke Thickness** to 5. You should see the border of the hexagon become 5 pixels thick.



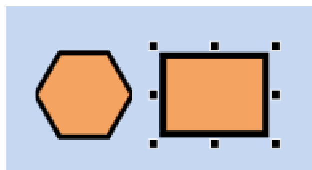
2. Right-click on the **Stroke Thickness** label, and from the drop-down menu, select **Copy Reference**.



3. Select the rectangle (linked control), and in the **Basic Properties**, right click the **Stroke Thickness** label, and from the drop-down menu, select **Paste Link**,



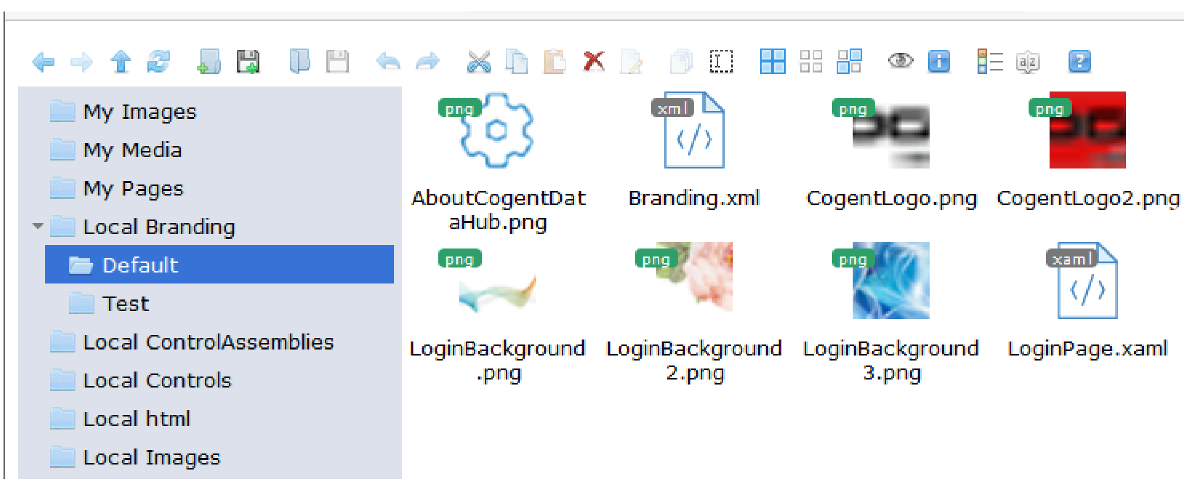
The border of the rectangle will change to 5 pixels. It is now bound to the width of the hexagon's border, and will change whenever that gets changed.



Managing Files

Browsing the Server

In design mode you can browse the server to access your files. From the **File** menu select **Browse Server**. This opens a web-based browser interface that presents all of the WebView content folders.



This interface lets you do the following:

- Drag and drop files into the folders that start with **My** or **Local**. They will only accept the indicated type of file content. You can also drag content between folders such as moving a file from **My Images** to **Local Images**.

- Delete or rename content in these folders.
- Use the tool bar or right-click on a file to bring up a context menu of actions that can be done with the file. Press **Esc** to close dialog boxes as needed.
- Content placed in a **My** folder will only be available to the WebView current user. Content placed in the **Local** folders will be available company wide.
- When you add custom images to either **My Images** or **Local Images**, they will be immediately available for selection in the **Image File** drop-down list in the **Basic Properties** of an Image control element in WebView.

File Locations

The various WebView files have different locations, depending on their source and purpose. There are two general locations: for installed content, and for user content; and within user content you'll find your organization content.

Installed Content - `[WebRoot]`

Installed content is read-only, not to be modified by the user. It is installed (and re-installed) whenever the DataHub program is installed, and includes the stock WebView demo pages. Installed content is located here (32-bit/64-bit versions of the DataHub program):

```
C:\Program Files (x86)\Cogent\Cogent DataHub\plugin\WebServer\html\Content\
C:\Program Files\Cogent\Cogent DataHub\plugin\WebServer\html\Content\
```

We use the placeholder `[WebRoot]` in this document to refer to this path.

This path, up to `html` is the default DataHub install directory. It is also the document root directory for the DataHub Web Server, and can be reconfigured in the Properties window Web Server option, if desired.

User Content - `[UserContentRoot]`

User content such as pages, images, scripts, and so on is read/write, and is located in this directory:

```
C:\Users\<username>\AppData\Roaming\Cogent DataHub\WebContent\Content\
```

We use the placeholder `[UserContentRoot]` in this document to refer to this path.

You can change this path using the `-H` DataHub command-line option, or by setting it through the DataHub Service Manager application.

Your Organization Content - `[OrgLocal]`

The path for files pertaining to your organization is:

```
[UserContentRoot]\Organizations\Local\
```

We use the placeholder `[OrgLocal]` in this document to refer to this path. Within it are sub-directories for various types of files. Here are some examples of types of users and the directories for the files they would typically use:

Type of Users	Typically use files in these sub-directories
Operators	`[OrgLocal]\Pages`

Page builders	`[OrgLocal]\Pages`
	`[OrgLocal]\Images`
	`[OrgLocal]\Media`

Advanced/Admin	`[OrgLocal]\Branding` `[OrgLocal]\Scripts`

Control Developers	`[OrgLocal]\Controls`
	`[OrgLocal]\ControlAssemblies`
	`[OrgLocal]\Symbols`

There are two possible instances of each of these directories: for shared content, and for user-specific content, and each can optionally have sub-directories.

Shared Content

This content is available to all logged-in WebView users in your organization. For example:

```
[OrgLocal]\Pages\TestPage1.xml
[OrgLocal]\Pages\<optional sub-directory>\TestPage1.xml
```

User-Specific Content

User-specific content is available only to users logged into the WebView application with a given user name. This content is placed in the `Users` sub-directory, and organized in a parallel way to shared content. For example:

```
[OrgLocal]\Users\<username>\Pages\MyPage1.xml
[OrgLocal]\Users\<username>\Pages\
                   <optional sub-directory>\MyPage1.xml
```

And finally, there is one more aspect of user content organization that is *relevant only to developers of custom controls*.

Custom Controls

Starting with DataHub Version 9, custom controls and control assemblies were differentiated between Silverlight and WPF (used by Desktop WebView) versions. Now Microsoft has deprecated Silverlight, and Desktop WebView is referred to as simply WebView.

Legacy WebView controls created in Silverlight will only work in Silverlight. Those created in WPF will only work in the Desktop WebView application. You need to compile these controls separately for the Desktop or Silverlight WebView applications. For example:

```
[OrgLocal]\Controls\<publisher>\
[OrgLocal]\Controls\<publisher>\Silverlight\
[OrgLocal]\Controls\<publisher>\WPF\

[OrgLocal]\ControlAssemblies\Silverlight\<publisher>\
[OrgLocal]\ControlAssemblies\WPF\<publisher>\
```

You must similarly distinguish XAML and XML files for your custom controls if they are different between Silverlight and WPF versions.

Editing WebView XML Files

It is possible to edit the XML code in WebView pages. By default, the pages are zipped, so you will need to ensure they are saved as plain text. To do that:

1. Open the WebView application in Design mode.
2. From the **Tools** menu, select **Options**.
3. Scroll to the section **Design Mode: Performance (Advanced)**.
4. Check the setting for `Zip files on server` and if it is `True` change it to `False`.
5. If you changed that setting, then for each page that you need to edit, open the page and then save it again.

You should now be able to make edits to those pages with any text or XML editor.

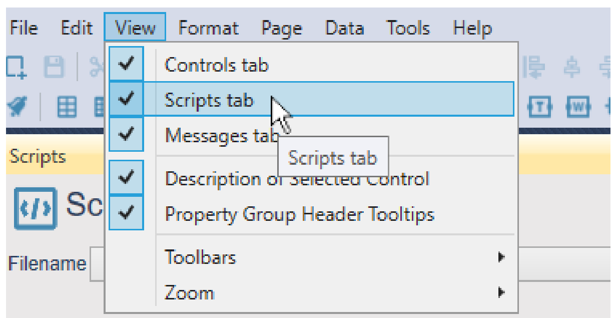
WebView Scripting

There are two resources for learning about WebView Scripting:

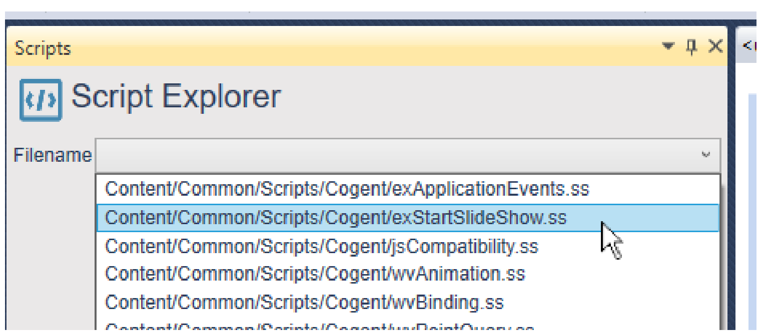
- For online documentation, please refer to the DataHub WebView Scripting Manual.
- For examples of WebView scripting implementations, please view the last group of these videos, under the title DataHub WebView Video Blog (Advanced Topics), on the Cogent DataHub website.

Pre-Loaded and Sample Scripts

Several WebView scripts are installed with the DataHub archive. These are found in the installed content file location, under `Content/Common/Scripts/Cogent`. You can view these scripts by opening the **Scripts tab** in Design mode.



You can use the Script Explorer to browse the scripts:



Scripts whose names start with ex are example scripts. Those that start with `wv` contain helper functions that enable you to easily leverage advanced capabilities like element animation and slide shows. This interface is read-only, because none of these scripts should be edited.

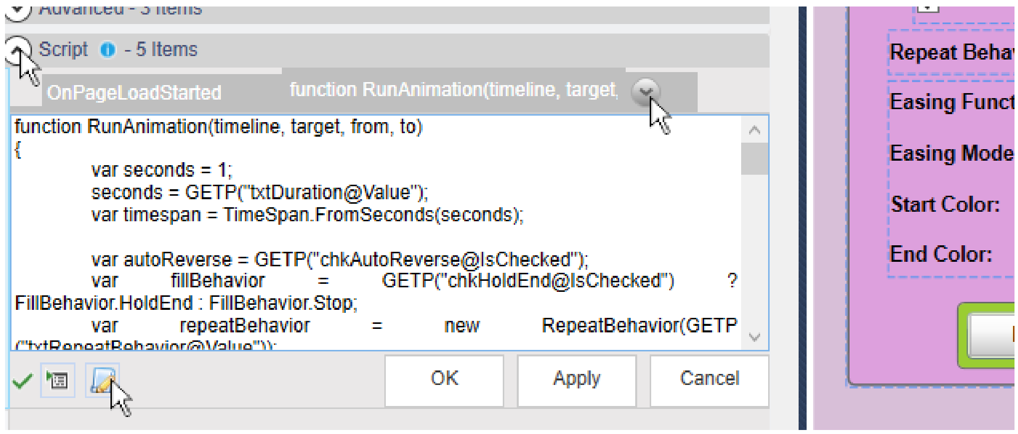
You can edit an example (ex) script by first copying it to your user content file location, and modifying the copy. This way it will not be replaced by the default script when the DataHub program is updated. However, you should not edit any of the `wv` scripts like this, as that may lead to unexpected results.

Script Editor

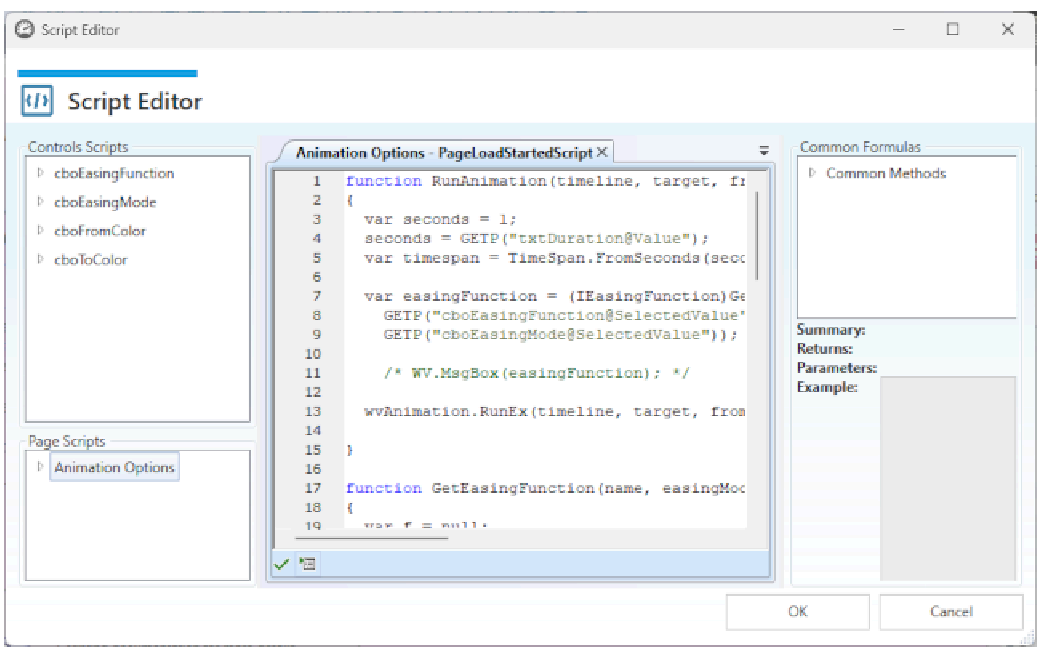
The Script Editor provides an intuitive coding environment with advanced features like syntax highlighting and search/replace.

To use the Script Editor:

1. Go to the Properties tab of a page or control and expand the Script property group.
2. Select a script, and click the arrow button at the end to view the script in the basic script editor.



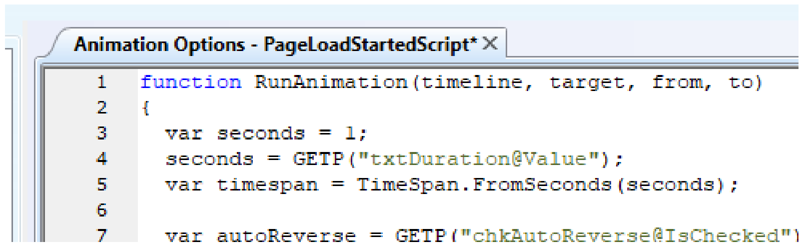
3. Click the Open in Editor button ( ) to open the Script Editor.



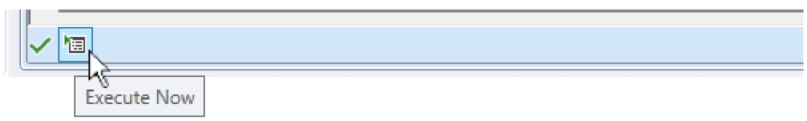
Panels

Main editing panel

The script is displayed with newlines, indentation, and syntax highlighting, ready for editing. You can access all of the scripts that are saved with the page, including the ones for controls on the page, and add scripts as needed. Multiple scripts are displayed in tabs, and you can copy and paste between them.

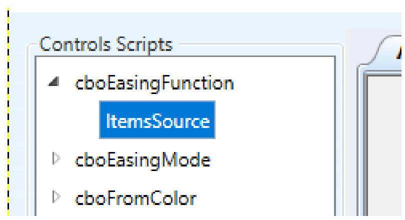


A button in the bottom left corner of this panel lets you execute the script at any time. Any error messages will display in this area.



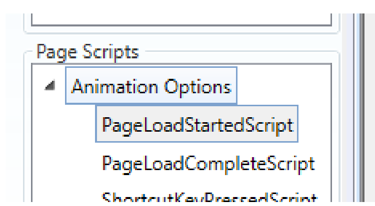
Controls Scripts

A list of the scripts associated with controls. You can open them by double-clicking on them.



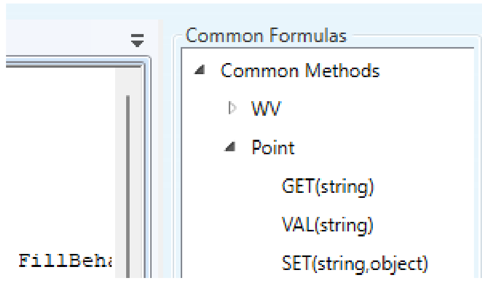
Page Scripts

A list of scripts associated with the page. You can open them by double-clicking on them.

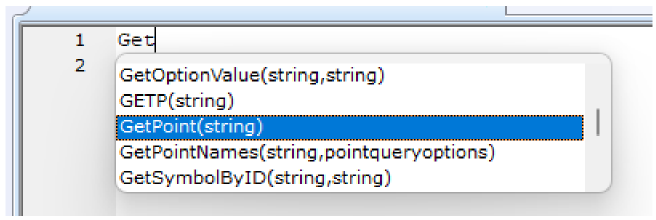


Common Formulas

A complete list of all the WV and point-related method calls with descriptions, return values, parameters and examples provided below.



These functions are also available through the auto-completion feature.



Clicking the **OK** button applies all changes and closes the editor. Clicking the **Cancel** button reverts all changes and closes the editor

Example Slide Show Script

The `exStartSlideShow.ss` script starts a slide show that rotates through selected WebView pages in kiosk view every few seconds.

```
/*
 * This file contains example script that uses the
 * Application_UserChanged application event to run a
 * slide show when the <slideshow> user logs in.
 *
 * If you want to customize this function, make a copy
 * of this file and add your code to the copy.  Do not
 * edit the original, as your changes will be destroyed
 * when you update the application.
 */

/*
function Application_UserChanged(userName)
{
    // In V10, userName includes the organization
    // name, e.g., "Local/slideshow"
    if (userName == "slideshow")
    {
```

```
        WV.ExecuteCommand("EnterRunMode", true);
        WV.ExecuteCommand("ToggleKioskView", true);
        WV.ExecuteCommand("ToggleScriptDebugWindow", false);

        var pages = new List<|string|>();
        pages.Add("Common/Cogent/Circular Gauges");
        pages.Add("Common/Cogent/Trend Charts");
        pages.Add("Common/Cogent/Water Treatment");

        wvSlideShow.EmitDebugMessages = false;
        // Start the slide show, advancing every 15 seconds.
        wvSlideShow.Start(pages, 15);
    }
}
*/
```

You can make a copy of this script to your user content file location, uncomment the function code, and edit the user name, pages, and number of seconds as needed. Here are some additional tips:

- It's a good idea to create a DataHub *`slideshow`* user in DataHub Security that is specific to your purpose, i.e., don't use your `admin` user.
- The `userName` parameter is case-sensitive. If you want a name with upper-case characters, like *`SlideShow`*, you can change this line of the code:

  ```
  if (username == "slideshow")
  ```

  To this:

  ```
  if (username.ToLower() == "slideshow")
  ```

- You can modify the script to access any of your own web pages that are listed in the WebView **My Pages** drop-down list by editing a `pages.Add()` line in the code, like this:

  ```
  pages.Add("Users/username/Pages/pagename");
  ```

  That path can be modified for other page locations, if necessary.
- The slide show functionality implemented by the `wvSlideShow` object in the script is defined in `Scripts/Cogent/wvSlideShow.ss`. You can review that file to understand more about this script.

Dynamic Binding

Using WebView Scripting, it is possible to dynamically bind DataHub points to symbols and controls, and use these capabilities to make template pages.

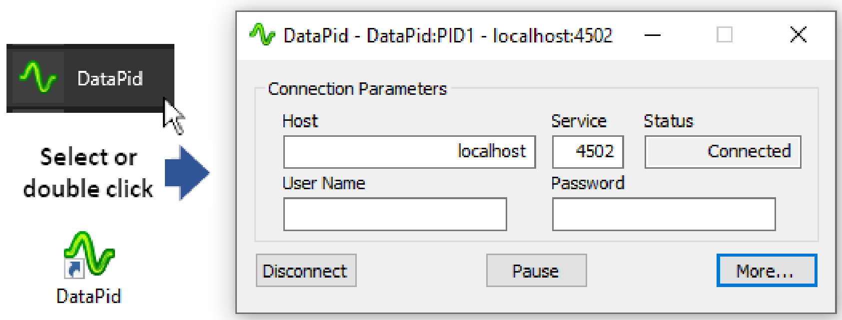
Dynamic Point Binding

Dynamic point binding allows you to change the DataHub points associated with a control at run time. This tutorial shows two different ways to do this (simple array and dynamic list), using two controls - ComboBox and ListBox.

Combo Box control

Binding a Combo Box to a Circular Gauge using a simple array

1. Start the DataPid program from the Windows **Start** menu, the command line, or by clicking on the desktop icon.



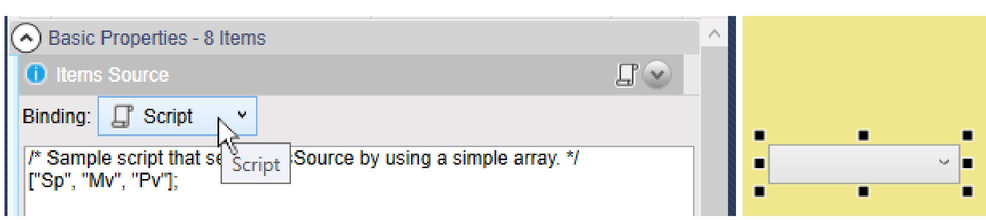
As soon as DataPid starts, it attempts to connect to a DataHub instance and begins generating data.

2. Open the WebView application, open a new page, and add a ComboBox control to the page.

3. In the **Basic Properties** of the Combo Box, for the **Items Source**, select the **Script** binding type and edit the default script to read:

```
["Sp", "Mv", "Pv"];
```

Then press the **Apply** button.

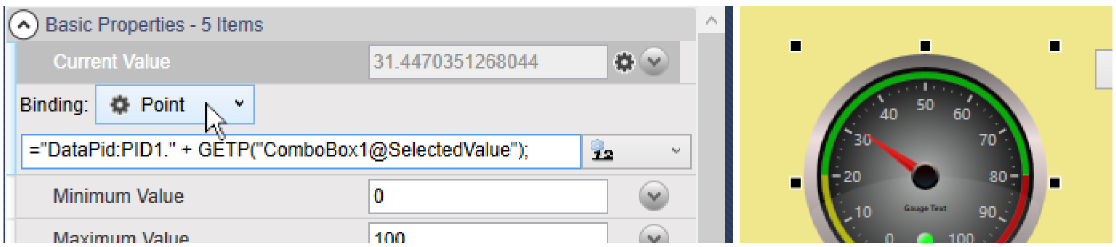


In this line of script, the [and] characters tells the WebView scripting engine that this is an array of comma-separated strings, each of which should be assigned to one value in the Combo Box control.

> As an alternative to using an array, it is possible to use a script to list the items, as explained in the List Box control section, below.

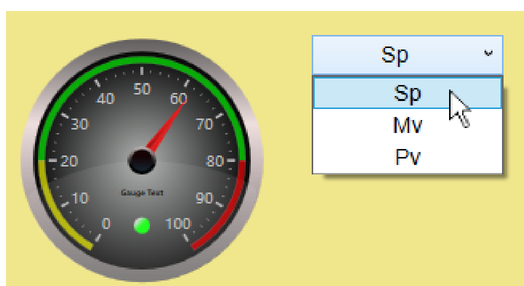
4. Add a Circular Gauge 2 control to the page.
5. In the **Basic Properties** of the Circular Gauge 2, for the **Current Value**, select the **Point** binding type and make a script:

```
="DataPid:PID1." + GETP("ComboBox1@SelectedValue");
```



> When a line of script is entered as a point binding as we see here, the = sign tells the WebView scripting engine that the point name will be assigned. In this example, this allows the name of the point to be constructed by concatenating strings. The `GETP` function gets the property of a control. The syntax for the `GETP` argument is a string consisting of the name of the control, an @ symbol, and the name of the parameter that you need to get.

6. Switch to Run mode and choose selections from the Combo Box and see the results in the Circular Gauge.



List Box control

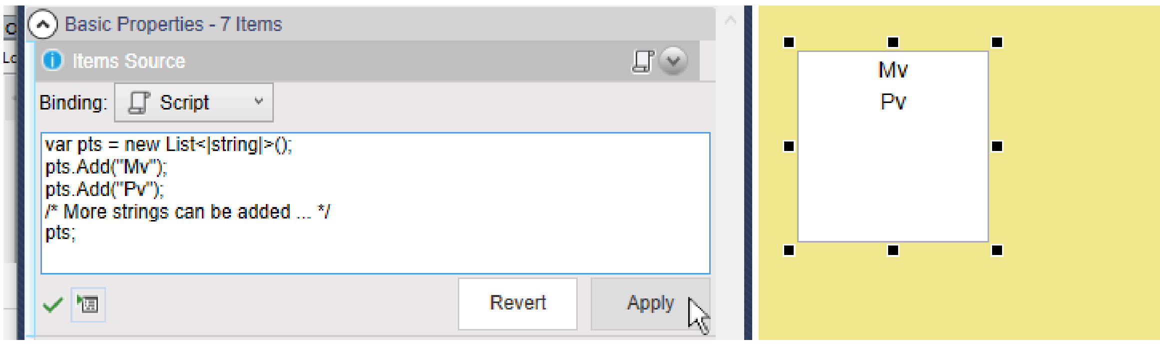
Binding a List Box to a Trend Chart using a script

1. Ensure that the DataPid program is running, or start it from the Windows **Start** menu, the command line, or by clicking on the desktop icon.
2. Open the WebView application, open a new page, and add a List Box control to the page.
3. In the **Basic Properties** of the List Box, for the **Items Source**, select the **Script**

binding type and edit the default script to read:

```
var pts = new List<|string|>();
pts.Add("Mv");
pts.Add("Pv");
/* More strings can be added ... */
pts;
```

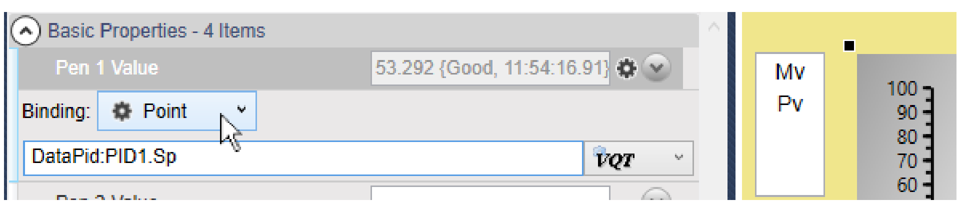
Then press the **Apply** button.



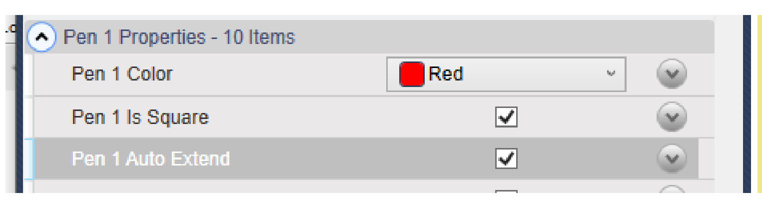
This example script creates a list of strings, and then adds two strings (point names in this case) to the list. The list can hold any number of strings. The final line of the script calls the `pts;` variable, which causes the list of strings to be passed to the List Box as its source of items.

As an alternative to using a script, it is possible to use a an array to list the items, as explained in the Combo Box control section, above.

4. Add a Trend Chart (3 pens) control to the page.
5. In the **Basic Properties** of the Trend Chart control, for the **Pen 1 Value**, select the **Point** binding type enter the value **`DataPid:PID1.Sp`**.

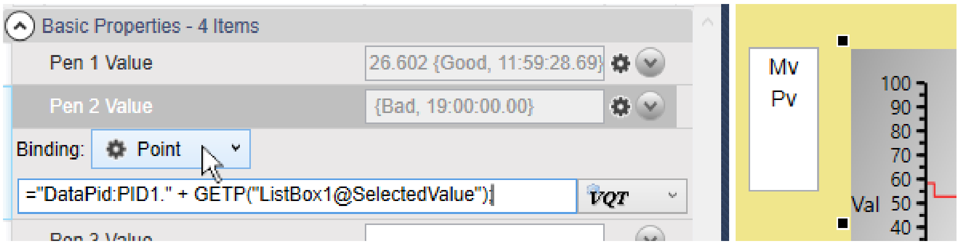


6. In the **Pen 1 Properties** of the Trend Chart control, check the **Pen 1 is Square** and **Pen 1 Auto Extend** to make the plot more accurate.

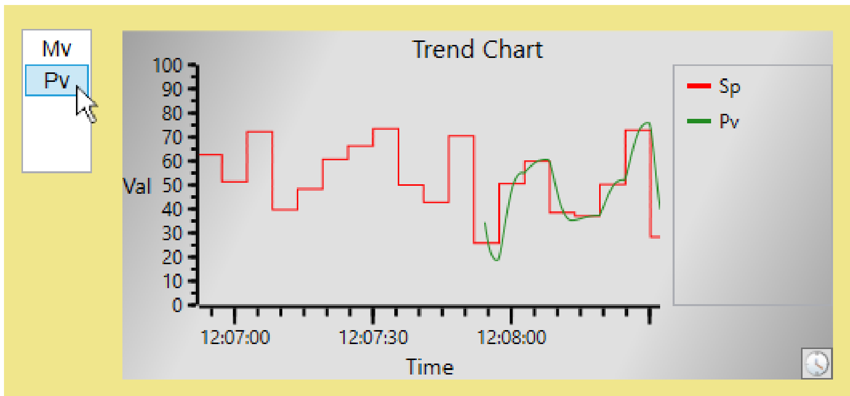


7. For the **Pen 2 Value**, select the **Point** binding type and make a script:

```
="DataPid:PID1." + GETP("ListBox1@SelectedValue");
```



8. Switch to Run mode and choose selections from the List Box and see the results in the Trend Chart.



Dynamic Control and Symbol Binding

Dynamic control and symbol binding allow you to change bindings on a control or symbol at run time. This tutorial shows how to use a Combo Box to change the color of a Shining Light, and then how to change a light switch symbol to appear as if it is being switched on and off.

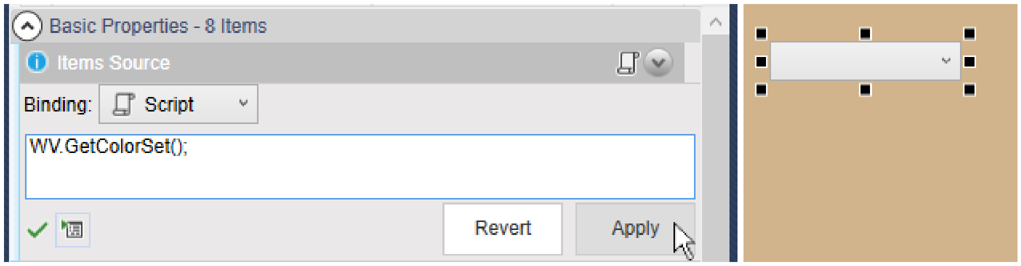
Control Binding

Bind a Combo Box to a Shining Light

1. Open the WebView application, open a new page, and add a Combo Box control to the page.
2. In the **Basic Properties** of the Combo Box, for the **Items Source**, select the **Script** binding type and edit the default script to read:

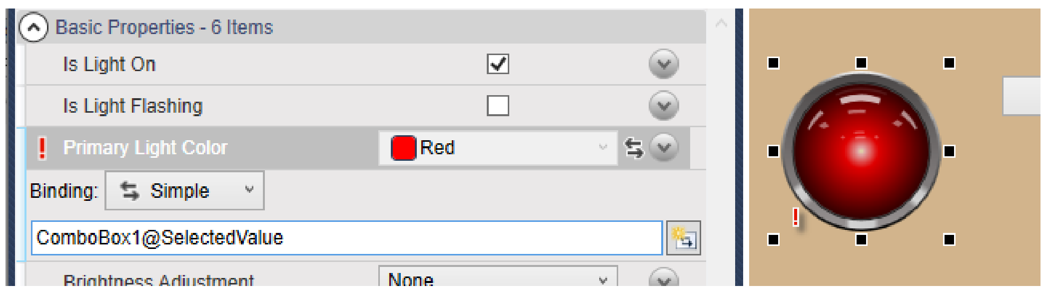
   ```
   WV.GetColorSet();
   ```

   Then press the **Apply** button.

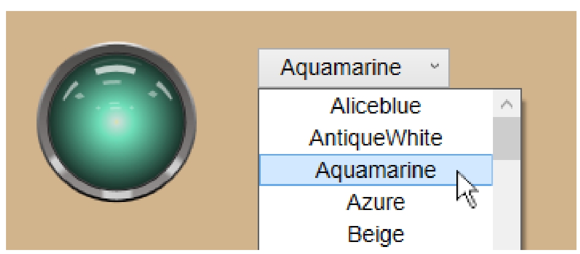


3. For **Display Member Path**, choose **Name**.
4. For **Selected Value Path**, choose **Color**.
5. Add a Shining Light control to the page.
6. In the **Basic Properties** of the Shining Light, for the **Primary Light Color**, select the **Simple** binding type and enter the value:

```
ComboBox1@SelectedValue
```



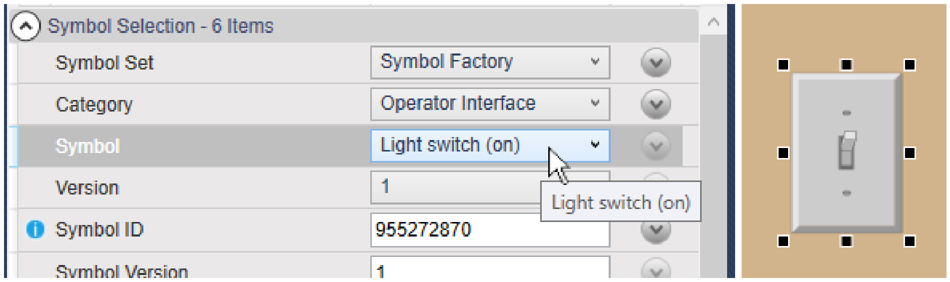
7. Switch to Run mode and choose selections from the List Box and see the results in the Trend Chart.



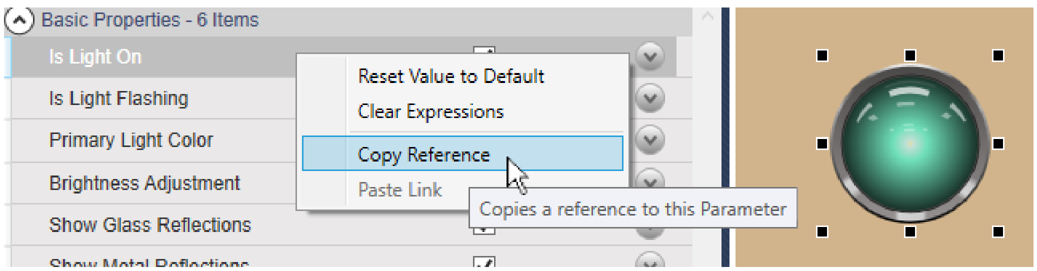
Symbol Binding

Change a Light Switch Symbol Binding to Simulate On and Off

1. Using the same page as above, add a Symbol control.
2. In the **Symbol Selection** for the **Symbol Set**, select **Symbol Factory**, for the **Category**, select **Operator Interface**, and for the **Symbol**, select **Light switch (on)**.



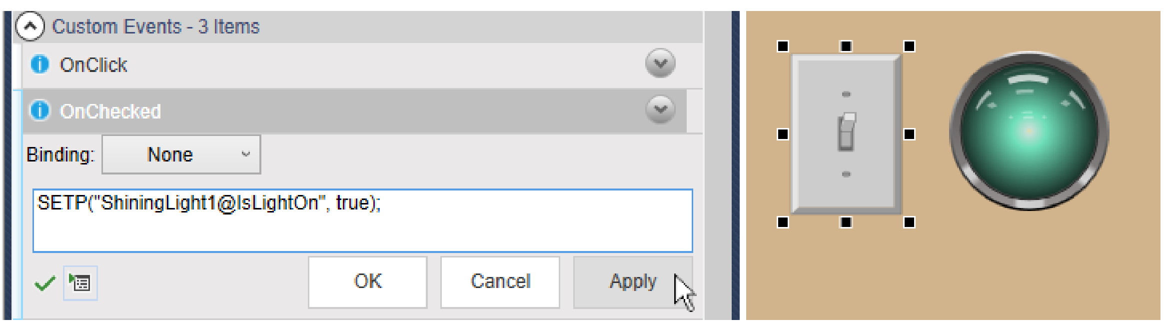
3. Select the ShiningLight control, and in the **Basic Properties**, right mouse click on **Is Light On** to copy the reference.



4. Select the Symbol (light switch) and in **Custom Events**, for **OnChecked Event**, enter:

```
SETP("ShiningLight1@IsLightOn", true);
```

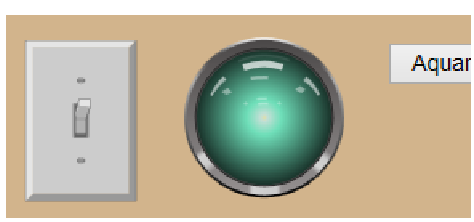
Then press the **Apply** button.



5. In **Custom Events**, for **OnUnChecked Event**, enter:

```
SETP("ShiningLight1@IsLightOn", false);
```

6. Switch to Run mode and click the light switch symbol to turn the Shining Light on and off.



This works OK, but it looks strange to have the light go off when the light switch is still in the ON position. We'll fix that next.

7. Select the Symbol (light switch) and in **Custom Events**, for **OnChecked Event**, add one more line:

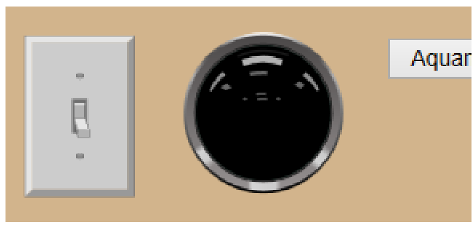
   ```
   SETP("ShiningLight1@IsLightOn", true);
   SETP("@SymbolID", 955272870);
   ```

   For this and the next step, the string `@SymbolID` refers to the symbol itself.

8. In **Custom Events**, for **OnUnChecked Event**, add one more line:

   ```
   SETP("ShiningLight1@IsLightOn", false);
   SETP("@SymbolID", 1685125442);
   ```

9. Switch to Run mode and click the light switch symbol to turn the Shining Light on and off.



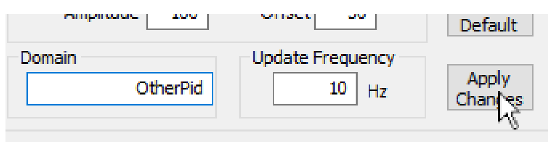
Now the symbol changes from Light switch (on) to Light switch (off) as the light goes on and off.

Creating a Template Page

This tutorial shows how to create a page where you can switch between data sources in a single display, at the click of a button.

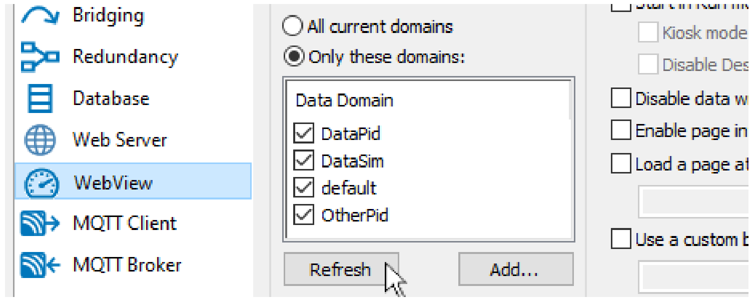
Creating an Identical Data Source

1. With DataPid running, start another instance of DataPid. In the second DataPid instance, click the **More...** button to expose the DataPid **Configurable Options**
2. Change the **Domain** to **`OtherPid`** and click the **Apply Changes** button. Then press the **Reconnect** button.



If you look in the DataHub Data Browser, you should see a new data domain, `OtherPid` with data changing values.

3. Go to the **WebView** option of the DataHub Properties window, and in the **Data Domains Visible to WebView** section, click the **Refresh** button.



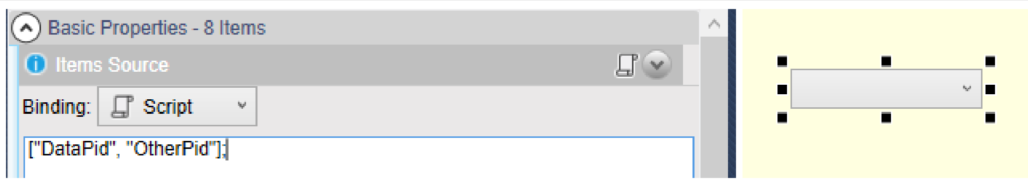
4. The domain name `OtherPid` should appear in the list. Check the checkbox to make the OtherPid domain visible to the WebView application, and make its points accessible. Now we have two identical point sets with different data to demonstrate our template page.

Creating the Template Page

1. Restart the WebView application if it is already running, for the changes to take effect. Open a new page, and add a Combo Box control to the page

2. In the **Basic Properties** of the Combo Box, for the **Items Source**, select the **Script** binding type and edit the default script to read:

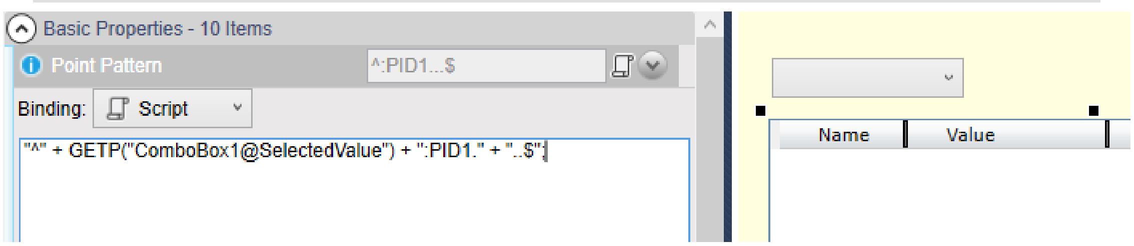
```
["DataPid", "OtherPid"];
```



3. Add a Point Data Table control to the page.

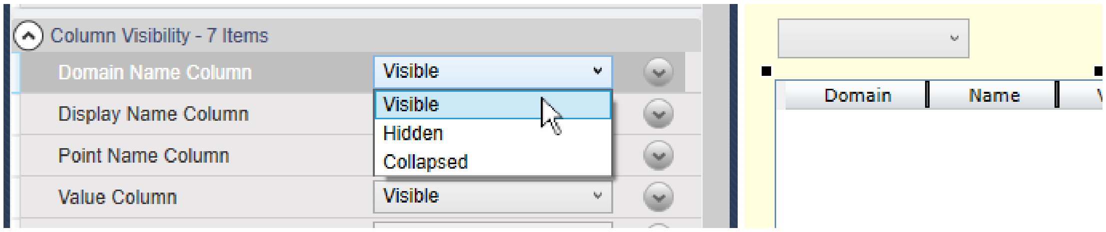
4. In the **Basic Properties** of the Point Data Table, for the **Point Pattern**, select the **Script** binding type and edit the default script to read:

```
"^" + GETP("ComboBox1@SelectedValue") + ":PID1." + "..$";
```

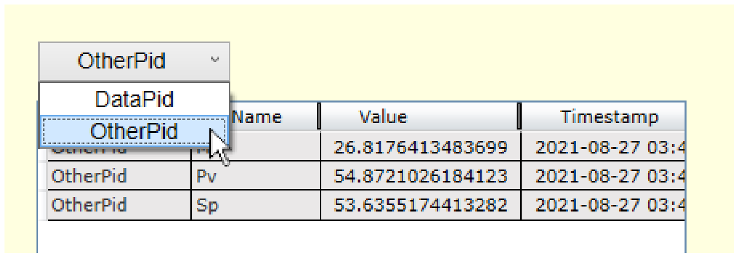


The ^ symbol allows any combination of prefix characters, while the `GETP` expression pulls in the value from the ComboBox. The `..$` string allows for any combination of suffix characters after the required `PID1.` string.

5. In the **Columns Visibility** property, change the **Domain Names** entry from **Collapsed** to **Visible**.



6. Switch to Run mode and change the data domain in the Combo Box from **DataPid** to **OtherPid** to view the two different sets of data points.



Adding a Trend Chart to the Page

1. Add a Trend Chart (3 pens) control to the page.
2. In the **Basic Properties** of the Trend Chart, for the **Pen 1 Value**, select the **Point** binding type and enter:

```
=GETP("ComboBox1@SelectedValue") + ":PID1.Sp";
```

When a line of script is entered as a point binding as we see here, the = sign tells the WebView scripting engine that the point name will be assigned. In this example, this allows the name of the point to be constructed by concatenating strings. The `GETP` function gets the property of a control. The syntax for the `GETP` argument is a string consisting of the name of the control, an @ symbol, and the name of the parameter that you need to get.

3. To give a better shape to the trend line for the Sp point, in the **Pen1 Properties** check the boxes for the **Pen 1 Is Square** and the **Pen 1 Auto Extend** options.
4. Back in the **Basic Properties**, for the **Pen 2 Value** select the **Point** binding type and enter:

```
=GETP("ComboBox1@SelectedValue") + ":PID1.Mv";
```

And for the **Pen 3 Value** select the **Point** binding type and enter:

```
=GETP("ComboBox1@SelectedValue") + ":PID1.Pv";
```

You should now see all three trends.

5. Switch to Run mode, and again change the data domain in the Combo Box from **DataPid** to **OtherPid**. Now both the table and the trend chart alternate between the two different sets of data points.

Following this example, you can build a page to display multiple identical sets of data in any group of controls. with the ability to switch between data sets at the click of a button.

Customizing the WebView Application

Long strings in some examples have been wrapped. The code examples in this chapter, and possibly others, may include very long strings that do no render well in the printed output of this documentation. For this reason, we have wrapped those strings in the examples. Please be aware that those examples may not work properly in your code if you copy them verbatim. You may need to unwrap the strings.

Simple Branding

Simple branding allows a WebView administrator to create a branded login page, to specify the application title, and to add company-specific links to the **Help** menu. Simple branding is intended for site administrators who want to provide their users with a general sense that the application is an integral part of the company's software solution for systems and processes.

In addition to simple branding options, OEM branding allows a distributor to replace Cogent-specific logos and references with icons and text of its own choosing. This level of branding is intended for Cogent partners and licensed distributors who need to re-brand the application to leverage their own corporate brand and to capitalize on specific market opportunities. For more information on OEM Branding, please contact Cogent.

Here's how to make changes.

1. Copy all the files that were installed in the DataHub Branding directory, here:
   ```
   C:\Program Files\Cogent\Cogent
   DataHub\Plugin\WebServer\html\Content\Common\Branding\Default
   ```
2. Put the copies into your user's Branding directory, here:
   ```
   C:\Users\username\AppData\Roaming\Cogent
   DataHub\WebContent\Content\Organizations\Local\Branding\Default
   ```
3. Add into that directory your own images for the company logo, product logo, and background, as desired, to be used in place of the existing `CogentLogo.png`, `WebViewLogo.png`, and `LoginBackground.png` images.
4. Edit the `LoginPage.xaml` file to change what the user sees when they first log in. Simply change the relevant `BitmapImage` code for the company logo, product logo, and background image for your new image file names. For example, to change the Cogent logo image to `MyCompanyLogo.png`, you would need to change this:
   ```
   ...
   <Image.Source>
       <BitmapImage UriSource="CogentLogo.png"/>
   </Image.Source>
   ...
   ```

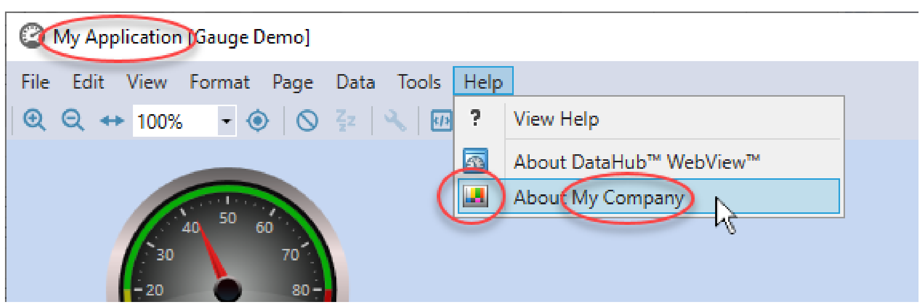
to this:

```
...
<Image.Source>
    <BitmapImage UriSource="MyCompanyLogo.png"/>
</Image.Source>
...
```

5. To see the changes, you need to shut down the WebView application and restart it.

6. You can also edit the `Branding.xml` page, changing the `ApplicationName`, `CompanyName`, `CompanyImageSource`, and `CompanyUrl` variables.

   To see the changes, you need to shut down and restart both the DataHub instance and WebView application.



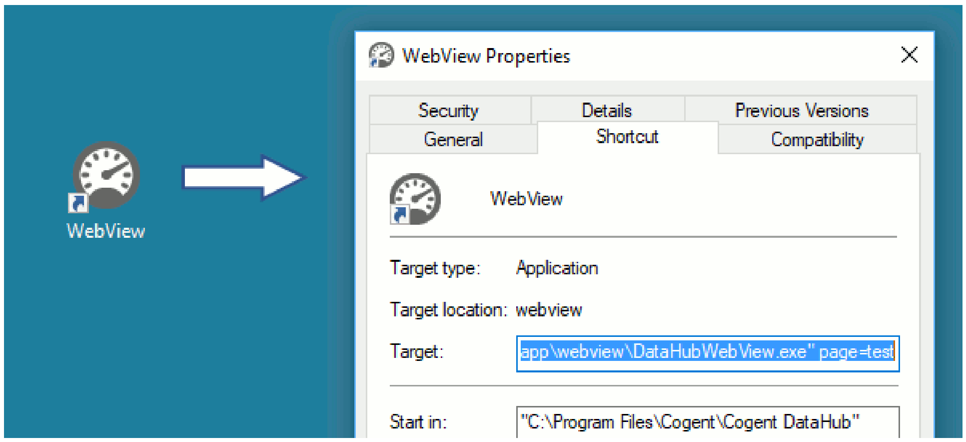
Initialization Parameters

The WebView application offers a number of initialization parameters that give you some control over the connection, log-in, initial view of a page, and designer controls when a page gets loaded.

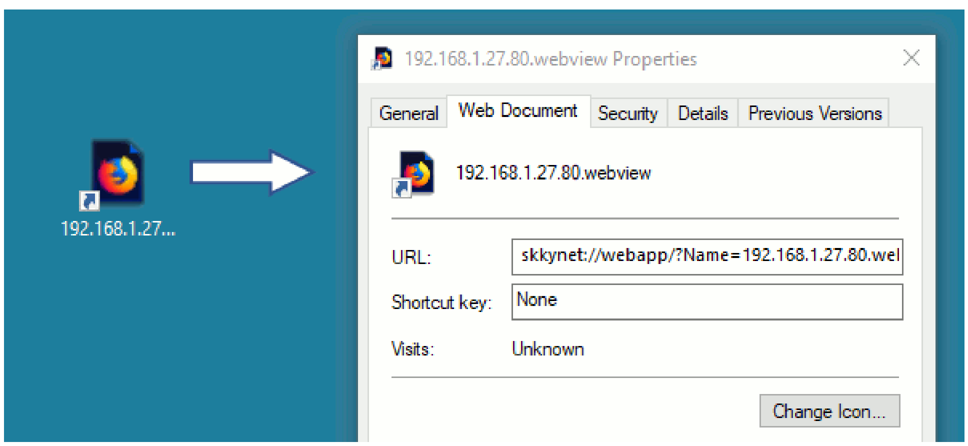
Specifying Parameters

You can put any of the initialization parameters into the properties of desktop shortcut that you use to launch the WebView application. Each of the two scenarios for running the WebView application has its own desktop shortcut, which must be configured separately.

1. **Running Locally** Create a desktop shortcut for the WebView application if you don't already have one, and right-click on it to expose the **Target** properties.



2. **Web Launch** Create a desktop shortcut for the WebView application if you don't already have one as explained here, and right-click on it to expose the **URL** properties.



For either of these, you can add parameters by inserting a space, followed by the parameter, an equal sign (=), and the value. Multiple parameters are allowed. For example:

```
StartInRunMode=true Page="Circular Gauges"
```

```
StartInRunMode=true Page=Notifications
```

Shortcuts for a locally-running DataHub instance can contain spaces, as long as the value is in quotation marks, such as `"Circular Gauges"` above. Web launch shortcuts that use URLs do not allow spaces in the value. It must be a single string, as in the second example above (`Notifications`).

Please refer to the Parameter List to see all of the available parameters.

Parameter List

The following tables show all of the initialization parameters available in the WebView application. The parameter names are not case sensitive, but the parameter arguments may be, depending on the meaning of the argument. The **Properties** column indicates whether the parameter can be set via a selection in the DataHub Properties window.

Connection

`TcpPort`

Value	Properties	Description
Integer	Advanced Options Data Port	The port number used to connect to the DataHub data feed. The default is `4502`.

`WebPort`

Integer	Advanced Options	The HTTP port number on which the DataHub Web Server is listening. The default is `80`.

`Host`

String	Advanced Options	The name or IP address of the computer on which the DataHub instance is running.

`DataProtocol`

String	Advanced Options	There are two options: `"TCP"` or `"WebSocket"` to specify the data protocol. The default is `"TCP"`.

`UseSsl`

True/False	Advanced Options	When `True`, the WebView application will use the SSL protocol for the `TcpPort`. The default is `False`.

`UseHttps`

True/False	Advanced Options	When `True`, the WebView application will use HTTPS for the `WebPort`. The default is `False`.

Credentials and Login

UserName

String	Running WebView	The user name. If this is specified then the WebView application will bypass the login screen and automatically log in using this user name.

Password

String	Running WebView	The password for *UserName*.

Start Page, Page Data, and Initial Editor Mode

Page

Value	Properties	Description
String	WebView	The WebView page to show when the user first logs in. This page will be loaded even if the user starts in Design mode. The page name must include any path components separated by / characters. The page name does not include an extension. Example: `Users/admin/mypage`

PageData

name=value pairs	WebView	These values become global variables in the script context. Each *name=value* pair is separated by a comma, as in: `PageData=a=5,b=6`. Please see Page Data in the WebView Scripting manual for more information.

StartInRunMode

True/False	WebView	When `True`, the WebView application will enter Run mode when the user logs in, otherwise it will enter Design mode if the user has permission to do so.

DisableDesignMode

True/False	WebView	When `True`, the WebView application will not allow the user to enter Design mode, even if the user has permission to do so. Also, when `True`, this parameter hides dialogs that require user interaction.

UseKioskView

True/False	WebView	When `True`, the WebView application will start in Kiosk mode, removing the menu and icon bars.

UseFullScreenMode

True/False	WebView	When `True`, the WebView application will start in Full Screen mode, displaying only the page.

RunSilently

True/False	WebView	When `True`, in Run mode only, this parameter hides dialogs that require user interaction. The default is `False`.

HideLoadingPageMessage

True/False	WebView	When `True`, in Run mode only, this parameter hides dialogs that do not require user interaction (such as any "Wait" dialog). For this to work, *ForceNonInteractiveDialogs* must be set to `True` and *RunSilently* to `False`. The default for this parameter is `False`.

ForceNonInteractiveDialogs

True/False	No	When `True`, in Run mode only, this parameter overrides the *RunSilently* parameter and displays non-interactive dialogs (such as any "Wait" dialog). The default is `False`.

FreezeScreenWhileLoadingPage

True/False	No	When `True` (the default), then the current page is frozen and the new page is loaded in the background. If this is `False` then the current page is erased and the new page is loaded in the foreground, with controls on the screen appearing as they load.

ShowExitConfirmation

UnsavedChanges, Never, Always	No	This setting determines whether to prompt the user when he attempts to exit the WebView application. If set

		to `Never`, then the user will not be prompted on exit. If set to `Always` then the user will be prompted. If set to `UnsavedChanges` then the user will only be prompted if there are unsaved changed on the current page. The default is `Always`.

Branding

`BrandingFolder`

Value	Properties	Description
String	WebView	The path to a folder to search for custom branding information. This folder is relative to the WebView installation `Branding` directory. The path separator is the `/` character.

Page Designer Functionality

`DisablePageInformationButton`

Value	Properties	Description
True/False	WebView	When `True`, the page information button will not be displayed in Run mode. The default is `False`.

`MakeDataPointsReadOnly`

True/False	WebView	When `True`, the WebView application will be unable to write data to the DataHub instance's data set, regardless of the configuration or user permissions. The default is `False`.

`ShowHiddenControls`

True/False	No	When `True`, controls that are normally hidden will be visible in Design mode. Hidden controls are controls that act as base classes for other controls, are deprecated, or are experimental. In any case, these controls should not be used by a page designer. The default is `False`.

Adding Controls

Control designers and power users who want to complement or extend the suite of controls that ship with the WebView application can create their own custom controls.

Creating custom controls requires an understanding of how to develop Microsoft .NET class libraries, including:

- Familiarity with Visual Studio.
- An understanding of XML.
- Familiarity with XAML.
- Access to the DataHub installation directories and files.

For more information, contact Cogent support.

WebView Controls

Advanced Check Box

Advanced Check Box — toggles between two states, each with advanced properties.

Description

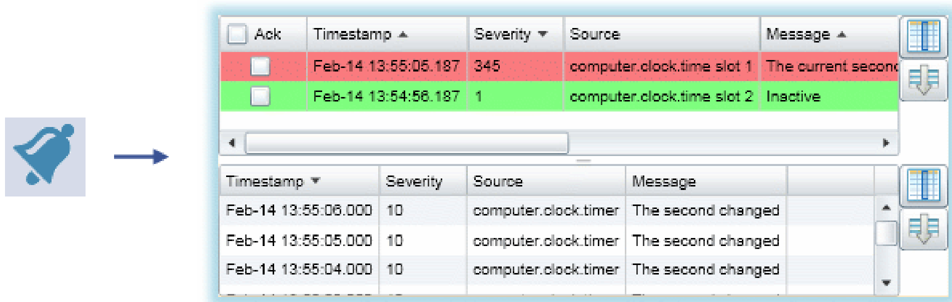
Changes between two states: checked and unchecked. Each state has additional user properties: a numeric value, a string, a DateTime, and a color.

Alarm List

Alarm List — a table that displays alarms and events.

Description

The Alarm control lets you view the most recent alarms at the top and events at the bottom. The alarms data comes from a data domain in the DataHub instance that has been configured for OPC Alarms and Events (OPC A&E).



Use

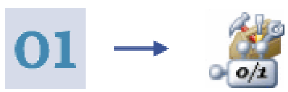
The **Select Columns** button for each section lets you choose which columns to display. The **Default Sort** button for each section reverts the sort order back to the default setting. The **Ack** button allows you to acknowledge and remove all the alarms, while the buttons in that column let you acknowledge and remove individual alarms.

Boolean Converter

Boolean Converter — a program block that selects between two states.

Description

Selects an output value, an output DateTime and an output color based on an input boolean value (True/False). This is a design-time control and is not visible in Run mode.

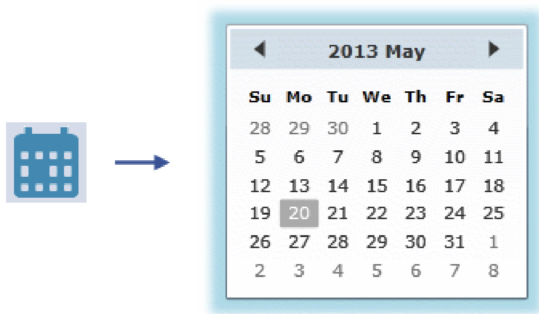


Calendar

Calendar — displays a calendar.

Description

Displays a calendar, enabling the user to select a date.

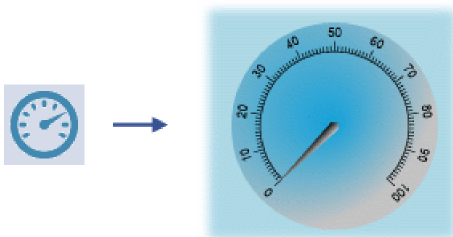


Circular Gauge 1

Circular Gauge 1 — simple circular gauge.

Description

Used to graphically represent real-time data. In its default configuration, this gauge is a simple circle with a needle. With Edit mode set to Drag, the user can interact with the gauge in Run mode. This is a highly-configurable control. Properties like value, value range, editing ability, and angle range are all modifiable.

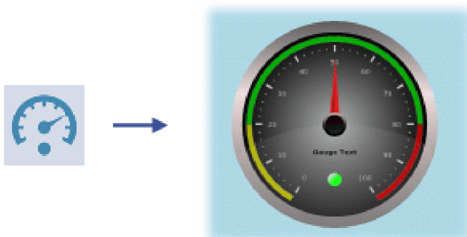


Circular Gauge 2

Circular Gauge 2 — circular gauge with varying value ranges and an indicator light.

Description

Used to graphically represent real-time data. This gauge has an indicator light that shows whether the needle is in the optimal range, below optimal, or above optimal. This gauge does not allow user interaction in Run mode. All ranges, sizes, values, and colors can be changed.

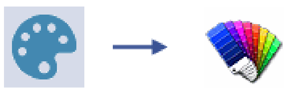


Color Selector

Color Selector — a palette used to store specific colors and to access application theme colors.

Description

Used to set a variety of colors as Custom Colors and to access application Theme Colors. These colors can then be used as binding sources for other controls on the page. This makes it easy to create and maintain custom color themes. This is a design-time control and is not visible in Run mode.

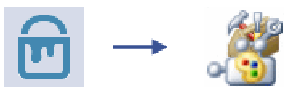


Color Selector

Color Selector — a program block that uses ARGB values to produce a color.

Description

Uses four numeric inputs (alpha, red, green, blue), each in the range 0-255, to build a color. Alternatively, references a color from a Color Palette. This is a design-time control and is not visible in Run mode.



ComboBox

ComboBox — a simple dropdown list used for item selection.

Description

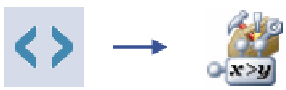
Enables the user to select from among available items. The list of items can be configured as a comma-separated list, or bound to the result of an expression.

Comparator

Comparator — a program block that compares two values and outputs the results.

Description

Compares two inputs (DataPoints or values) and produces various output values. Optionally, accepts a numeric tolerance to stabilize comparisons based on rapidly-changing inputs. This is a design-time control and is not visible in Run mode.

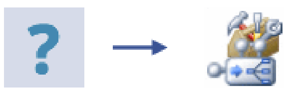


Condition Selector

Condition Selector — a program block used to select among five different states.

Description

Selects output text and values based on a condition input value. The input can be treated as a boolean to produce a two-state result, or can be compared to each state's value range. If states have overlapping ranges, the first match is used. Each state can be associated with text, colors and values. Typically, these configurable state settings feed other controls and processes. This is a design-time control and is not visible in Run mode.

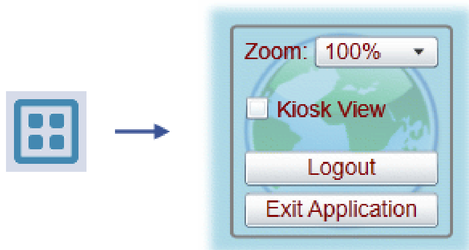


Control Panel

Control Panel — supports Run mode option changes.

Description

Enables the user to change various options while in Run mode.



Date Picker

Date Picker — allows a user to select a date.

Description

Displays an entry field that opens a calendar, enabling the user to select a date.

Format Strings

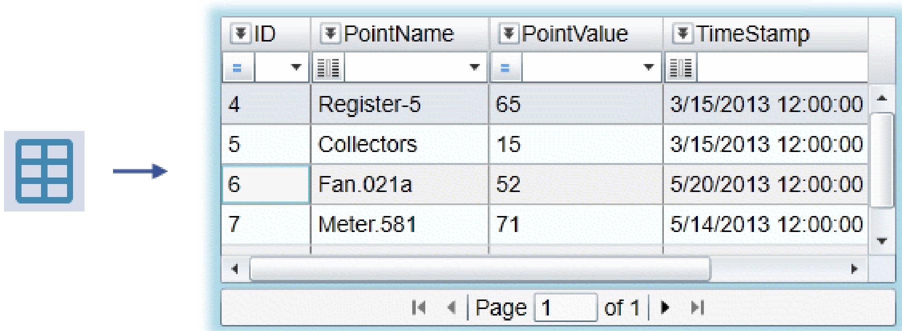
Numeric values, text, dates, and times can be formatted using Windows standard and custom format strings. For example, to format a numeric value to two decimal places, specify a format of `0.00`. For more information on formatting numbers, text, dates and times, please see the section called “Format Strings”.

Filtered Data Table

Filtered Data Table — row/column results from a database query.

Description

Presents the result of a row/column data set in a table. Columns can be reordered and pinned. Rows can be filtered and grouped.



Hi/Low Indicator

Hi/Low Indicator — changes color to indicate high and low values.

Description

Responds to real-time data updates by changing color. The color corresponds to a matching value range. Five ranges can be configured: Low Low, Low, Normal, High, and High High. It has modifiable text, limits, colors, and transition time.

Format Strings

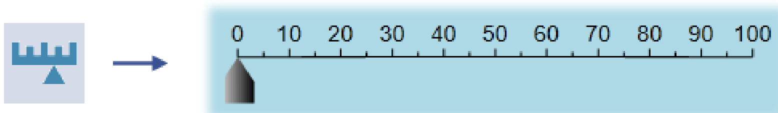
Numeric values, text, dates, and times can be formatted using Windows standard and custom format strings. For example, to format a numeric value to two decimal places, specify a format of `0.00`. For more information on formatting numbers, text, dates and times, please see the section called “Format Strings”.

Horizontal Linear Gauge

Horizontal Linear Gauge — a linear horizontal gauge with a slider,

Description

Used to graphically represent real-time data. In its default configuration, this linear gauge is oriented horizontally. With Edit mode set to Drag, the user can interact with the gauge in Run mode. This is a highly-configurable control. Properties like the value, value range, editing ability, and angle range are all modifiable.



Hyperlink Button

Hyperlink Button — acts as a hyperlink to another page or a URL.

Description

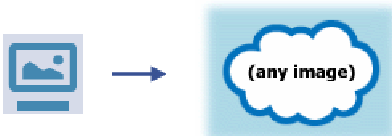
Uses a button to link the user to another page or to an external URL. This control is often used to provide navigation support among a collection of related pages.

Hyperlink Image

Hyperlink Image — acts as a hyperlink to another page or a URL.

Description

Uses an image to link the user to another WebView page or to an external URL. This control is often used to provide navigation support among a collection of related pages.

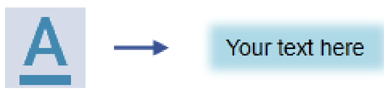


Hyperlink Text

Hyperlink Text — acts as a hyperlink to another page or a URL.

Description

Uses a text label to link the user to another page or to an external URL. This control is often used to provide navigation support among a collection of related pages.

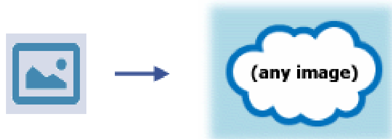


Image

Image — an image file container.

Description

Displays an image located in the images file directory. server.

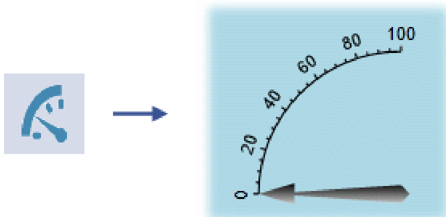


Left 90 Degree Gauge

Left 90 Degree Gauge — a quarter-circle gauge.

Description

Used to graphically represent real-time data. In its default configuration, this gauge is a quarter-circle with a needle. With Edit mode set to Drag, the user can interact with the gauge in Run mode. This is a highly-configurable control. Properties like the value, value range, editing ability, and angle range are all modifiable.

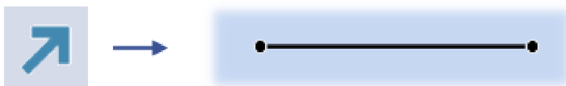


Line and Arrows

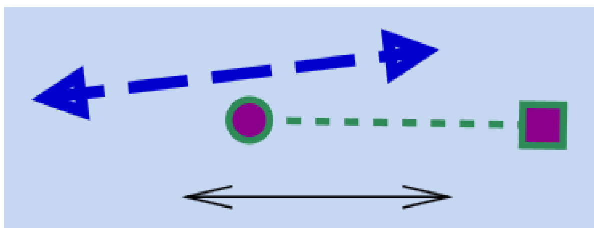
Line and Arrows — creates line segments with optional arrowheads.

Description

Insert lines onto the drawing canvas with editable thickness, color, dashes, and arrowheads.



Examples:

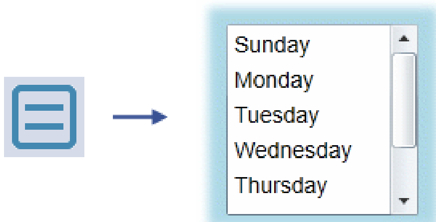


List Box

List Box — a simple list used for item selection.

Description

Enables the user to select from among available items. The list of items can be configured as a comma-separated list, or bound to the result of an expression.

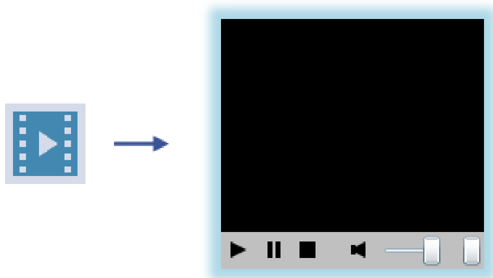


Media Player

Media Player — plays audio and videos.

Description

Displays media located in the media file directory on the web server. Typical playback controls are available. Media can be configured to auto play and auto repeat. Audio controls are also available.

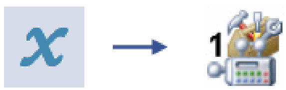


One Input Calculator

One Input Calculator — a program block that performs calculations on a single input value.

Description

Calculates a variety of values based on a single input. Calculations include Boolean and Duration conversions, mathematical operations (Abs, Sign, Ceiling, Floor, Exponent, Log, Square, SquareRoot), and trigonometric functions (Sin, Cos, Tan, etc). This is a design-time control and is not visible in Run mode.

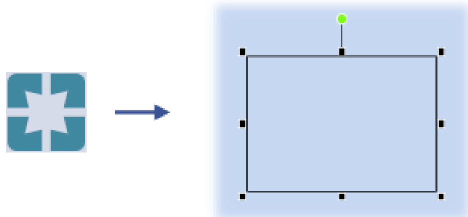


Page Viewer

Page Viewer — supports multiple page displays.

Description

Provides support for rapid viewing of multiple pages, or to rapidly switch between pages. See how to use this control here.

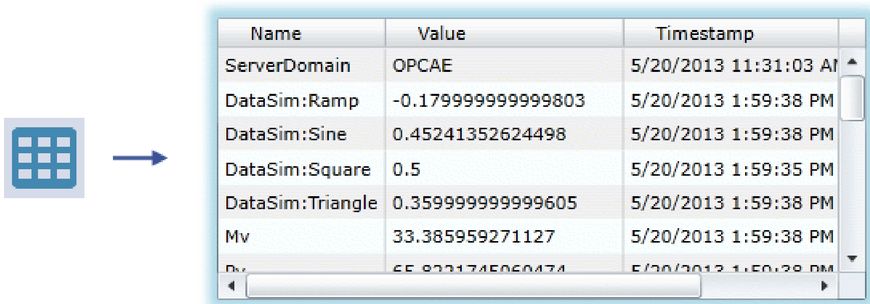


Point Data Table

Point Data Table — a table consisting of all available data points.

Description

Presents all available data points in the DataHub instance in a table format. The columns available are Point Name, Display Name, Value, Timestamp, Quality Name, and Quality.



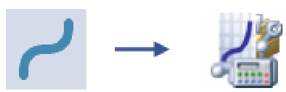
Name	Value	Timestamp
ServerDomain	OPCAE	5/20/2013 11:31:03 AI
DataSim:Ramp	-0.179999999999803	5/20/2013 1:59:38 PM
DataSim:Sine	0.45241352624498	5/20/2013 1:59:38 PM
DataSim:Square	0.5	5/20/2013 1:59:35 PM
DataSim:Triangle	0.359999999999605	5/20/2013 1:59:38 PM
Mv	33.385959271127	5/20/2013 1:59:38 PM

Polynomial Calculator

Polynomial Calculator — a program block that calculates the result of a polynomial expression.

Description

Calculates the result of a polynomial expression (up to 5th order). This is a design-time control and is not visible in Run mode.

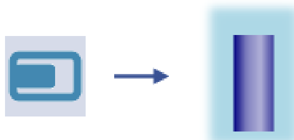


Progress Bar

Progress Bar — an expanding/shrinking progress bar.

Description

Used to graphically represent real-time data. This control shows the input value by expanding or shrinking in size. The bar's orientation, range, and size can all be modified. The progress bar also accommodates color change based on five ranges: Low Low, Low, Normal, High, and High High.



QR Code Generator

QR Code Generator — generates QR code images of text strings.

Description

Encodes text for a QR image for scanning by a QR code reader. Use the Text To Encode entry field to enter the text.

Radio Button

Radio Button — a button that offers a choice of mutually exclusive options.

Description

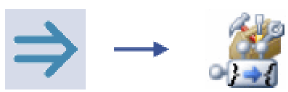
Used in groups where only one of the buttons in the group can be checked at a time (i.e., mutually exclusive). The Control Value for each radio button in a group should be bound to a single source (e.g., data point), which will be treated as the group's input. The radio button whose value matches the Control Value will be selected.

Range Mapper

Range Mapper — a program block that maps an input to an output, using ranges.

Description

Maps a single input (DataPoint or value) to a value in a corresponding output range. Ranges are specified with an input minimum and maximum, and an output minimum and maximum. The input can be clamped for limited, linear interpolation, or unclamped for extrapolation. This is a design-time control and is not visible in Run mode.



Rising/Falling Indicator

Rising/Falling Indicator — a display that changes according to the rise or fall of a value.

Description

Responds to real-time data updates by changing color. The color reflects how quickly the input value is rising or falling. It has modifiable text, colors, transition time, and steady time.

Format Strings

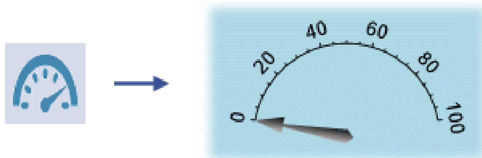
Numeric values, text, dates, and times can be formatted using Windows standard and custom format strings. For example, to format a numeric value to two decimal places, specify a format of `0.00`. For more information on formatting numbers, text, dates and times, please see the section called "Format Strings".

Semi-circular Gauge

Semi-circular Gauge — a semi-circular gauge.

Description

Used to graphically represent real-time data. In its default configuration, this gauge is a semi-circle with a needle. With Edit Mode set to Drag, the user can interact with the gauge in Run mode. This is a highly-configurable control. Properties like the value, value range, editing ability, and angle range are all modifiable.

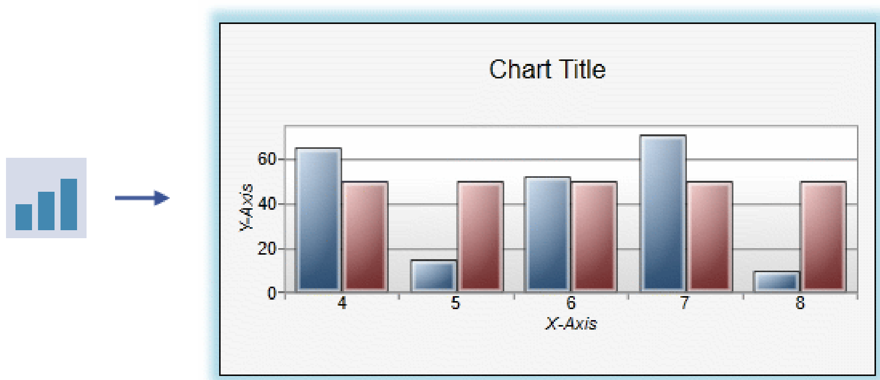


Series Chart

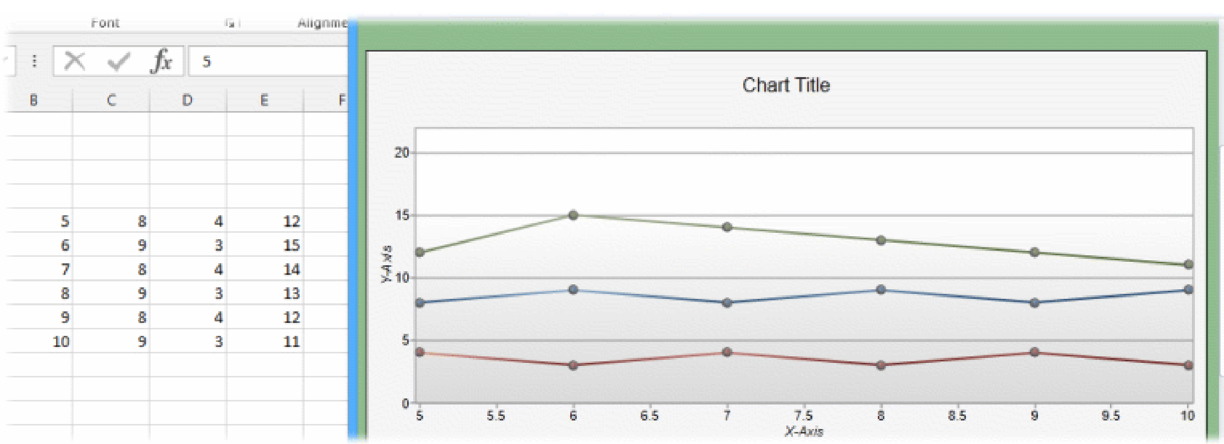
Series Chart — displays data in chart format - bars, lines, pie, etc.

Description

Provides a number of different chart formats for displaying related data values.



The Series Chart control requires tabular data, where the first column of the table is the X axis and all other columns are the Y axis data. The control automatically treats all data columns after the first one as independent series sharing the same X axis. You need to construct such a table in a database or as an Excel range, and write it to a single data point in the DataHub instance. That point can then be bound to the Series Chart control. It is possible to display multiple series charts.

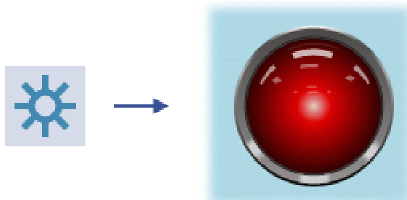


Shining Light

Shining Light — an indicator light that can flash and change color.

Description

Displays a light which responds to boolean triggers and color changes. This control is typically used for notification. Boolean inputs control whether the light is on or flashing. The light color can be set with a single input, or configured using gradient colors and offsets. Duration, auto reverse, and repeat behavior are also modifiable.



Simple Button

Simple Button — a simple, clickable button.

Description

Provides a simple way to attach script code to a button click event.

Simple Check Box

Simple Check Box — toggles between two states.

Description

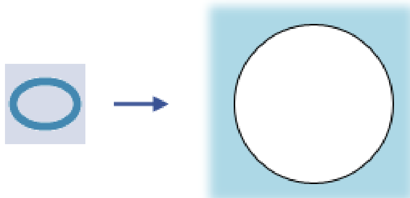
Changes between two states: checked and unchecked. Typically, a DataPoint is bound to the input value and used to toggle between states. Each state has an associated value which can be used to feed another control or process.

Simple Ellipse

Simple Ellipse — a simple ellipse with editable appearance and properties.

Description

A simple ellipse with modifiable fill color, stroke color, and stroke thickness.

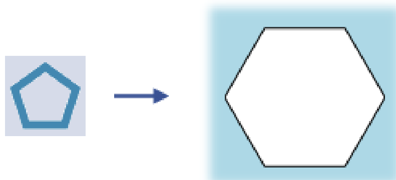


Simple Path

Simple Path — a path that can create any shape.

Description

A simple path that can be used to create any shape through mapping out each point using XAML path notation. Fill color, stroke color, canvas size, stroke thickness, stroke caps, stroke joins, and stroke miter limit are all modifiable. Please see the XAML path notation for Path Markup Syntax in the online Microsoft reference library for more information.

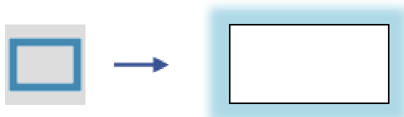


Simple Rectangle

Simple Rectangle — a simple rectangle with editable appearance and properties.

Description

A simple rectangle with modifiable fill color, stroke color, stroke thickness and corner radius.

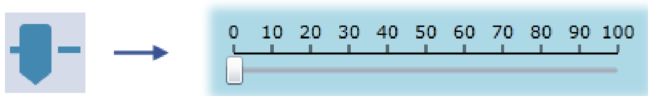


Slider

Slider — a scale with an adjustable slider to control or view values.

Description

Enables the user to select a value along a configurable scale by dragging the slider. The slider can be configured either horizontally or vertically. Axis labels can be displayed before or after the scale.

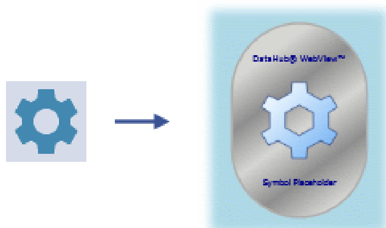


Symbol

Symbol — a container for over 4000 symbols.

Description

A common container for over 4000 industry standard symbols. Symbols can be configured to blink, rotate and show progress. Output states are selected based on a condition input value. The input can be treated as a boolean to produce a two-state result, or can be compared to each state's value range. If states have overlapping ranges, the first match is used. Each state is associated with a value range, color, text, blinking, blink rate, rotating, and rotation rate. Symbols can be automatically updated when new versions of the symbol are available.

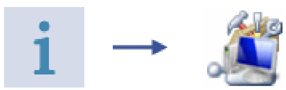


System Information

System Information — a program block that can access system, user, and page information.

Description

Accesses information about the system and page. Outputs include local time, user, page name, file name, description, and owner. Typically, these values are used for page titles and footers. This is a design-time control and is not visible in Run mode.



Text Entry Field

Text Entry Field — a simple textbox used for data entry.

Description

Enables the user to input a text string or numeric value while in Run mode.

Format Strings

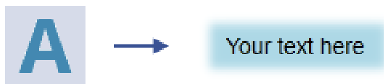
Numeric values, text, dates, and times can be formatted using Windows standard and custom format strings. For example, to format a numeric value to two decimal places, specify a format of `0.00`. For more information on formatting numbers, text, dates and times, please see the section called “Format Strings”.

Text Label

Text Label — a textual display with no entry field.

Description

A text label that displays text, but does not have an entry field. Color is modifiable.



Format Strings

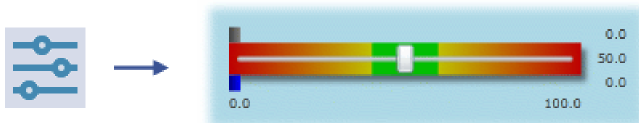
Numeric values, text, dates, and times can be formatted using Windows standard and custom format strings. For example, to format a numeric value to two decimal places, specify a format of `0.00`. For more information on formatting numbers, text, dates and times, please see the section called “Format Strings”.

Three Point Slider

Three Point Slider — a horizontal gauge that shows up to three data points on a slider.

Description

Used to graphically represent real-time data. This slider shows up to three values and has optimal, below optimal, and above optimal ranges. It has a slider for the primary value, which the user can drag in Run mode, and a progress bar for each of the other values. It also has an error indicator which flashes when the primary value is outside the optimal range.



Time Picker

Time Picker — allows a user to select a time.

Description

Displays an entry field that enables the user to select a time.

Format Strings

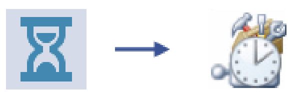
Numeric values, text, dates, and times can be formatted using Windows standard and custom format strings. For example, to format a numeric value to two decimal places, specify a format of `0.00`. For more information on formatting numbers, text, dates and times, please see the section called “Format Strings”.

Timer

Timer — a program block executes that provides timer and counter behavior.

Description

Provides timer behavior to control process execution. Counter functions include Increment, Decrement and Toggle. Supports common repeat behavior. This is a design-time control and is not visible in Run mode.



Toggle Button

Toggle Button — a push button with an optional two-state toggle.

Description

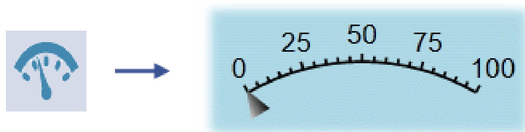
Has a normal and a pushed state that can have toggle behavior or a press-and-release behavior. Each state has associated text, text color, and a numeric value.

Top Sweep Gauge

Top Sweep Gauge — a horizontal curved gauge.

Description

Used to graphically represent real-time data. In its default configuration, this gauge is a curved upper-portion of a circle with a needle. With Edit mode set to Drag, the user can interact with the gauge in Run mode. This is a highly-configurable control. Properties like the value, value range, editing ability, and angle range are all modifiable.

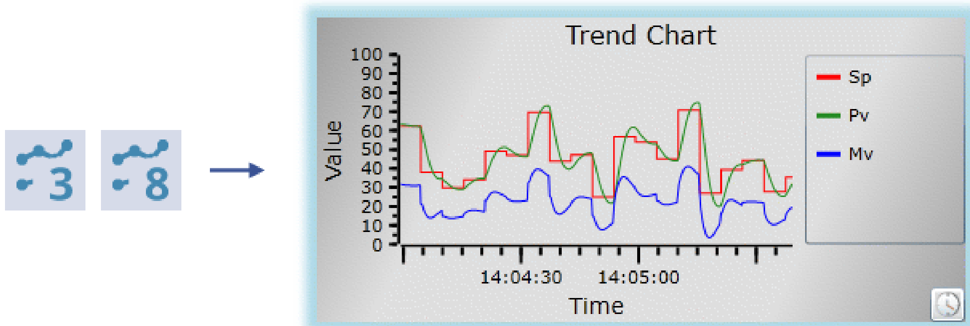


Trend

Trend — two chart controls can track up to 3 or 8 data points.

Description

These two charts (3-pen and 8-pen) allow a user to assign values and data points to three or eight trend lines. They track the values and variations of each point as they change over time. These Trend Charts also leverage the power of the Data Historian.

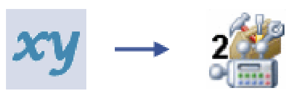


Two Input Calculator

Two Input Calculator — a program block that performs calculations on two input values.

Description

Calculates various mathematical and logical output values using two inputs (DataPoints or values). Functions include: Sum, Difference, Product, Quotient, Modulo, Minimum, Maximum, Round, etc. This is a design-time control and is not visible in Run mode.

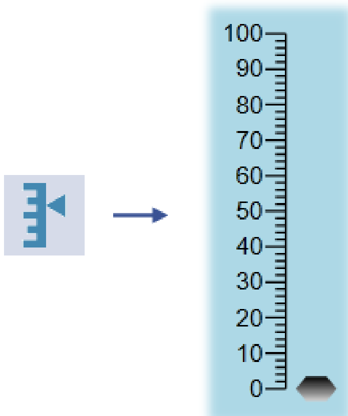


Vertical Linear Gauge

Vertical Linear Gauge — a linear vertical gauge with a slider.

Description

Used to graphically represent real-time data. In its default configuration, this linear gauge is oriented vertically. With Edit mode set to Drag, the user can interact with the gauge in Run mode. This is a highly-configurable control. Properties like the value, value range, editing ability, and angle range are all modifiable.



DataHub™ Scripting

Version 11.0

An implementation of the Gamma scripting language for use in Cogent DataHub™ software.

Table of Contents

Introduction

The Cogent DataHub program has a powerful, built-in scripting language called *Gamma*. Using the Gamma language, you can interact with the DataHub program and its data in various ways, such as:

- Run a script whenever a data point value changes.
- Build custom dashboards and summary displays,
- Create self contained DataHub applications.
- Create alarm condition scripts that display warning messages.
- Connect to ODBC compliant relational databases to extract data as well as create records from live data.
- Create server simulation programs to test production systems before you 'go live'.

What's Different About DataHub Scripting?

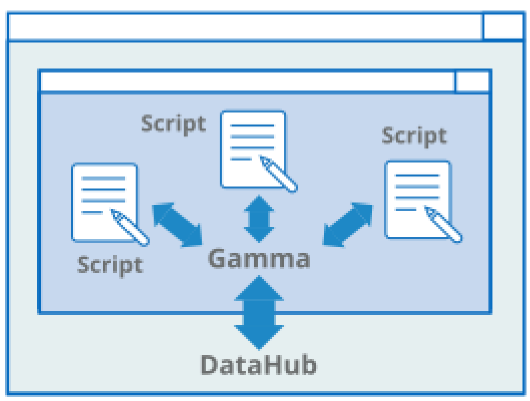
Scripts and their Environment

The DataHub scripting environment is different from most other programming paradigms because its primary purpose is to allow users to interact with the highly dynamic real-time process data that flows through a DataHub instance. Although syntactically similar to C, DataHub scripts offer unique capabilities, due in part to these features:

- Dynamic Environment
- Event Driven
- Object Oriented

Dynamic Environment

DataHub scripts run in a *dynamic environment*. The DataHub scripting engine, called Gamma, starts when a DataHub instance starts, and runs continuously until the DataHub instance shuts down. You can think of Gamma as a kind of processing power grid that's always switched on and running in the background. All of the data in the DataHub instance is available in this grid. DataHub users can tap into the power of the grid through scripts.



Scripts are like tools plugged into the grid. All of the live data in the DataHub instance is available to each script. A user script can be started manually or automatically, and typically runs until the DataHub instance shuts down. Scripts can range in complexity from the simple Hello World example in this manual to the entire Data Logging interface of the DataHub program itself.

In addition to scripting, you can access the Gamma engine interactively, from a command line in the Script Log.

Event Driven

DataHub scripts are *event-driven*, meaning that they respond to events as they occur. In our power grid analogy above, when you start a script, it's like switching on a tool that's plugged into the grid. The tool sits in standby mode, ready to respond when needed. It has a been programmed to respond in a particular way to certain events.

This behavior is difficult to achieve using a typical linear program that gets executed instruction by instruction. For example, a DataHub script has no mainline. Instead, a DataHub script contains two major elements:

1. **Event handlers** contain the code to be run when a DataHub point changes value.
2. **The `.OnChange` method** specifies the event (usually a data change) for which an event handler should be invoked. This change may be caused by an alarm condition or a timer firing or any other real-world event represented by a point in the DataHub instance. The `.OnChange` method binds a data change event in the DataHub instance to a specific event handler.

   Please refer to Partial Evaluation for an example.

When the script is run, the Gamma engine loads all the bound event handlers into memory, and waits. Whenever a bound point in the DataHub instance changes value, the Gamma engine executes the event handler code.

Object Oriented

DataHub user scripts are *object oriented*. Each user script creates a class derived from a base class called the `Application` class. This approach keeps the variables and methods of the script together in a tidy package, allowing them to be global in scope within the class, but separate from any other scripts running in the Gamma engine. To make the scripts easy to write, the New Script File dialog from the Scripting option of the DataHub Properties window creates an instance of the `Application` class automatically, complete with templates for methods. Based on this template, a typical script contains the following:

1. A Gamma `require` function to load the `Application` class.
2. A class definition for the script's class. By default this class gets the same name as the script.
3. Method definitions for event handlers and other functions.
4. A `constructor` method, containing one or more calls to the `.OnChange` method of the `Application` class (see explanation above). This is as close to a "mainline" as a DataHub script gets, but in reality there is no linear flow to the program once all the code has been read in.
5. A `destructor` method, specifying any code that needs to be cleaned up when the class is destroyed or the script shuts down.
6. Class instantiation. Once the class has been instantiated, it just sits there and responds to events.

Example

Here is what a new, unedited template for the class `MyApp` would look like:

```
/* All user scripts should derive from the base "Application"
   class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

//require ("WindowsSupport");
//require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */
class MyApp Application
{
}

/* Use methods to create functions outside the 'main line'. */
method MyApp.samplemethod ()
{
}

/* Write the 'main line' of the program here. */
method MyApp.constructor ()
{
}

/* Any code to be run when the program gets shut down. */
method MyApp.destructor ()
{
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
```

```
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (MyApp);
```

Symbols, Variables, and Evaluation

Complementing their dynamic environment and event-driven behavior, DataHub scripts have a slightly different approach to symbols and variables compared to other programming languages like C or Java.

Symbols and Variables

One of the fundamental units of the Gamma language, is a symbol. Symbols are made up of one or more alphanumeric characters, as well as "_". A symbol gets created whenever a unique group of characters appears in a script for the first time; from that point on the symbol is a unique object for the Gamma scripting engine. When first created, symbols are variables. The value of a variable can be assigned and reassigned at any point in the script. Variables that are not assigned a value have a default value of `_undefined_`.

Variable Scoping and Dynamic Typing

Similar to many programming languages, variables in the Gamma language can be local or global in scope. At the same time, to provide maximum flexibility, these variables are dynamically typed. Each time a variable is assigned a value, the Gamma engine assigns or reassigns the type for that variable, based on the new value. This facilitates rapid development and eliminates the need to type or even declare all variables before they are used. Of course, good programming principles must still be observed when writing scripts to ensure that the variables are of the correct type for the circumstances.

The Read/Evaluate Cycle

When a DataHub script is run, the Gamma engine first parses the script, reading and evaluating each statement in turn. For functions or methods, first each argument gets evaluated, and then each statement gets evaluated. Variables get evaluated to their value. Literals like numbers, strings, arrays, and so on get evaluated to themselves. This read/evaluation cycle iterates through the progam on a recursive basis until the entire code gets read and evaluated. When the process is complete, the Gamma engine executes the code.

Preventing Evaluation

Sometimes you might not want the Gamma engine to evaluate a statement or variable when it parses the code. For example, when attaching an event handler to the `.OnChange` method, you don't want the code of the event handler to run until the event actually occurs. To prevent evaluation of a statement or variable, you can use the # character, a Gamma quote operator. Putting the # quote operator in front of any Gamma expression turns it into a literal, causing it to be evaluated to itself, as if it were a number or a string.

Example 1

This example shows an interactive session with the Gamma engine in the Script Log. The `-->` symbols indicate where the user has input an expression, and the next line shows what the Gamma engine has returned as the result of evaluation.

1. First we assign a value of `5` to the variable `myvar`:

   ```
   --> myvar = 5;
   5
   ```

   The Gamma engine returns the value of `myvar`, which is `5`.

2. Then we pass the variable `myvar`, to the Gamma engine:

   ```
   --> myvar;
   5
   ```

   The Gamma engine evaluates it and returns the value, `5`.

3. Now we pass the variable `myvar`, to the Gamma engine, this time quoted using the # symbol.

   ```
   --> #myvar;
   myvar
   ```

   And now the Gamma engine evaluates `myvar` as its literal name, `myvar`, The expression itself has passed through the evaluator intact, without being evaluated.

Partial Evaluation

In some circumstances you might need the Gamma engine to evaluate part of your statement, but not all of it. For this, there are two more quote operators. The ` quote operator indicates that this stament should not be evaluated, *except* for those places marked by the @ quote operator.

Example 2

In this example, we use the the Gamma `list` function to illustrate how partial evaluation works. The `list` function creates a space-separated list out of its arguments

1. First, let's define our variables and demonstrate the `list` function.

   ```
   --> myvar = 5;
   5
   --> yourvar = 9;
   9
   --> list(myvar, yourvar);
   (5 9)
   ```

   The Gamma engine first evaluates the arguments of the `list` function to `5` and `9`, then applies the `list` function and puts them into a list: `(5 9)`.

2. Now let's use the # quote operator:

```
--> list(#myvar, #yourvar);
(myvar yourvar)
--> #list(myvar, yourvar);
(list myvar yourvar)
```

   First we quoted the individual arguments, then the entire expression. Do you see the difference in the result? The second return value, `(list myvar yourvar)` illustrates the internal syntax of the Gamma language, which is Lisp. Lisp functions are always of this syntax: (*function_name arg*$_1$ *arg*$_2$ ...).

3. Now, suppose we want to partially evaluate the expression. First, let's use the ` quote operator alone:

```
--> `list(myvar, yourvar);
(list myvar yourvar)
```

   This gives the same result as the # operator, above. Now let's use the ` operator with the @ to allow partial evaluation, like this:

```
--> `list(@myvar, @yourvar);
(list 5 9)
--> `list(myvar, @yourvar);
(list myvar 9)
```

   In the first line, we prevented the evaluation of the `list` function itself, but allowed the Gamma engine to evaluate both of its arguments. In the second line, we allowed the evaluation of only one argument.

4. Here are a few more examples, incorporating the Gamma `string` function, which turns an expression into a string:

```
--> string(list(myvar, yourvar));
"(5 9)"
--> string(#list(myvar, yourvar));
"(list myvar yourvar)"
--> string(`list(@myvar, @yourvar));
"(list 5 9)"
--> `string(list(@myvar, @yourvar));
(string (list 5 9))
--> `string(@(list(myvar, yourvar)));
(string (5 9))
```

   In each case, the ` quote operator prevents the evaluation of the overall expression, while the @ operator allows the evaluation of the sub-expression that immediately follows it.

5. How does this apply to events in a typical DataHub script? Here is an example, using the `.OnChange` method in a class named `Example` with a method called `MethodA`:

   This the most important example, because this syntax is commonly used with the .OnChange method for handling events.

```
class Example Application
{
...
}

method Example.MethodA (x, y)
{
...
}

method Example.constructor ()
{
     .OnChange (#V1, `(@self).MethodA (#V1, #V2));
}
```

In this example, we want to apply MethodA of our Example class to the values of variable V1 and V2 at the exact moment when V1 changes its value. To do this we protect V1 and V2 from evaluation, using the # quote operator. We also do not want to evaluate the MethodA method, but we do have to evaluate the key variable indicating the class (self). So we use the ` operator to prevent the evaluation of the method, and the @ operator to allow the key variable self to be evaluated. This way the Gamma engine knows which class the .MethodA belongs to.

Forcing Evaluation

In some cases you might need to force the Gamma engine to evaluate an expression. For this, you can use the Gamma eval function. For example:

```
--> myvar = 5;
5
--> #myvar;
myvar
--> eval(#myvar);
5
```

Access to DataHub Points

The main purpose of writing DataHub scripts is to interact with the live data represented by DataHub points. The Gamma scripting language, has a few special provisions for working with DataHub points. Understanding these will make your task much easier.

Point Names

First, a DataHub point name is not a legal symbol in the Gamma language. A DataHub point names uses a colon (:) to separate the point name from the domain name, and commonly use a dot (.) as well, like this: DataSim:Sine or MyDomain:Plant1.Tank3.Valve2. Colons and dots are not normally allowed in a

Gamma variable name, so we use the Gamma symbol character operator $ to turn the whole string of characters into a single, valid Gamma variable. For example, these expressions:

```
$DataSim:Sine
$MyDomain:Plant1.Tank3.Valve2
```

are valid Gamma variables.

The $ operator tells the Gamma engine that all characters except white space (space, tab, newline, carriage return, form feed) and the the set: `[]()",';` are accepted in the symbol name. To get any of the above characters in a symbol name, you need to precede that character by a backslash. So, for example, this DataHub point::

```
default:plant.water level[1]
```

would be written in a script like this:

```
$default:plant.water\ level\[1\]
```

In brief, you need to put a $ before any DataHub point name in a DataHub script, and use a backslash within the name before any white space or `[]()",';` character.

Point Values

Often when we use a DataHub point as a variable in a script, we don't want to evaluate it at the time that the code is being read. We want to simply quote it, and let it be evaluated when an event occurs. In these cases, we use the # quote operator when referring to a DataHub point, like this:

```
#$DataSim:Sine
```

Or, if the point name is within an expression that requires partial evaluation, the syntax would be like this:

```
@$DataSim:Sine
```

Please refer to the section called “The Read/Evaluate Cycle” for more details about evaluation, or to the section called “Accessing Data” for an example of this syntax in use.

Point Timestamps and Qualities

In addition to the value of a DataHub point, you might need to know its timestamp or quality at the moment of an event. This information can be accessed through two special Gamma scripts: `Time.g` and `Quality.g`. You can require these scripts by adding a require function at the beginning of your script, like this:

```
require ("Application");
...
require ("Time");
```

```
require ("Quality");
...
```

The `Time.g` script offers a number of time-related functions, while the `Quality.g` file has a single function that converts a numerical quality code into a human-readable text string. These scripts are both located in the `require` folder of your DataHub installation.

ODBC and Windows Scripting

DataHub ODBC (Open Database Connectivity) Scripting

DataHub ODBC support allows the DataHub program to interface with ODBC-compliant databases. Please refer to the DataHub ODBC Scripting manual for more information.

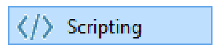
DataHub Windows Scripting

DataHub Windows scripting gives access to over 1700 of the most important classes used for programming in MS Windows, wrapped as Gamma classes. Please refer to the DataHub Windows Scripting manual for more information.

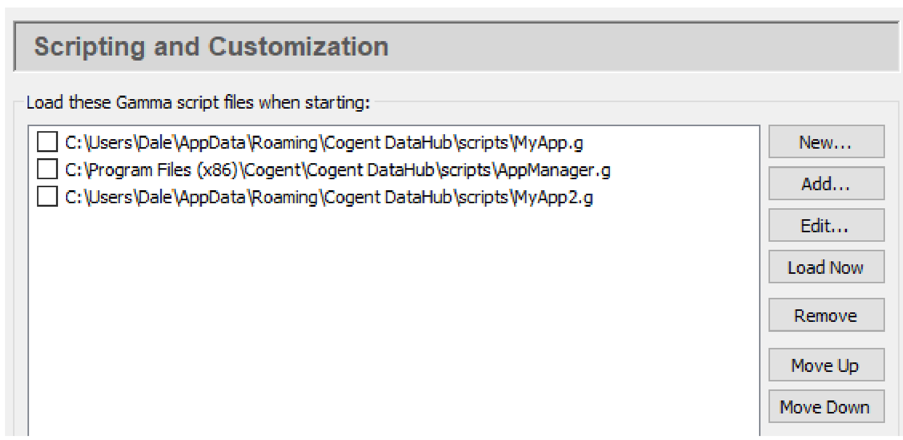
Getting Started

How to Run a Script

DataHub scripts run on the Gamma scripting engine, which starts up whenever a DataHub instance starts and runs continuously as long as the DataHub instance runs. You can access DataHub scripts and scripting capabilities by pressing the **Scripting** button in the **Properties** window.



This will display the **Scripting and Customization** screen. The upper half of the screen shows the Gamma files currently configured in the DataHub instance:



To run an existing script for the first time, you will need to first add it to the list of scripts. To create a new script, please refer to the section called “Creating a Script”

1. To add a script to the list, press the **Add** button and choose the script from the file selector. Scripts are kept in the DataHub `scripts` folder. Scripts that come with the DataHub program are installed here (32-bit or 64-bit):

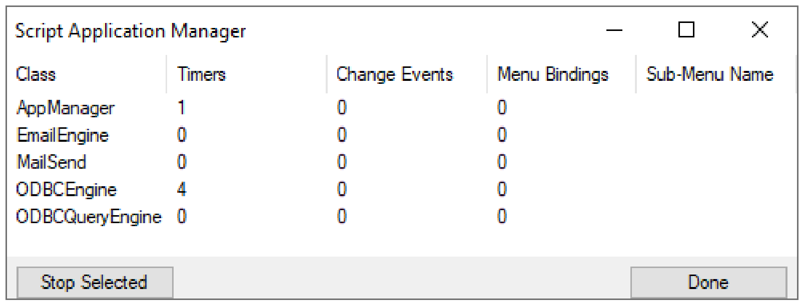
   ```
   C:\Program Files (x86)\Cogent\Cogent DataHub\scripts\
   C:\Program Files\Cogent\Cogent DataHub\scripts\
   ```

   All content in this directory will be replaced by the default content when the DataHub program is re-installed. If you plan to edit one of these scripts, or to write a new script, you should keep it in this folder for user-created scripts:

   ```
   C:\Users\Username\AppData\Roaming\Cogent DataHub\scripts
   ```

2. If you need to edit the script before running it, press the **Edit** button to open the selected script in the Script Editor.
3. To run the script manually, press the **Load Now** button.
4. To see any script output or error messages, you can press the **Script Log** button near the bottom of the Properties window to open the Script Log.

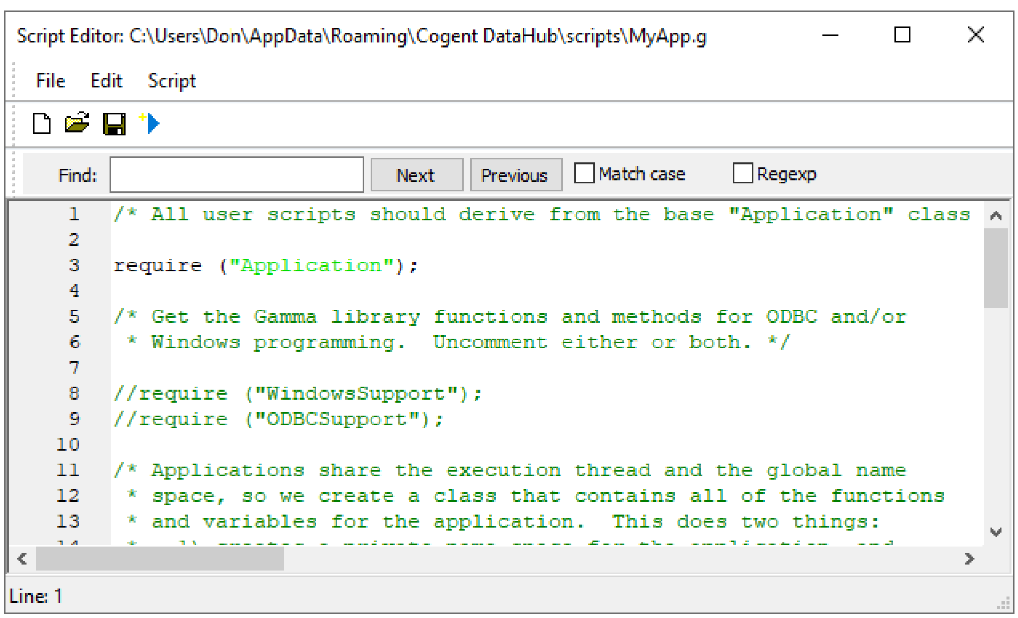
5. To configure a script to run automatically at startup, check the checkbox next to it ☑. The next time you start a DataHub instance, this script will load and run automatically.
6. Once a script is started, it will continue running until the DataHub instance shuts down. To stop the script without shutting down the DataHub instance, press the **Script Manager** button to open the Script Application Manager.



Highlight the script you want to stop, and press the **Stop Selected** button.

The Script Editor

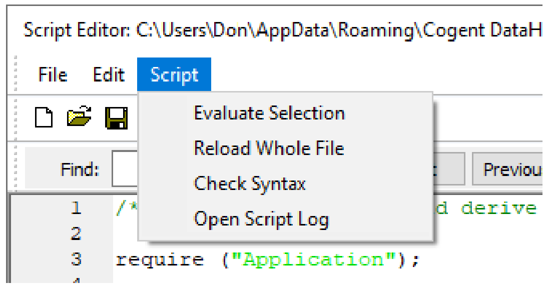
The DataHub program comes with a built-in Script Editor[1]. You can open the Script Editor from the **Scripting** option of the Properties window of a DataHub instance. Select a file name, press the **Edit** button, and the Script Editor will open:



The Script Editor offers basic script editing features such as context-sensitive highlighting, prompted fill-ins for functions and variable names, automatic indenting, text string

[1]This editor is based on the Scintilla and SciTE editor.

searches, and so on. In addition to the normal menu and toolbar options, it has a **Script** menu that provides the following options:



- **Evaluate Section** sends whatever block of text you have selected to the Gamma engine for immediate processing.
- **Reload Whole File** sends the entire file to the Gamma engine for immediate processing, without you having to save the file first. This functionality is also activated by pressing the blue arrow icon on the toolbar.
- **Check Syntax** checks the syntax of the whole file without running the script. Any errors will be displayed in the Script Log.
- **Open Script Log** opens the Script Log.

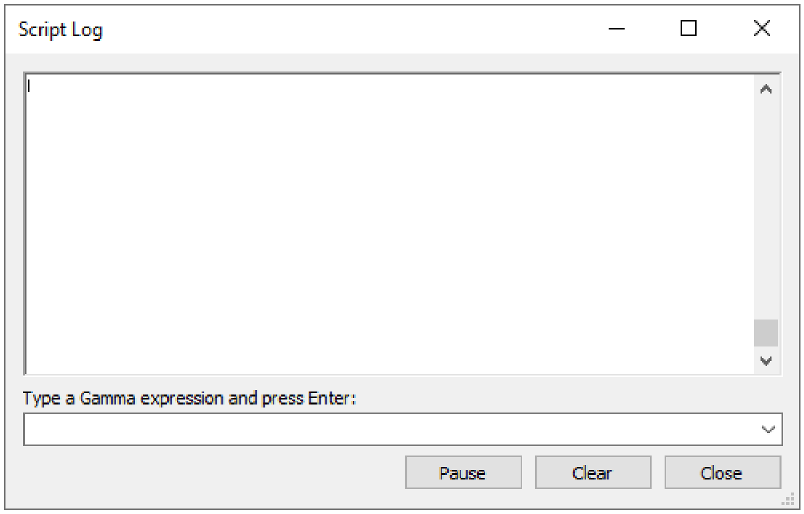
The Script Editor toolbar has a blue arrow icon  in addition to three standard icons for creating, opening, and saving files. Clicking the blue arrow saves the script as written and runs it.

The Script Log

The Script Log displays output from Gamma scripts, and can also be used to conduct interactive sessions, like a terminal. You can open this window in either of two ways:

- Click the **Script Log** button in the Properties window.

The Script Log should appear on your desktop:



You can use the text entry field at the bottom to send code to the Gamma engine. Try the following:

1. Type: **`a = 5;`** and press **Enter**

   You should see the following on the screen:

   ```
   --> a = 5;
   5
   ```

   You have just created a *symbol* (a) and assigned it a value (5). That symbol is a variable, and is now available to the Gamma engine until the DataHub instance shuts down. Notice that the Script Log inserts a prompt (`-->`) and shows your command to help you identify what you typed in.

2. Press the **Clear** button to clear the Script Log. Press the **Close** button to close the Script Log window, then reopen it.

3. Type: **`a;`** and press **Enter**

   You should see the following on the screen:

   ```
   --> a;
   5
   ```

   Sure enough, the value of a is still in the Gamma engine.

4. Type: **`princ("Hello world.\n");`** and view the results:

   ```
   --> princ("Hello world.\n");
   Hello world.
   t
   ```

   Why the `t`? It is the return value from the `princ` function, a logically true value. Every Gamma function returns a value. The string '`Hello world.`' is the byproduct or result of running the function, but the actual return value is `t`. For more details on Gamma programming, please refer to the Gamma manual.

5. Now, let's see a value in the DataHub instance. Start DataSim, then type: **`$DataSim:Sine;`** and press **Enter**. You should see something like this:

```
--> $DataSim:Sine;
-0.47552825816976968
```

This was the value of the `Sine` point in the `DataSim` domain of the DataHub instance at the moment you pressed the **Enter** key.

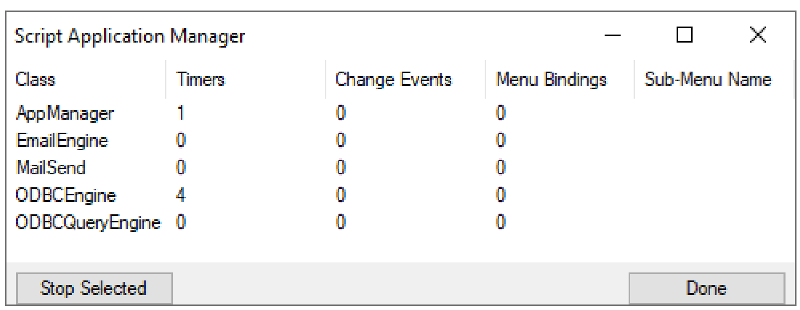
The colon character (`:`) is used to divide the domain name from the point name. The dollar sign character ($) tells the Gamma engine that the colon is part of the variable name, not a syntactic element.

6. You can re-enter up to the last 10 commands by pressing the down arrow on your keyboard. Try it now. Press the down arrow until you see the last command, **`$DataSim:Sine;`**, and press **Enter**. Try it several times. You will get different values because the DataSim program is running.

This gives you a taste of working with the Gamma engine, but to accomplish anything really useful and to save your work, you'll need a script. The following sections will explain how to access and edit scripts, and create your own.

The Script Application Manager

The Script Application Manager lets you view the scripts currently running in the DataHub instance, and stop selected scripts if desired. You can open the Script Application Manager by pressing the **Script Manager** button from the Scripting option of the DataHub Properties window.



To stop a script, highlight it, and press the **Stop Selected** button.

The columns display the following information:

- **Class**: the name of the instance of the Application class created in the script.
- **Timers**: the number of timers active in this script.
- **Change Events**: the number of change events active in this script.
- **Menu Bindings**: the number of menu entries that this script has placed in the system tray menu.
- **Sub-Menu Name**: the name of the submenu in the system tray menu into which this script has placed its menu entries.

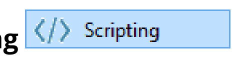
Writing Scripts

Writing a script for the DataHub program is not difficult, particularly when you follow a few basic principles. Working directly with DataHub points and the Gamma interpreter environment creates special opportunities, and you can take best advantage of them by using the suggestions offered here.

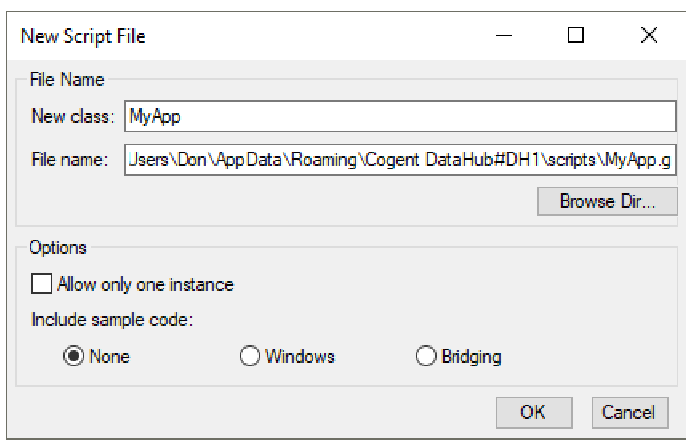
Most of the examples in this chapter use DataSim, which is installed with the DataHub program. You should ensure that it is connected and sending data to your DataHub instance before attempting these examples. For more information, please refer to DataSim in the Cogent DataHub manual.

Creating a Script

The best way to write a DataHub script is to create a single class in which your entire script runs. This keeps all variables and functions (methods) local to the class and isolated from any other script running in the Gamma engine. Rather than create the class from scratch, the DataHub program writes a template for you that contains what you need. Here's how it works:

1. Open the DataHub Properties window and select the **Scripting** 

option.
2. Click the **New** button. This dialog will appear:

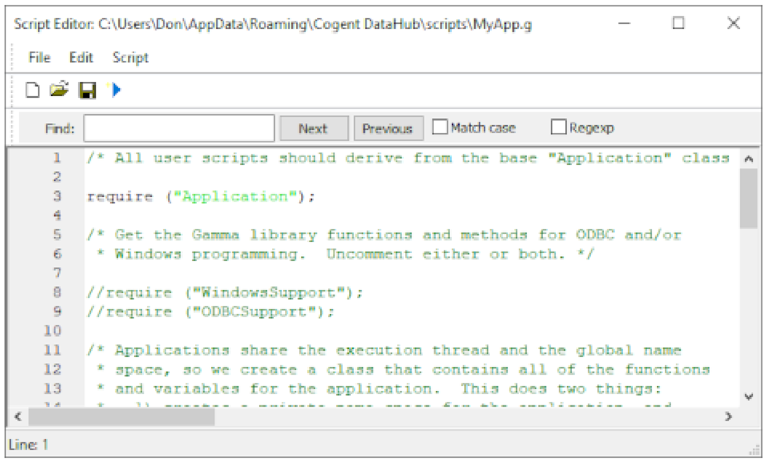


3. In the **New class:** field, enter a name of your choice. The default is `MyApp`.
4. Look at the **File name:** field to make sure this is where you want the script to be created. If not, you can browse your file system for a better location.
5. Checking the **Allow only one instance** box will ensure that each instance of the class gets destroyed whenever a new instance is created. Thus you will only ever have one instance. If you want your code to create multiple simultaneous instances of the class, don't check this box.
6. The **Include sample code** option lets you choose one of the following:

- **None** will generate no sample code.
- **Windows** will generate code to help you create windows.
- **Data Manipulation** will generate code for doing linear transformations and other data manipulation.

These options will be illustrated and discussed in upcoming sections.

7. Click the **OK** button to create the file.



The Script Editor should open, displaying a script template ready for editing. The basic template looks like this:

```
/* All user scripts should derive from the base "Application"
   class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

//require ("WindowsSupport");
//require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */
class MyApp Application
```

```
{
}

/* Use methods to create functions outside the 'main line'. */
method MyApp.samplemethod ()
{
}

/* Write the 'main line' of the program here. */
method MyApp.constructor ()
{
}

/* Any code to be run when the program gets shut down. */
method MyApp.destructor ()
{
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (MyApp);
```

The following sections explain how to edit this template and run the finished script.

Hello World

This simple example demonstrates how to edit a new script by editing the `.constructor` method.

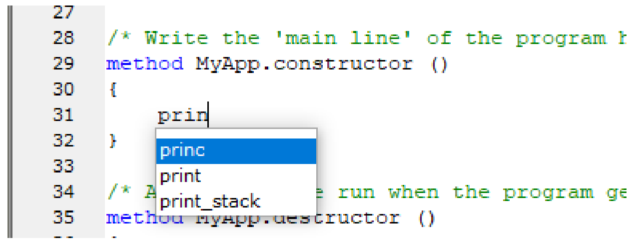
Edit the Constructor

1. Create a new script whose main class is called '`HelloWorld`'. Here's how.
2. The body of a typical script is written as part of the `.constructor` method. Find the following lines to start editing:

   ```
   /* Write the 'main line' of the program here. */
   method HelloWorld.constructor ()
   {
   }
   ```
3. In between the brackets of the `.constructor` method, enter the following:

```
pri
```

Notice that a drop-down box appears:



This box will appear any time you begin to write a function or variable name that is already available in the Gamma engine.

4. Continue writing:

```
princ(
```

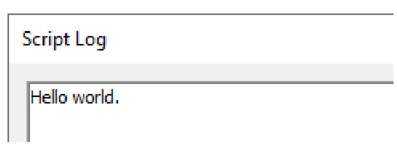
The box now shows you the `princ` function syntax, in this case a symbolic expression (s_exp), commonly know as a symbol. Please refer to the Gamma manual for more information about function syntax and arguments.

5. Continue editing the `princ` function until your `.constructor` function looks like this:

```
/* Write the 'main line' of the program here. */
method HelloWorld.constructor ()
{
    princ("Hello world.\n");
}
```

Run the Script

Click the blue arrow icon in the Script Editor toolbar to run the script, and then check the results in the Script Log window:



If you don't get a '`Hello world`' string in the Script Log, see Appendix A, *Basic Troubleshooting*.

Evaluate a Selection

Here's a way to evaluate just a part of your code:

1. In the Script Editor, use the cursor to select just the text:

```
princ("Hello world.\n");
```

2. From the **Script** menu, select **Evaluate Selection**.

You should see the string 'Hello world.' appear in the Script Log.

This feature of the Script Editor lets you run any part of a script without running the whole thing.

Accessing Data

A DataHub script has complete access to all the data in the DataHub instance. Every point in the DataHub instance is available in the Gamma engine as a global variable, with the syntax:

```
$domain_name:point_name
```

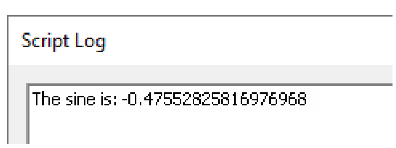
The dollar sign character ($) tells the Gamma engine that the colon is part of the variable name. A colon in the Gamma language is normally a syntactic element and can't be used in a variable name. However, the DataHub program uses a colon (`:`) in point names to separate the domain name from the rest of the point name. So we need to use the dollar sign. The dollar sign is not part of the variable name.

For these examples, ensure that the DataSim program is running and connected to the DataHub instance.

Access a Value Once

To start with, here's how to read a value one time.

1. Create a new script with a class named `AccessData`, selecting **Allow only one instance**. Here's how.
2. Scroll down to the `.constructor` method, and enter the following:
```
method AccessData.constructor ()
{
    princ("The sine is: ", $DataSim:Sine, "\n");
}
```
3. Make sure the DataSim program is running, and that the Script Log is open so you'll be able to see the script output.
4. Click the blue arrow icon in the Script Editor toolbar. You should see a value appear in the Script Log window, like this:



5. Click the blue arrow icon several more times. Each time, a new value should appear in the Script Log. The values will differ because the value for the sine wave in DataSim is constantly changing.

Access Values Continuously

Getting a single value from the DataHub instance is fine, but we can do much better. Let's print each new value from a point every time it changes.

1. First you should move the `princ` statement out of the `.constructor`. This may seem trivial in this example, but it is a good habit to get into. Move the `princ` statement to the `AccessData`.sample method, and edit the method name and `princ` statement to look like this:

   ```
   method AccessData.print_point (pt)
   {
       princ("The sine is: ", pt, "\n");
   }
   ```

2. Edit the `.constructor` method like this:

   ```
   method AccessData.constructor ()
   {
       .OnChange(#$DataSim:Sine,
                 `(@self).print_point($DataSim:Sine));
   }
   ```

   The `OnChange` method is inherited from the parent class, `Application`. This method is a wrapper for the on_change function, which tells the Gamma engine to evaluate an expression when a given symbol changes value. In this case, the symbol is `$DataSim:Sine` and the expression is our `print_point` function. The first expression is protected from evaluation by the # quote operator.

   The second expression is also quoted so that it doesn't run until the point actually changes. However, the `self` that is usually understood must be explicitly written and evaluated so that the Gamma engine knows what the `.print_point` method applies to. Therefore, we use the ` and @ quote operators.

3. Click the blue arrow icon in the Script Editor toolbar.

   A new value gets written twice a second. To see it really fly, bring up the DataSim window, click the **More** button, and change the **Update Frequency** to 200 (don't forget to click **Apply Changes**). To make it stop, click DataSim's **Pause** button.

   But what if you can't stop the data flow? How do you get the `princ` function to stop?

Stop Accessing Values

Often you will want a script's change functions to stop when the class instance is destroyed. Conveniently, the Application class has a destructor that runs any time a child class gets destroyed, and which removes all `OnChange` functions. One way to destroy the instance of class is with a timer.

The timer is used here for demonstration purposes. Most Windows programs get destroyed by clicking a button or some other means.

1. Go to `.constructor` method and adding the following code:

```
after(3, `destroy(@self));
```

This uses the Gamma `after` timer function, which in this case will activate 3 seconds after the instance is constructed and cause the instance to destroy itself. Again, to prevent the `destroy` function from being evaluated and destroying our instance prematurely, we have to quote it. And again, we use the ` and @ quote operators to evaluate the `self` argument. After 3 seconds, the `destroy` function will be evaluated, and the instance gets destroyed.

2. Your two methods should now look like this:

```
method AccessData.print_point (pt)
{
    princ("The sine is: ", pt, "\n");
}

method AccessData.constructor ()
{
    .OnChange(#$DataSim:Sine,
              `(@self).print_point($DataSim:Sine));
    after(3, `destroy(@self));
}
```

3. Run the script. You should see output in the Script Log for 3 seconds, then nothing.

Verify Results

1. To verify that the instance of the class has been destroyed, type **`instance_p(_AccessData_Singleton)`** in the text entry field at the bottom of the Script Log and press **Enter**. The output should look like this:

```
--> instance_p(_AccessData_Singleton);
nil
```

The `instance_p` function is a Gamma predicate that checks to see if `accessdata` is an instance. The Gamma engine returns `nil`, indicating that it is not an instance.

2. Since `accessdata` was an instance and is no more, it is probably a destroyed instance. To check, type **`destroyed_p(_AccessData_Singleton);`** and press **Enter**. The output should look like this:

```
--> destroyed_p(_AccessData_Singleton);
t
```

The Gamma engine returns `t`, indicating that it is a destroyed instance.

Modifying Data

DataHub scripting lets you modify data as it passes through a DataHub instance. This example script makes a linear transformation, writes the results to a different DataHub point, and incidentally prints the value of point and the conversion.

1. Create a new script whose main class is called '`ModifyData`'. Here's how.
2. Change the name of `.samplemethod` to `.convert` and edit it like this:

```
method ModifyData.convert (pt1, !pt2, multiplier, adder)
{
    local output;
    set(pt2, ((pt1 * multiplier) + adder));
    princ(format("The sine is: %2.3f    Converted it is: %2.3f\n",
                 pt1, eval(pt2)));
}
```

This method does the conversion and prints the output. Notice that the `pt2` argument has an exclamation point (`!`) in front of it. This protects the argument from being evaluated, because we only want the point name, not its value. Please refer to Function Arguments in the Gamma manual for more information.

We need to assign a value to the point, but keep the variable name associated with the DataHub point, not the value. This requires the `set` function, because using the equals sign would just assign the value to the variable, and it would never reach DataHub point.

3. Edit the `.constructor` method to look like this:

```
method ModifyData.constructor ()
{
    multiplier = 3;
    adder = 5;

    if (undefined_p($default:ConvertedSine))
        datahub_command ("(cset default:ConvertedSine \"\")", 1);

    .OnChange(#$DataSim:Sine,
              `(@self).convert($DataSim:Sine,
                               $default:ConvertedSine,
                               multiplier, adder));

    after(3, `destroy(@self));
}
```

We don't make the `multiplier` and `adder` variables local because they'll be used by the `Application class's .destructor` method. We use the `datahub_command` function call the `cset` function to have the DataHub instance create the `ConvertedSine` point and set its value to an empty string. We then use the inherited `.OnChange` method to set up the `.convert` method.

4. The script is ready to run. Open the Data Browser window right-clicking the DataHub icon in the System Tray and selecting **View Data** from the pop-up menu. Select the **default** domain. Also make sure the DataSim program is running and the Script Log is open.

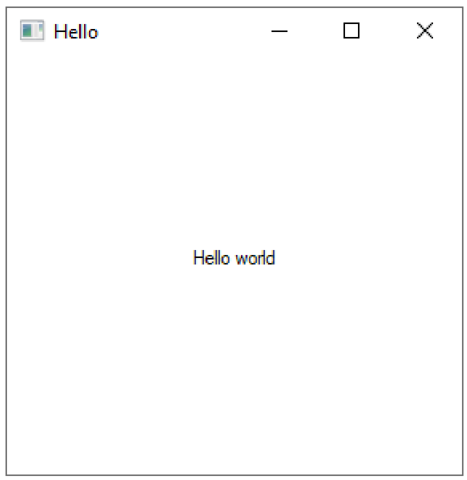
5. Run the script. It should run for 3 seconds, writing data to the Script Log, and changing the values to the point `ConvertedSine` in the default domain.

   Of course, the data printed in the Script Log is just for convenience. You could comment out the `princ` statement, or remove it altogether. The main thing is the data updating in the Data Browser.

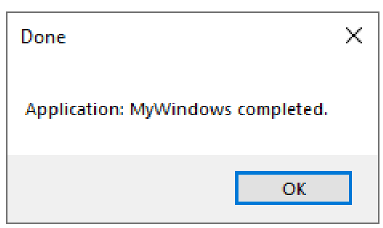
Making a Window

DataHub scripting offers many of the Windows classes wrapped as Gamma classes. Thus you can create windows, buttons, entry forms, tabs, dialogs, and so on. The DataHub Windows Scripting manual contains more information. This is how you create a basic window.

1. Open the Properties window, select the **Scripting** option, and click the **New** button to create a new script.
2. In the New Script File dialog, name the main class '`MyWindows`' and select the **Windows** option. More details.
3. Add the file to your list of files, and load it now. Here's how. A new window will open:



4. Click the close icon in the top right corner. The window will close, and you will see this dialog box:



This is an example of a basic window. Here are the main parts of your `MyWindows.g` script:

```
class MyWindows Application
{
    window;
}
```

The window itself is an instance variable of the `MyWindows` class.

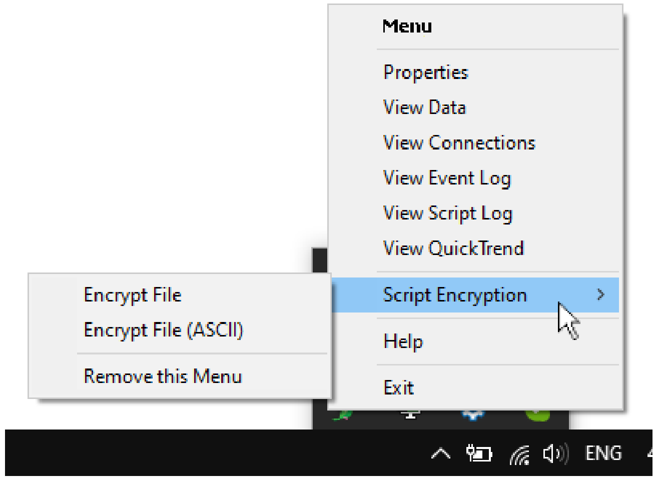
```
method MyWindows.constructor ()
{
    local    rect = CreateRect (0, 0, 300, 300), txt;
    .window = new GWindow();

    .window.Create (0, rect, "Hello", WS_OVERLAPPEDWINDOW, 0);
    .window.CenterWindow();
    txt = .window.CreateControl (GStatic, 0, 0, 280, 22,
                                 "Hello world", SS_CENTER);
    txt.CenterWindow();
    .window.MessageHandler (WM_DESTROY, `destroy(@self));
    .window.ShowWindow (SW_SHOW);
}

method MyWindows.destructor ()
{
    // The WM_DESTROY message could come before or after this
    // destructor depending on whether the application instance
    // is destroyed or the window is closed first.  We protect
    // against the case where the window is closed first.
    if (instance_p(.window) && .window.GetHwnd() != 0)
        .window.PostMessage (WM_CLOSE, 0, 0);
    MessageBox(0, string ("Application: ", class_name(self),
                          " completed."), "Done", 0);
}
```

More information about Windows scripting and the Windows classes and methods can be found in the DataHub Windows Scripting manual.

Encrypting a Script

The DataHub installation archive contains a script called `EncryptScript.g` that makes an encrypted copy of any Gamma script. You can encrypt your scripts as follows:

1. Run the `EncryptScript.g` script. Here's how.
2. Right-click on the DataHub icon in the system tray to open the DataHub menu. You should see a new menu entry: **Script Encryption**.



There are two options for encrypting a file. The **Encrypt File** option uses 8-bit characters, which produces a smaller, faster loading file than an ASCII file, but it may not transfer properly through some mail or FTP servers. If that is an issue, you can use **Encrypt File (ASCII)**.

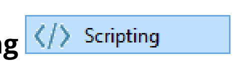
3. Choose either **Encrypt File** or **Encrypt File (ASCII)**. This will open a file selection dialog.
4. Select the Gamma (`.g`) file that you want to encrypt. If the encryption succeeds, you will get a success message. The encrypted script will have the same name as the original script, except with a `.gmc` extension.
5. You can add the encrypted script to your list of scripts now, and run it. Here's how. The encrypted script should behave exactly the same as the `.g` file, but will be difficult for a user to examine.

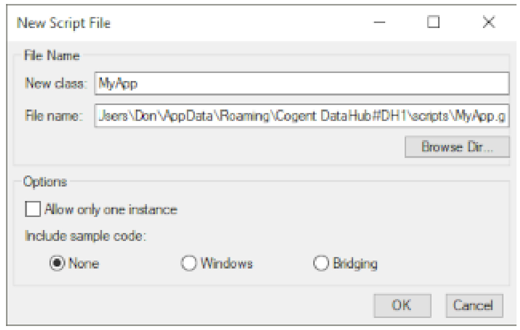
Scripting Tips

Here are some ways to facilitate scripting.

Copying a complete tutorial

The code from DataHub tutorials can be copied directly from the text into the Script Editor. Here's how to make a new script from a complete tutorial.

1. Open the DataHub Properties window and select the **Scripting**  option.
2. Click the **New** button. This dialog will appear:



3. In the **New class:** field, enter a name of your choice.
4. Click the **OK** button to create the file. The Script Editor will open, displaying a script template.
5. Using the cursor or **Ctrl-A**, select all the text and delete it.
6. Copy a complete tutorial from the DataHub Windows Help manual or online documentation into the Script Editor.
7. Save and run the script using the blue arrow icon .

Setting up a scripting environment

If you are working on one script regularly and need to restart the DataHub instance often, here's a way to automatically open the Properties window, the Script Log and the Script Editor with your file loaded.

1. Open the Properties window and Script Log.
2. Position them on the screen, then close them. They will come up in the same place the next time you open them. (The Script Editor does not yet have this feature.)
3. Write a script of these three lines:

```
    datahub_command ("(show_properties 1)");
    datahub_command ("(show_script_log 1)");
    edit_file ("c:\\projects\\myfile.g");
```

   Two slash marks (\\) are necessary—the first slash mark escapes the second one.
4. Add this script to the list of scripts in the DataHub instance, and check the activation box beside it. Then next time you start DataHub instance, the properties and script log windows will come up where they were before, and an editor will be opened on the file `c:\projects\myfile.g`.
5. When you don't want the script to auto-load, just un-check the activation box.

The Require folder

The DataHub installation includes a number of Gamma scripts containing classes, methods, and functions for specific scripting needs. These scripts are accessed using require or include statements. They can all be found in the require folder, located here (32-bit or 64-bit):

```
C:\Program Files (x86)\Cogent\Cogent DataHub\require\
C:\Program Files\Cogent\Cogent DataHub\require\
```

A detailed description of each function and method is outside the scope of this documentation, but you may find it helpful to view the code of these scripts to find out what functions and methods they provide, and to get some understanding of what they do.

We do not recommend editing any of these scripts, because other DataHub scripts may use them, which cam lead to unexpected results. Furthermore, all content in this folder gets replaced by the default content whenever the DataHub program is re-installed, so any edits will be lost.

The Application class

The Application class is the parent class for all the applications you create with the **New** button in the **Scripting** option of the Properties window. It provides an environment that makes it easy for you to program for changes and events. It also allows you to set up timers, and to add menus for your scripts to the DataHub pop-up system tray menu. This chapter contains an overview of the Application.g file, where the Application class and its methods are defined.

Class Definition

This code defines the base Application class:

```
/* A base application class that keeps track of change functions
   and removes them when the object is destroyed */

if (undefined_p(Application) || !class_p(Application))
{
    class Application
    {
        _ChangeFunctions;
        _TimerIDs;
        _MenuActions;
        _SubMenus;
    static:
        _Instances;
        _MenuItemID = 20000;
        _MenuItems;
        _TraySubmenu;
        _AllMenuActions;
        _TrayMenuPosition = 6;
    }
}
```

Before defining the class, we test to see if it already exists, using the Gamma predicates undefined_p and class_p functions in an if statement. We want only a single instance of the class so that there is only one copy of the _Instances static variable in the system. This _Instances variable tracks the currently loaded applications, and we do not want several different copies of it floating about.

The instance variable _ChangeFunctions is a list of all the change functions that are defined by the class's .OnChange method. The _TimerIDs, _MenuActions, and _Submenus instance variables are similar lists for any timer IDs, menu actions, and custom submenus that may be defined for the class.

Construction and Destruction

The constructor and destructor methods help with general class housekeeping.

```
method Application.constructor ()
{
    ._Instances = cons (self, ._Instances);
}
```

The constructor adds each instance of the class to the list of all the class instances currently defined in the Gamma engine. The Gamma cons function is used to build the list.

```
method Application.destructor ()
{
    local   id;

    ._Instances = remove (self, ._Instances);
    .RemoveAllEventHandlers ();
    .RemoveAllMenus ();

    if (!._AllMenuActions)
    {
        .RemoveSystemMenu();
    }
}
```

When an instance of the class gets destroyed, this destructor method will be run first. It removes this instance of the class from the _Instances list using the Gamma remove function. Then it removes all event handlers and menus, using the RemoveAllEventHandlers, RemoveAllMenus, and RemoveSystemMenu, as applicable.

Handling Events

Event handlers are bound to events using the OnChange method.

```
method Application.OnChange (sym, fn)
{
    local    chfn = cons (sym, fn);
    ._ChangeFunctions = cons (chfn, ._ChangeFunctions);
    on_change (sym, fn);
    chfn;
}
```

The OnChange method is a wrapper for the on_change function that does the actual binding of the event handler. First the OnChange method creates a two-member list (chfn) consisting of a symbol (sym) and the function that should run (fn) when the symbol changes value. That short list is added to the class's _ChangeFunctions list. All lists are constructed using the Gamma cons function. Finally, the on_change function links the symbol to the event-handling function. What gets returned, chfn, is a two member list—exactly what the unwrapped on_change function would have returned.

One way to remove an event handler is with the RemoveChange method.

```
method Application.RemoveChange (chfn)
{
    ._ChangeFunctions = remove (chfn, ._ChangeFunctions);
    remove_change (car(chfn), cdr(chfn));
}
```

This is a wrapper on remove_change, to be used when you need to remove just a single function from _ChangeFunctions rather than all of them. See also RemoveAllChanges and RemoveAllEventHandlers.

Timers

There are three different methods for attaching a timer to an event-handling method or function: TimerAt, TimerAfter, and TimerEvery. They use the Gamma functions at, after, and every respectively. For example:

```
method Application.TimerEvery (seconds, fn)
{
    local    tid = every (seconds, fn);
    ._TimerIDs = cons (tid, ._TimerIDs);
    tid;
}
```

This is a wrapper on the Gamma every function. It creates a timer ID and adds it to the class's list of timer IDs (_TimerIDs). This way the timer can be identified and removed when necessary.

```
method Application.RemoveTimer(tid)
{
    if (find_equal (tid, ._TimerIDs))
    {
        cancel (tid);
        .droptimer (tid);
    }
}
```

This method uses the Gamma find_equal function to locate a timer according to its ID number (tid), and then uses the Gamma cancel function to cancel it.

Timers created using TimerAt, TimerAfter, and TimerEvery are automatically cancelled when the Application instance is destroyed.

Menus

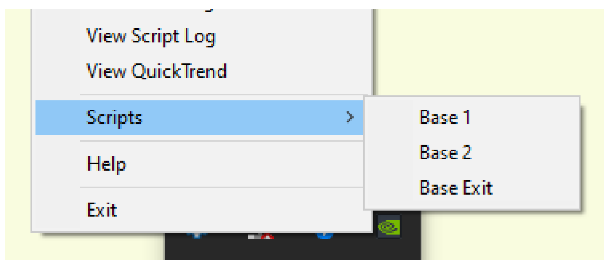
There are a number of methods in the `Application` class that you can use to create submenus and menu items on the DataHub pop-up system tray menu. Rather than examining the code, let us look at what kinds of menus can be generated. Each of the menus below has two regular items that simply print their name in the Script Log, as well as an "`Exit`" item that shuts down the script. A complete, working script containing all of these examples is given below. All of the methods used here are documented in *Methods and Functions from `Application.g`*.

Putting Menu Items in the Scripts Submenu

The methods used here cause a **Scripts** submenu to be created on the main DataHub pop-up menu, and attach items directly to that submenu. This code:

```
.AddCustomMenuItem("Base 1", `princ("Base 1\n"));
.AddCustomMenuItem("Base 2", `princ("Base 2\n"));
.AddStopMenuItem("Base Exit");
```

Would add these menu items.

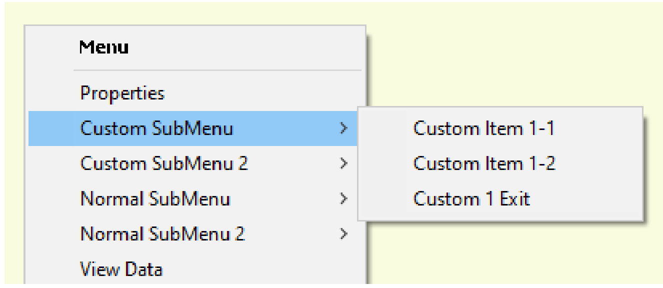


Creating a Submenu using Convenience Methods

The methods used here are convenience methods that wrap the standard methods used below. They create a submenu on the main DataHub menu, attaching menu items to the immediately preceding parent, in the order written in the code. This code:

```
    .AddCustomSubMenu("Custom SubMenu", 3);
    .AddCustomMenuItem("Custom Item 1-1",
                       `princ("Custom Item 1-1\n"));
    .AddCustomMenuItem("Custom Item 1-2",
                       `princ("Custom Item 1-2\n"));
    .AddStopMenuItem("Custom 1 Exit");
```

Would put up this submenu.

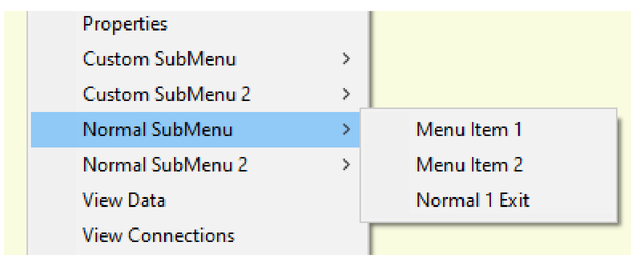


Creating Submenus on the Main Menu

The methods used here are the standard methods used to create submenus on the main DataHub menu. Each menu item is identified by its parent, so menu items can be added in any order. This code:

```
    local    mymenu, mymenu2;
    mymenu = .AddSubMenu(get_tray_menu(), 3, "Normal SubMenu");
    mymenu2 = .AddSubMenu(get_tray_menu(), 4, "Normal SubMenu 2");
    .AddMenuItem(mymenu, -1, "Menu Item 1",
                 `princ("Menu Item 1-1\n"));
    .AddMenuItem(mymenu2, -1, "Menu Item 1",
                 `princ("Menu Item 2-1\n"));
    .AddMenuItem(mymenu, -1, "Menu Item 2",
                 `princ("Menu Item 1-2\n"));
    .AddMenuItem(mymenu2, -1, "Menu Item 2",
                 `princ("Menu Item 2-2\n"));
    .AddMenuItem (mymenu, -1, "Normal 1 Exit", `destroy (@self));
    .AddMenuItem (mymenu2, -1, "Normal 2 Exit", `destroy (@self));
```

Would put up two submenus, the first of which is open here.



The menutest.g script

This script contains all of the above examples.

```
/* All user scripts should derive from the base "Application" class */

require ("Application");
```

```
/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

//require ("WindowsSupport");
//require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */
class menutest Application
{
}

/* Use methods to create functions outside the 'main line'. */

/* Create submenus and add items to them, using the AddCustom*
   convenience methods. Note that the items are added in sequential
   order for each menu. */
method menutest.custom()
{
    .AddCustomSubMenu("Custom SubMenu", 3);
    .AddCustomMenuItem("Custom Item 1-1",
         `princ("Custom Item 1-1\n"));
    .AddCustomMenuItem("Custom Item 1-2",
         `princ("Custom Item 1-2\n"));
    .AddStopMenuItem("Custom 1 Exit");

    .AddCustomSubMenu("Custom SubMenu 2", 4);
    .AddCustomMenuItem("Custom Item 2-1",
         `princ("Custom Item 2-1\n"));
    .AddCustomMenuItem("Custom Item 2-2",
         `princ("Custom Item 2-2\n"));
    .AddStopMenuItem("Custom 2 Exit");
}

/* Create regular submenus and add items to them, using the Add*
   methods. Note that the items can be added in any order. */
method menutest.direct()
{
    local    mymenu, mymenu2;
    mymenu = .AddSubMenu(get_tray_menu(), 3, "Normal SubMenu");
```

```
    mymenu2 = .AddSubMenu(get_tray_menu(), 4, "Normal SubMenu 2");
    .AddMenuItem(mymenu, -1, "Menu Item 1",
   `princ("Menu Item 1-1\n"));
    .AddMenuItem(mymenu2, -1, "Menu Item 1",
   `princ("Menu Item 2-1\n"));
    .AddMenuItem(mymenu, -1, "Menu Item 2",
   `princ("Menu Item 1-2\n"));
    .AddMenuItem(mymenu2, -1, "Menu Item 2",
   `princ("Menu Item 2-2\n"));
    .AddMenuItem (mymenu, -1, "Normal 1 Exit",
    `destroy (@self));
    .AddMenuItem (mymenu2, -1, "Normal 2 Exit",
    `destroy (@self));
}

/* Write the 'main line' of the program here. */
method menutest.constructor ()
{
    /* Add menu items to a "Scripts" submenu that gets created
       automatically. */
    .AddCustomMenuItem("Base 1", `princ("Base 1\n"));
    .AddCustomMenuItem("Base 2", `princ("Base 2\n"));
    .AddStopMenuItem("Base Exit");

    /* Create the normal menus. */
    .direct();

    /* Create the custom menus. */
    .custom();
}

/* Any code to be run when the program gets shut down. */
method menutest.destructor ()
{
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (menutest);
```

Example Scripts

AutoCalculation.g

AutoCalculation.g — automatically calculates formulas based on data points.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * Automatically calculate formulas based on data points.  Create data
 * points where necessary to store the results back to the DataHub
 * data set.
 *
 * To use:
 *  - create a file, like c:/tmp/calculations.txt
 *  - in the file, create any number of calculations of the form
 *      $default:test = $DataPid:PID1.Mv * 10;
 *      $default:test2 = $DataPid:PID1.Mv / 10;
 *  - change the fileName member in the AutoCalculation class below
 *    to refer to your file
 *  - run the script
 *
 * Any symbol in the calculation of the form $domain:name is assumed
 * to be a DataHub point, and will be created if necessary.  The point
 * on the left hand side of the equal sign will be automatically
 * updated whenever any point on the right hand side of the equal sign
 * changes.
 *
 * You can include complex Gamma expressions, like:
 *   $default:output = progn {
 *      local a = $DataPid:PID1.Mv;
 *      local b = $DataPid:PID1.Pv;
 *      if (b != 0)
 *              a / b;
 *      else
 *              a;
 *      };
 *
 * You can define functions within this file, though it is better to
 * put functions into a separate script file:
```

```
 *
 *      function average(a,b)
 *      {
 *          a + b / 2;
 *      }
 *
 *      $default:output = average($DataPid:PID1.Mv, $DataPid:PID1.Pv);
 */

require ("Application");

class AutoCalculation Application
{
    fileName = "C:/tmp/calculations.txt";
    fp;
}

class Computation
{
    app;        // the Application instance defining this computation
    output;     // a symbol
    inputs;     // a list of symbols
    code;       // the code to execute
}

method Computation.constructor(app, expression)
{

    .app = app;
    .code = expression;
    .output = .findOutput(expression);
    .inputs = .findInputs(expression);

    if (.output)
    {
        datahub_command(format("(create %s 1)", stringc(.output)), 1);
        with input in .inputs do
        {
          datahub_command(format("(create %s 1)", stringc(input)), 1);

          .app.OnChange(input, `(@self).compute());
        }
    }
    .compute();
}
```

```
method Computation.compute()
{
    try
    {
        eval(.code);
    }
    catch
    {
        princ ("Assignment to ", .output, " failed: ",
        _last_error_, "\n");
    }
}

method Computation.findOutput (expr)
{
    if (car(expr) == #setq)
        cadr(expr);
    else
        nil;
}

method Computation.findInputsRecursive (expr)
{
    local   inputs, partial;
    if (list_p(expr))
    {
        with part in expr do
        {
            partial = .findInputsRecursive(part);
            inputs = nappend(inputs, partial);
        }
    }
    else if (symbol_p(expr) && strchr(string(expr), ":") != -1)
    {
        inputs = cons(expr, inputs);
    }
    inputs;
}

method Computation.findInputs (expr)
{
    .findInputsRecursive(cddr(expr));
}

method AutoCalculation.readFile()
{
```

```
    if ((.fp = open(.fileName, "r", t)) != nil)
    {
        //create some local variables
        local line;

        //loop until we have read the entire file.
        while((line = read(.fp)) != _eof_)
        {
            local comp = new Computation(self, line);
        }

        //once we have read the entire file we need to close it.
        close(.fp);
    }
    else
    {
        princ ("AutoCalculation: Could not open file: ",
        .fileName, ": ", strerror(errno()), "\n");
    }
}

/* Write the 'main line' of the program here. */
method AutoCalculation.constructor ()
{
    .readFile();
}

/* Any code to be run when the program gets shut down. */
method AutoCalculation.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (AutoCalculation);
```

SimpleAverage.g

SimpleAverage.g — computes average point values over a period of time.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * Compute simple averages for points over a selected time period.
 * Write the average to a new data point continuously or
 * periodically as the input changes, resetting the average at
 * the end of the period.
 */

require ("Application");
require ("ModelSupport");

class SimpleAverage Application
{
    // One of "day", "hour", "minute", "10sec"
    period = "10sec";

    // A pattern containing %s where the point name is inserted to
    // create the average point name
    outputPattern = "%sAvg";

    // Select running average (constant updating) or write at the
    // end of period.  Use t for running average, or nil for update
    // at the end of the period.
    isRunningAverage = t;

    // Do not edit this
    accumulators = new Dictionary();
    model = new ModelEmitter();
}

/*
 * This is the start-up method.  Add code here to monitor other data
 * points by calling .monitor for each point, or by iterating through
 * all points to monitor those that you want.
```

```
 */
method SimpleAverage.constructor ()
{
    .monitor("DataPid:PID1.Mv");

    // After setting up the monitored points, emit the model to place
    // the points into the point heirarchy, then start the timer to
    // reset the average periodically.
    .model.Emit();
    .startResetTimer();
}

/* -------------- Implementation starts here ----------------- */

class Accumulator
{
    point;
    sum = 0;
    count = 0;
}

method Accumulator.getAverage()
{
    .count > 0 ? .sum / .count : 0;
}

method Accumulator.reset()
{
    .sum = .count = 0;
}

method SimpleAverage.update (pointSym, value)
{
    local accumulator = .accumulators[pointSym];
    if (!accumulator)
    {
        accumulator = new Accumulator();
        accumulator.point = pointSym;
        .accumulators[pointSym] = accumulator;
    }
    accumulator.count++;
    accumulator.sum += number(value);

    if (.isRunningAverage)
        .writeAverage(accumulator);
}
```

```
method SimpleAverage.writeAverage(accumulator)
{
    local avgName = format(.outputPattern, string(accumulator.point));
    local value = accumulator.getAverage();
    //princ (avgName, " = ", value, "\n");
    datahub_write(avgName, value, t);
}

method SimpleAverage.monitor(pointName)
{
    local sym = symbol(pointName);
    local current;
    .OnChange(sym, `(@self).update(this, value));
    if (!undefined_p(current = eval(sym)))
        .update(sym, current);

    local avgName = format(.outputPattern, pointName);
    .model.MapPoint(avgName, ".", "R8", "r");
}

method SimpleAverage.reset()
{
    //princ ("Reset\n");
    with accumulator in .accumulators.values do
    {
        if (!.isRunningAverage)
            .writeAverage(accumulator);
        accumulator.reset();
    }
}

method SimpleAverage.startResetTimer()
{
    if (.period == "10sec")
    {
        .TimerAt(nil, nil, nil, nil, nil, list(0, 10, 20, 30, 40, 50),
                 `(@self).reset());
    }
    else if (.period == "minute")
    {
        .TimerAt(nil, nil, nil, nil, nil, 0, `(@self).reset());
    }
    else if (.period == "hour")
    {
        .TimerAt(nil, nil, nil, nil, 0, 0, `(@self).reset());
```

```
    }
    else if (.period == "day")
    {
        .TimerAt(nil, nil, nil, 0, 0, 0, `(@self).reset());
    }
    else
    {
        princ ("No period set - will average over all time\n");
    }
}

/* Start the program by instantiating the class. */
ApplicationSingleton (SimpleAverage);
```

LogFile.g

LogFile.g — logs data to a text file when a point changes value.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/* This script shows how to log data to a text file. It uses a
 * trigger point to signal an alarm condition (non-zero), which
 * causes a value to be written to the file.
 *
 * To use this script with your points, replace 'default:triggerpt'
 * in the LogFile class with your trigger point, and replace
 * 'default:loggedpt' with the point whose value you wish to log.
 * You can also change the name of the log file.
 */

/* All user scripts should derive from the base "Application" class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both.
 */

require ("WindowsSupport");
//require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */

class LogFile Application
{
```

```
    // The trigger point whose value determines when logging
    // takes place.
    trigger = #$default:triggerpt;

    // The point whose value gets logged.
    logged = #$default:loggedpt;

    // The name of the log file.
    log_file_name = "c:/tmp/logfile.txt";

    // The file handle to the open file
    log_file;
}

/*
 * This method writes the trigger value and the logged point value
 * for alarm conditions and non-alarm conditions.  The first argument
 * is the actual value of the trigger point, and the second is the
 * symbolic name of the point to be logged.
 */
method LogFile.AlarmOccurred(triggervalue, !logpoint)
{
    local    value = eval (logpoint);
    if (triggervalue != 0)
    {
        writec (.log_file, format ("Alarm:   %-20s = %10g\n",
       string(logpoint), value));
        princ ("Alarm condition: ", logpoint, ", ", value, "\n");
    }
    else
    {
        writec (.log_file, format ("Cleared: %-20s = %10g\n",
       string(logpoint), value));
        princ ("No alarm: ", logpoint, ", ", value, "\n");
    }
    flush (.log_file);
}

/* Write the 'main line' of the program here. */
method LogFile.constructor ()
{
    /* If the trigger and logged points don't exist in the DataHub
       instance, create them.*/
    datahub_command (string ("(create ", .trigger, " 1)"), 1);
    datahub_command (string ("(create ", .logged, " 1)"), 1);
```

```
    /* Attempt to open the log file. */
    .log_file = open (.log_file_name, "a");
    if (!.log_file)
    {
        MessageBox (0, string ("Could not open alarm log file: ",
          .log_file_name),
                              "Error opening file", 0);
    }
    else
    {
        /* Log the data whenever the trigger point changes. */
        .OnChange (.trigger, `(@self).AlarmOccurred (value,
           @.logged));
    }
}

/* Any code to be run when the program gets shut down. */
method LogFile.destructor ()
{
    if (.log_file)
        close (.log_file);
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (LogFile);
```

ReadCSV.g

ReadCSV.g — reads a CSV file and writes the points and values to the DataHub instance.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * This script reads a CSV file and writes the values found there
 * into a set of data points in a DataHub instance.  The format of
 * the file is:
 *
 * row 1:  name1, name2, name3, ...
 * row 2:  value1, value2, value3, ...
 * row 3:  value1, value2, value3, ...
 *  ...
 * row N:  value1, value2, value3, ...
 *
 * The script will read all rows in the file, but ignore all but
 * the first and last.  The first row contains the point names and
 * the last contains the most recent data.
 * If a name is left blank then that column is ignored.
 * If a point name does not contain a domain name, then the domain
 * set in the "domain" member of the application is used.
 *
 * e.g.,
 *    default:point1, default:point2, default:point3
 *    1, 2, 3
 *    4, 5, 6
 *
 * will result in:
 *    default:point1 = 4
 *    default:point2 = 5
 *    default:point3 = 6
 *
 * Strings containing ',' characters must be quoted within double
 * quotes, like this:
 *    "hello, friend"
 *
```

```
 * Double-quotes within strings must be escaped, like this:
 *    "He said, \"hello\"."
 *
 * This script will guess whether a value is a number or a string.
 * If the value can be parsed to a number, it is treated as a number.
 * Otherwise it is a string.
 *
 * This script looks for new data at a set time interval.
 *
 * This script will operate in one of two modes:
 *    In "reload" mode, the file is re-read from the beginning on each
 *    timer tick.
 *    In "append" mode, the file is kept open, and the file is read
 *    from the last read position on each timer tick.  This mode will
 *    not work if the writing application does not open the file
 *    as "shared".
 *
 * This script adds a menu item to the DataHub system tray icon
 * that allows the user to re-load the file, change read mode, and
 * toggle logging to the Script Log window.
 */

require ("Application");

class ReadCSV Application
{
    mode = #reload;  // set to #reload or #append
    domain = "default";
    filename = "c:/tmp/data.csv";
    verbose = t;
    update_secs = 5;
    separators = ","; // e.g, use " " for space separated,
                      // or "\t" for tab-separated

    /* --- No need to change these --- */
    columns;
    fptr;
    modemenu;
    verbosemenu;
}

/* Logging function that prepends the time to the output. */
method ReadCSV.Log (args...)
{
    if (.verbose)
    {
```

```
        funcall (princ, cons (date(), cons(": ", args)));
        princ("\n");
    }
}

/* Open the given file, if possible. */
method ReadCSV.OpenFile (filename)
{
    .fptr = open(filename, "r");
    if (!.fptr)
    {
        .Log ("Could not open file: ", filename);
    }
    else
    {
        .filename = filename;
        .Log ("File: ", filename, " opened");
        .ReadColumns();
    }
    .fptr;
}

method ReadCSV.CloseFile ()
{
    if (.fptr)
    {
        close(.fptr);
        .Log ("File: ", .filename, " closed");
        .fptr = nil;
    }
}

method ReadCSV.Trim(str)
{
    local  l = strlen(str), start, end;
    for (start=0; start<l && strchr(" \t",str[start]) != -1;)
        start++;
    for (end=l-1; end >= start && strchr(" \t",str[end]) != -1;)
        end--;
    if (start != 0 || end != l-1)
        substr(str,start,end-start+1);
    else
        str;
}

method ReadCSV.ReadColumns ()
```

```
{
    local  line = read_line (.fptr);
    local  i;

    if (line != _eof_)
    {
        line = list_to_array(string_split(line,.separators,
       0,t,"\"\"",t,"\\",nil));
        for (i=0; i<length(line); i++)
        {
            if (.Trim(line[i]) == "")
            {
                line[i] = nil;
            }
            else
            {
                if (strchr(line[i],':') == -1)
                    line[i] = string(.domain,":",line[i]);
                line[i] = symbol(line[i]);
                datahub_command(format("(create %s 1)",
           stringc(line[i])),1);
            }
        }
        .columns = line;
        .Log("Set columns to ", .columns);
    }
}

method ReadCSV.GuessTypeValue (str)
{
    local  value;

    try
    {
        value = parse_string(str,nil);
        if (!number_p(value))
            value = str;
    }
    catch
    {
        value = str;
    }
    value;
}

method ReadCSV.ApplyLine (line)
```

```
{
    local  i, value;

    .Log ("Applying line: ", line);
    if (line)
    {
        line = list_to_array(string_split(line,.separators,
       0,t,"\"\"",nil,"\\",nil));
        for (i=0; i<length(.columns); i++)
        {
            if (.columns[i])
            {
                value = .GuessTypeValue(line[i]);
                //.Log ("Set: ", .columns[i], " to ", stringc(value));
                if (value)
                    set(.columns[i], value);
            }
        }
    }
}

method ReadCSV.ReadLines ()
{
    local  line, input;

    .Log ("Looking for new data...");
    while ((input = read_line(.fptr)) != _eof_)
    {
        if (.Trim(input) != "")
            line = input;
    }
    if (line)
    {
        .ApplyLine(line);
    }
}

method ReadCSV.ReadFile (filename)
{
    if (!.fptr)
        .OpenFile(filename);
    if (.fptr)
    {
        .ReadLines();
        if (.mode == #reload)
            .CloseFile();
```

```
    }
}

method ReadCSV.SetMode (mode)
{
    .mode = mode;
    .Log("Set read mode to ", mode);
    .ChangeMenuItemLabel(.modemenu,
                         string("Set ",
    (mode == #append) ?
    "Reload" :
    "Append",
                                " Mode"));
    if (.filename)
        .Reload(.filename);
}

method ReadCSV.ToggleMode ()
{
    .SetMode((.mode == #append) ? (#reload) : (#append));
}

method ReadCSV.ToggleVerbose ()
{
    .SetVerbose(!.verbose);
}

method ReadCSV.SetVerbose (mode)
{
    .verbose = t;
    .Log("Set verbosity to ", (mode ? "verbose" : "quiet"));
    .verbose = mode;
    .ChangeMenuItemLabel(.verbosemenu,
                         string(mode ? "Quiet" : "Verbose", " Mode"));
}

method ReadCSV.Reload (filename)
{
    .CloseFile();
    .ReadFile(filename);
}

/* Write the 'main line' of the program here. */
method ReadCSV.constructor ()
{
    .TimerEvery(.update_secs, `(@self).ReadFile((@self).filename));
```

```
    .AddCustomSubMenu("CSV File Reader");
    .AddCustomMenuItem("Reload CSV File",
         `(@self).Reload((@self).filename));
    .modemenu = .AddCustomMenuItem("Set Append Mode",
       `(@self).ToggleMode());
    .verbosemenu = .AddCustomMenuItem("Verbose",
          `(@self).ToggleVerbose());
    .SetVerbose(.verbose);
    .SetMode(.mode);
}

method ReadCSV.ChangeMenuItemLabel (menuitemid, label)
{
    local parent = .CreateSystemMenu();
    local info = new MENUITEMINFO();

    if (cons_p(menuitemid))
        menuitemid = car(menuitemid);
    info.cbSize = 48;
    info.fMask = MIIM_STRING | MIIM_ID;
    info.fMask |= (WINVER < 0x0500 ? MIIM_TYPE : MIIM_FTYPE);
    info.fType = MFT_STRING;
    info.wID = menuitemid;
    info.dwTypeData = label;
    SetMenuItemInfo (parent, menuitemid, 0, info);
}

method ReadCSV.destructor ()
{
    .CloseFile();
}

ApplicationSingleton (ReadCSV);
```

WriteCSV.g

WriteCSV.g — writes data to CSV files.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * Write data to a number of different CSV files.  Each data set is
 * written at a different interval, either per second, per minute or
 * per hour.  A new CSV * file is created every hour or every day.
 *
 * The points names in each data set are read from a file.  The file
 * consists of each full point name (including domain name), one per
 * line.  The output file will contain a time stamp followed by the
 * value for each point in the order that the points are listed in
 * the point name file.
 *
 * To change the format of the file name, change the method
 * "GenerateFileName".
 *
 * To change the extension of the file, change the member variable
 * "filesuffix".
 *
 * To change the file names and timing, change the .NewDataSet calls
 * in the method WriteCSV.constructor.
 */

require ("Application");
require ("CSVSupport");

class WriteCSV Application
{
    datasets;
}

class MyCSVWriter CSVWriter
{
    pointfile;       // The name of a file containing the point list.
```

```
    sample_rate;       // one of #second, #minute, #hour or
                       // list(hour,minute,second)
    file_rotate_rate;  // one of #minute, #hour, #day or
                       // list(hour,minute,second)
    filesuffix = ".csv";  // normally .csv.  Override it to create
                          // .txt files.
}

/* This will produce a file name like:
 *     base_20090423_PM3.csv
 */

/*
method MyCSVWriter.GenerateFileName()
{
    local tm = localtime(nanoclock());
    format("%s_%d%02d%02d_%s%d%s", .filebase,
           tm.year+1900, tm.mon+1, tm.mday,
           tm.hour >= 12 ? "PM" : "AM",
           tm.hour > 12 ? tm.hour - 12 : (tm.hour == 0 ? 12 :
       tm.hour), .filesuffix);
}
*/

/* This will produce a file name like:
 *     base-20090423-1545.csv
 */
method MyCSVWriter.GenerateFileName()
{
    local tm = localtime(nanoclock());
    format("%s-%d%02d%02d-%02d%02d%s", .filebase,
           tm.year+1900, tm.mon+1, tm.mday,
           tm.hour, tm.min,
           .filesuffix);
}

/*
 * Create a new writer and start the timers to write new data and to
 * create a new log file.
 */
method WriteCSV.NewDataSet (output_file_base, pointfile, sample_rate,
       file_rotate_rate, separate_lines)
{
    local writer = new MyCSVWriter();
    if (writer.ReadPointsFromCSV(pointfile))
    {
```

```
        writer.sample_rate = sample_rate;
        writer.file_rotate_rate = file_rotate_rate;
        writer.SetFileBase(output_file_base);
        writer.SetSeparateLines(separate_lines);

        switch(writer.sample_rate)
        {
            case (#second):
                .TimerAt(nil,nil,nil,nil,nil,nil,
    `(@self).WriteData(@writer));
            case (#minute):
                .TimerAt(nil,nil,nil,nil,nil,0,
    `(@self).WriteData(@writer));
            case (#hour):
                .TimerAt(nil,nil,nil,nil,0,0,
    `(@self).WriteData(@writer));
            case (#day):
                .TimerAt(nil,nil,nil,0,0,0,
    `(@self).WriteData(@writer));
            default:
                if (list_p(writer.sample_rate))
                {
                    // List of hour, minute, second specification
                    local  times = list_to_array(writer.sample_rate);
                    .TimerAt(nil,nil,nil,times[0],times[1],times[2],
        `(@self).WriteData(@writer));
                }
                else // Default is hourly
                {
                    .TimerAt(nil,nil,nil,nil,0,0,
        `(@self).WriteData(@writer));
                }
        }
        switch(writer.file_rotate_rate)
        {
            case (#minute):
                .TimerAt(nil,nil,nil,nil,nil,0,
    `(@self).RotateFile(@writer));
            case (#hour):
                .TimerAt(nil,nil,nil,nil,0,0,
    `(@self).RotateFile(@writer));
            case (#day):
                .TimerAt(nil,nil,nil,0,0,0,
    `(@self).RotateFile(@writer));
            default:
                if (list_p(writer.file_rotate_rate))
```

```
                {
                    // List of hour, minute, second specification
                    local  times =
        list_to_array(writer.file_rotate_rate);
                    .TimerAt(nil,nil,nil,times[0],times[1],times[2],
        `(@self).RotateFile(@writer));
                }
                else // Default is hourly
                {
                    .TimerAt(nil,nil,nil,nil,0,0,
        `(@self).RotateFile(@writer));
                }
        }
        .datasets = cons(writer, .datasets);
    }
}

method WriteCSV.WriteData(writer)
{
    writer.WriteLine();
}

method WriteCSV.RotateFile(writer)
{
    .TimerAfter(0.1, `(@writer).IncrementFileName());
}

/* Write the 'main line' of the program here. */
method WriteCSV.constructor ()
{
    /* Specify the CSV files to write.  Modify the .NewDataSet lines
     * to specify how to write each CSV file.
     * Arguments are:
     *    output_file_base:  The first part of the file, before the
     *                       date string
     *    pointfile:  The name of a file containing the point names
     *                for this data set
     *    sample_rate:  One of #second, #minute, #hour or
     *                  list(hour,minute,second) telling how
     *                  frequently to write a line to the CSV file
     *    file_rotate_rate:  One of #minute, #hour, #day
     *                       or list(hour,minute,second) telling how
     *                       frequently to create a new CSV file.
     *    separate_lines:  If this is nil, write all point values on
     *                     one line.  If this is t, write each point
     *                     value on a separate line.
```

```
     *
     * This function will read the pointfile as a CSV file and treat
     * the first field in each row as the name of a point to be
     * recorded into the output file.
     *
     * When specifying timing, the input is the list of
     * (hour,minute,second) as accepted by the "at" function
     * (see documentation).  A value of nil for hour, minute or
     * second stands for all values for that parameter.  A list of
     * values for hour, minute or second specifies an event only
     * when the hour, minute or second matches one of the values in
     * the list.
     * Examples:
     *    list(nil,nil,nil)  - every second
     *    list(nil,list(0,15,30,45),0) - every 15 minutes
     *   list(nil,list(0,15,30,45),30) - every 15 minutes,
     *                                   30 seconds past the minute
     *    list(list(0,8,16), 0, 0)      - at midnight, 8AM and 4PM
     *                                   exactly
     *    list(list(0,8,16), 5, 0)      - at 12:05AM, 8:05AM and
     *                                   4:05PM
     *
     * The symbols #second, #minute, #hour, #day are conveniences for:
     *    second:   list(nil,nil,nil)  - any hour, any minute,
     *                                 every second
     *    minute:   list(nil,nil,0)    - any hour, every minute
     *                                 at 0 seconds
     *    hour:     list(nil,0,0)      - every hour, on the hour
     *    day:      list(0,0,0)        - at midnight (0 hour,
     *                                 0 minute, 0 second)
     */
    .NewDataSet("c:/tmp/Group1", "c:/tmp/Group1_Points.txt",
                #second, #hour, nil);
    .NewDataSet("c:/tmp/Group2", "c:/tmp/Group2_Points.txt",
                #second, list(nil,list(0, 15,30,45),0), nil);
    .NewDataSet("c:/tmp/Group3", "c:/tmp/Group3_Points.txt",
                #second, list(nil,nil,0), nil);
}

/* Any code to be run when the program gets shut down. */
method WriteCSV.destructor ()
{
    with writer in .datasets do
    {
        destroy(writer);
    }
```

```
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (WriteCSV);
```

XMLReader.g

XMLReader.g — reads an XML file from a URL.

Code

The script allows you to process the data you receive in any way you like, and gives an example of printing the data with the Gamma `princ` function. If instead you would like to write the data to a point in the DataHub instance, you can replace this code:

```
with point in model._xml_children do
{
    princ (point.name, " = ", point.value, "\n");
}
```

with this

```
with point in model._xml_children do
{
    datahub_write (string("domain_name:"
                   point.name), point.value);
}
```

where *`domain`* is the name of the domain in which you want the point to be created. Be sure to include the colon (:) at the end of the domain name, and make sure there are no other colons in the point name. For more information, please refer to the Data Domains section of the DataHub manual, and the `datahub_write` function in this manual.

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called "How to Run a Script" for more information on using scripts.

```
/*
This script reads an XML file from a URL and parses it into a class
hierarchy that can be used to run further scripts or to populate a
DataHub instance.

The example in this case requires that DataPid is running and that
the DataHub Web Server is turned on, as the script is simply reading
some data point values from the DataHub Web Server in XML format.
*/
```

```
require ("Application");

/* Get the Gamma library functions and methods for XML parsing and
   wget command-line tool */
require ("XMLSupport");
require ("WgetSupport");

class XMLReader Application
{
  //Note: The following line is wrapped for documenation formatting.
  //      You will need to restore it to aingle line to run the
  //      program.
    DocumentUrl = "http://localhost/points?name=DataPid:PID1.Mv|
                   DataPid:PID1.Pv|DataPid:PID1.Sp";
    TickSeconds = 5;
}

method XMLReader.loadXml ()
{
    // Call wget asynchronously.  Protect against the possibility
    // that the script is stopped while a wget command is still
    // outstanding.
    Wget(.DocumentUrl, `progn {
        if (!destroyed_p(@self))
            (@self).processWgetResult();
    });
}

method XMLReader.processWgetResult()
{
    if (ExitCode == 0) // success
    {
        // Print the raw XML document
        princ ("------- Original Document -------\n");
        princ (ResultString);
        princ ("--------------------------------\n");

        // Parse the XML into a class hierarchy that we can easily
 // manipulate
        local reader =
   scew_reader_buffer_create(string_to_buffer(ResultString));
        local parser = new scew_parser();
        local tree = parser.load(reader);
        local model = tree.create_model("myxml_");

        // Print the whole XML file model.
```

```
        // pretty_princ(model, "\n");

        // The XML model consists of a class instance for each XML
 // Element.  Each class has a member called _xml_children
 // that is an array of the sub-elements.
        // In addition, each class has member variables that are
 // named as the attributes of the XML element.  Replace this
 // with your own custom processing.
        with point in model._xml_children do
        {
            princ (point.name, " = ", point.value, "\n");
        }
    }
    else
    {
        princ ("XML read failed with exit code: ", ExitCode, "\n");
    }
}

/* Write the 'main line' of the program here. */
method XMLReader.constructor ()
{
    .TimerEvery(.TickSeconds, `(@self).loadXml());
}

/* Any code to be run when the program gets shut down. */
method XMLReader.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (XMLReader);
```

ParseExcel.g

ParseExcel.g — parses data from an Excel spreadsheet.

Description

This script shows how to read an array of data into a DataHub script from a source such as an Excel worksheet, and then parse and extract values as necessary. The values in this example are message strings that correspond with an alarm, but they could be any value. The results of the triggered alarm are written to a text file.

Required setup

1. In the Excel worksheet:
    a. Select a group of cells in the worksheet that is 2 columns wide by any number of rows deep.
    b. Give this region a name by entering the name `alarm_table` in the Excel Name Box located in the top-left corner of the worksheet.
    c. Select a cell outside of this range, and name it `time_stamp`.

    This example assumes that there is a data feed to this `time_stamp` cell updating it with the most recent time. You could set this up to be coming from a DataHub point if desired, or from any other source.

2. In the DataHub DDE properties:
    a. Add a new entry in the DDE Client section defined as follows:

Connection Name:	**`alarms`**
Service:	**`Excel`**
Topic:	**`Alarms.xls`** (the name of the Excel file)

    Enter the name `alarm_table` in the **Item Names** entry field, and choose **Add**. If the **Data Domain** column does not say `default`, double-click the name and change it to `default`.
    b. Now create another item named `time_stamp` in the same way.
    c. Select **OK** to close the DDE Item Definition window.
    d. Press **Apply** in the main properties window. The status of the DDE Connection should change to **Connected**.

3. In the DataHub Scripting properties:
    a. Select **Add...** to add a DataHub script.
    b. Navigate to the file `ParseExcel.g`, and choose **Open**. The script name should now appear in the list of scripts in the Scripting property page.
    c. Select the checkbox to the left of the `ParseExcel.g` file name, then press the

Apply button. This will cause the script to run whenever the DataHub instance starts.

d. With the `ParseExcel.g` file selected, press the **Edit...** button to open the file for editing in the Script Editor.

4. In the Script Editor:

   a. Go to line 35 and change the output file name to the name of a file that will receive the alarm log.

   b. Press the blue arrow icon or select **Reload Whole File** from the **Script** menu. The script is now running.

5. Close the Script Editor.

You can test the script by manually changing the alarm point values using the DataHub Data Browser window. If you want to see output to the Script Log as well as the output file, un-comment lines 106, 107, 113, and 114.

This script assumes that the data for the alarm points comes from an outside data source connected to the DataHub instance via some other configuration.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/* All user scripts should derive from the base "Application" class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

//require ("WindowsSupport");
//require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
```

```
 *      damaging an existing running instance.
 */

class ParseExcel Application
{
    domain = "default";

    // The point containing the alarm table from Excel.  This
    // is chosen from the DDE configuration tab in the OPC
    // DataHub properties.
    pt_alarm_table;
    pt_time_stamp;

    // The alarm lookup table.  We parse the table we get from
    // Excel into a more efficient lookup table.
    alarm_lut = make_array(0);

    // The name of the log file.
    log_file_name = "c:/tmp/alarmlog.txt";

    // The file handle to the open file
    log_file;
}

/*
 * Hold information for one alarm entry in the Excel spreadsheet
 */
class AlarmSpec
{
    tagname;
    point;
    description;
    eventid;
}

method AlarmSpec.constructor (domain, tag, description)
{
    .tagname = tag;
    .description = description;
    .point = symbol(string(domain, ":", tag));
}

/*
 * Comparison function for sorting.  We don't really need to sort
 * unless we plan to write code that looks up an alarm by name in
 * this table.  It is more efficient to use the event handler
```

```
 * (.OnChange) function to map a point change to its alarm
 * specification
 */
function CmpAlarmSpecs (alarm1, alarm2)
{
    symcmp (alarm1.point, alarm2.point);
}

method ParseExcel.NewAlarmTable(value)
{
    local    rows = string_split (string(value), "\r\n", 0);
    local    columns;
    local    tagsym;

    with alarm in .alarm_lut do
    {
        .RemoveChange (alarm.eventid);
    }

    .alarm_lut = make_array(0);
    with row in rows do
    {
        columns = list_to_array (string_split (row, "\t", 0));
        .alarm_lut[length(.alarm_lut)] =
   new AlarmSpec(.domain, columns[0], columns[1]);
    }
    .alarm_lut = sort (.alarm_lut, CmpAlarmSpecs);

    with alarm in .alarm_lut do
    {
        datahub_command (string ("(create ",
     stringc(alarm.point), " 1)"), 1);
        alarm.eventid = .OnChange (alarm.point, `(@self).
       AlarmOccurred
       (@alarm, value));
    }
}

/*
 * This method is called whenever the alarm condition point
 * changes in the OPC server.
 */
method ParseExcel.AlarmOccurred(alarm, value)
{
    if (value != 0)
    {
```

```
        writec (.log_file, format ("%-20s%-12s%s\n",
       $default:time_stamp,
               alarm.tagname, alarm.description));
        //princ (format ("%-20s%-12s%s\n", $default:time_stamp,
        //  alarm.tagname, alarm.description));
    }
    else
    {
        writec (.log_file, format ("%-20s%-12s%s cleared\n",
       $default:time_stamp,
               alarm.tagname, alarm.description));
        //princ (format ("%-20s%-12s%s cleared\n", $default:time_stamp
 // alarm.tagname, alarm.description));
    }
    flush (.log_file);
}

/* Write the 'main line' of the program here. */
method ParseExcel.constructor ()
{
    .log_file = open (.log_file_name, "a");
    if (!.log_file)
    {
        MessageBox (0, string ("Could not open alarm log file: ",
          .log_file_name),
                              "Error opening file", 0);
    }
    else
    {
        // Set the point name for the alarm table coming from Excel
        .pt_alarm_table = symbol (string
      (.domain, ":", "alarm_table"));
        .pt_time_stamp = symbol (string
     (.domain, ":", "time_stamp"));

        datahub_command (string ("(create ",
     stringc(.pt_alarm_table), " 1)"), 1);
        datahub_command (string ("(create ",
     stringc(.pt_time_stamp), " 1)"), 1);

        // Whenever somebody changes the Excel spreadsheet, update the
        // alarm table.
        .OnChange (.pt_alarm_table, `(@self).NewAlarmTable(value));

        // If we already have a value for the alarm table point,
 // create the alarm table.
```

```
        if (!undefined_p(eval(.pt_alarm_table)) &&
            string_p(eval(.pt_alarm_table)))
                .NewAlarmTable (eval(.pt_alarm_table));
    }
}

/* Any code to be run when the program gets shut down. */
method ParseExcel.destructor ()
{
    if (.log_file)
        close (.log_file);
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (ParseExcel);
```

LinearXform.g

LinearXform.g — performs linear transformation functions on points.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to the section called "How to Run a Script" for more information on using scripts.

```
/* This script creates a class that performs linear
   transformation functions on DataHub points. */
class LinearXform
{
    verbose;
}
method LinearXform.cbLinearXform (dst, value, mult, add)
{
    if (.verbose)
        princ ("xform ", dst, " = ", value, " * ", mult,
               " + ", add, "\n");
    if (number_p(value))
        set (dst, value * mult + add);
    else
        set (dst, value);
}
method LinearXform.AddLinearXform (app, src, dst, mult, add,
                                   bidirectional_p?=nil)
{
    datahub_command (string ("(create \"", src, "\" 1)"));
    datahub_command (string ("(create \"", dst, "\" 1)"));
    app.OnChange (src, `(@self).cbLinearXform (#@dst, value,
                                               @mult, @add));
    if (bidirectional_p && mult != 0)
    {
        allow_self_reference (src, 1);
        allow_self_reference (dst, 1);
        app.OnChange (dst, `(@self).cbLinearXform (#@src, value,
                                                   @(1/mult),
                                                   @(-add/mult)));
    }
}
```

MakeArray.g

MakeArray.g — creates an array point from individual points.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/* This script creates an output array point from an input set of
 * individual points.  The array can be any reasonable length, though
 * the algorithm is not efficient for large arrays whose constituent
 * points change quickly.
 *
 * The only part of the code that you need to alter to create your
 * own arrays is the MakeArray.constructor method.
 *
 * If a change is made to any individual point, the array will be
 * updated immediately.
 *
 * If a change is made to the array point, the change will not affect
 * the individual points that make up the array.
 */

require ("Application");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */
class MakeArray Application
{
}

/* Ensure that a point exists in the DataHub data store.  We do this
 * because the startup order of the DataHub instance vs. the data
 * source is not necessarily predictable. By creating the point now,
```

```
 * we are sure that it exists even if the data source starts later.
 */
method MakeArray.CreatePoint(pointname, type?=nil)
{
    datahub_command(format("(create \"%s\" 1)", pointname), 1);
    if (type)
        datahub_command(format("(set_canonical \"%s\" \"%s\" 1)",
          pointname, type), 1);
}

/* Write the array based on the input point list.  There are more
 * efficient ways to do this if the array is large or the data
 * updates very frequently.  It may also be reasonable to do it on
 * a timer rather than every time any constituent point changes.
 */
method MakeArray.EmitArray(arraypoint, inputpoints)
{
    local val = make_array(0), i=0, tmp;
    with point in inputpoints do
    {
        val[i++] = undefined_p(tmp =
          eval(symbol(point))) ? 0 : number(tmp);
    }
    set (symbol(arraypoint), val);
}

/* This is a convenient function that declares an array point to
 * create from a set of input points.  You can create as many of
 * these array points as you need, using any number of input points.
 * Just put all of the input points into the argument list of
 * the call (see the call in the constructor below).
 *
 * The arraytype is a VARIANT array type: I1, I2, I4, R4, R8, BSTR,
 * UI1, UI2, UI4 followed by a space and the word "array".
 * E.g., "R8 array" or "BSTR array".AddCustomMenuItem
 * BSTR means "string".
 */
method MakeArray.DeclareArray(arraypoint, arraytype, inputpoints...)
{
    .CreatePoint (arraypoint, arraytype);
    with point in inputpoints do
    {
        .CreatePoint(point);
        .OnChange(symbol(point),
    `(@self).EmitArray(#@arraypoint, #@inputpoints));
    }
```

```
    // After creating everything, call the EmitArray method once to
    // initialize the array.  We do this in case the constituent
    // points are already present in the data set when the script
    // starts.  Otherwise we would have to wait until one
    // of the points changes before the array gets initialized.
    .EmitArray (arraypoint, inputpoints);
}

/* Write the 'main line' of the program here.  Call the
 * .DeclareArray method one or more times to set up the event
 * handling to construct an array from individual points
 */
method MakeArray.constructor ()
{
    .DeclareArray ("default:pointarray", "R8 array",
     "default:pointname1", "default:pointname2",
                   "default:pointname3");
}

/* Any code to be run when the program gets shut down. */
method MakeArray.destructor ()
{
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (MakeArray);
```

BreakArray.g

BreakArray.g — breaks an array point into individual points.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * Break an array point into individual points.  For example, if we
 * have a point
 *     default:myarray = [ 1, 2, 3 ]
 * then we would like to create an output like
 *     default:myarray_0 = 1
 *     default:myarray_1 = 2
 *     default:myarray_2 = 3
 *
 * To set up an array to be broken into individual points,
 * call .MonitorArray().  This method takes a point name (of the
 * array), a format string and an index offset.  The format string
 * specifies a suffix to add to the base point name, and the index
 * offset determines where to start numbering the suffix.
 * Typically index offset is 0 or 1.
 *
 * For example, to create points like:
 *   default:myarray_0
 *     use .MonitorArray("default:myarray", "_%d", 0)
 *   default:myarray_001
 *     use .MonitorArray("default:myarray", "_%03d", 1)
 *   default:myarray[1]
 *     use .MonitorArray("default:myarray", "[%d]", 1)
 *
 * This script will automatically respond to changes in the size of
 * the array by creating new points as the array expands, or by
 * marking existing points as not connected as the array contracts.
 *
 * This script will create the point hierarchy of the newly generated
 * points by splitting the point names on the "splitChars" and using
 * each component in the split name as a branch in the hierarchy.
 * If you do not want to create the hierarchy, set splitChars to nil.
```

```
 */

require ("Application");

class BreakArray Application
{
    splitChars = ".";
    modeledPoints = new Dictionary();
}

/* Write the 'main line' of the program here.  You should only need
 *  to modify the constructor to match your data points. */
method BreakArray.constructor ()
{
    // Delete the calls to .setupTest.
    // They are just here to test this script.
    .setupTest ("default:test.myarray", [ 1, 2, 3, 4, 5 ]);
    .setupTest ("default:test.myarray2", [ 1, 2, 3, 4, 5 ]);

    // Add, remove or modify .MonitorArray calls to work with any
    // number of array points.
    .MonitorArray("default:test.myarray", "rw", "_%03d", 1);
    .MonitorArray("default:test.myarray2", "rw", "[%d]", 0);
}
/* ---------------------------------------------------------------- */

// You should not need to modify below this point.

/*
 * Create data points for an array using an index and a format string.
 * For example, to create points:
 * default:myarray_0
 *     use suffixformat="_%d", indexoffset=0
 * default:myarray[1]
 *     use suffixformat="[%d]", indexoffset=1
 * default:myarray_001
 *     use suffixformat="_%03d", indexoffset=1
 */
method BreakArray.MonitorArray(pointname, accessFlags,
                               suffixformat, indexoffset)
{
    local    value;
    .OnChange(symbol(pointname), `(@self).Break(this, value,
              @accessFlags, @suffixformat, @indexoffset, t));

    // If we have a current value,
```

```
    // break the array for the first time now.
    if (!undefined_p(value = eval(symbol(pointname))))
    {
        .Break(symbol(pointname), value, accessFlags, suffixformat,
               indexoffset, nil);
    }
}

method BreakArray.Break(pointname, value, accessFlags, suffixformat,
                        indexoffset, have_previous?=nil)
{
    local elementname, elementsym, suffix;
    local indx = indexoffset;
    local info = PointMetadata(pointname), elementinfo;
    local type, curlen, prevlen, i;
    local model = new ModelEmitter();

    if (array_p(value))
    {
        // Find the element type
        type = info.canonical_type & ~0xfffff000;

        // For each value in the array, create a point name for it.
        // If the point does not exist, or has an empty canonical
        // type, then create the point and set its canonical type
        // to the type of the parent array.
        with element in value do
        {
            suffix = format(suffixformat, indx);
            elementname = string(pointname, suffix);
            elementsym = symbol(elementname);
            elementinfo = PointMetadata(elementsym);
            if (!elementinfo || elementinfo.canonical_type == 0)
            {
                // This point has never been created in the DataHub
                // Create it and match its canonical type to the
                // array type.
                datahub_command (format("(create %s 1)",
                                 stringc(elementname)), 1);
                datahub_command (format("(set_canonical %s %d 1)",
                                 stringc(elementname), type), 1);
            }
            if (.splitChars && !.modeledPoints[elementname])
            {
                .modeledPoints[elementname] = elementname;
                model.MapPoint(elementname, .splitChars,
```

```
                                "Empty", accessFlags);
            }
            datahub_write(elementname, element, nil, info.quality,
                          info.timestamp);
            indx++;
        }
    }

    // Find the previous length.  If the array used to be longer then
    // we should mark the values that are no longer present as Not
    // Connected.  If this function is called from within a change
    // handler previous is implicitly defined.

    if (have_previous)
    {
        prevlen = (undefined_p(previous) ||
                   !array_p(previous)) ? 0 : length(previous);
        curlen = (array_p(value) ? length(value) : 0);

        for (i=curlen; i<prevlen; i++)
        {
            suffix = format(suffixformat, indx);
            elementname = string(pointname, suffix);
            elementsym = symbol(elementname);
            elementinfo = PointMetadata(elementsym);
            if (elementinfo)
            {
                //princ ("Set array element ", elementname,
                         " as not connected\n");
                datahub_write(elementname, elementinfo.value,
                              nil, OPC_QUALITY_NOT_CONNECTED,
                              info.timestamp);
            }
            indx++;
        }
    }

    model.Emit();
}

/*
 * This method is just used to create a test data set.
 */
method BreakArray.setupTest(pointname, value)
{
    local model = new ModelEmitter();
```

```
    model.MapPoint(pointname, ".", "R8 array", "rw");
    datahub_command (format("(create %s 1)",
                     stringc(pointname)), 1);
    datahub_command (format("(set_canonical %s \"R8 array\" 1)",
                     stringc(pointname)), 1);
    datahub_write (pointname, value);
    model.Emit();
}

/* Any code to be run when the program gets shut down. */
method BreakArray.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (BreakArray);
```

IntToBit.g

IntToBit.g — converts an integer data point into a set of single-bit points.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * Given an integer value, convert it to a set of data points where
 * each point represents a single bit in the original integer.
 *
 * Usage:
 * Modify the IntToBit.constructor to reflect the data points that
 * need to be broken into individual bits.  This consists of one or
 * more calls to
 *      .initPoint(point, format, nbits)
 *  where
 *      point - a symbol or string representing the input integer
 *              data point specify symbols with #$domain:symbol_name
 *              or as a string
 *      format - a format string defining how to create the point
 *               names for the individual bits, given the symbol name
 *               and a bit number (starting at 0). Use %a for the
 *               format specifier for input point name
 *      nbits - the number of bits to extract from the input,
 *              starting at the LSB
 */

require ("Application");

class IntToBit Application
{
}

/* Add any data points that you want to split into bits here */
method IntToBit.constructor ()
{
    .initPoint(#$default:test, "%a_%d", 8);
    .initPoint("default:test2", "%a_%02d", 16);
```

```
    .initPoint(format("default:test%d", 3), "%a_%02d", 32);
}

/* ------- Implementation: No need to change beyond here ---------- */

/* A callback that runs whenever the input integer changes value */
method IntToBit.processNewValue (inputsym, outputformat, value, nbits)
{
    if (string_p(inputsym))
        inputsym = symbol(inputsym);

    local bitsym, bitvalue, i;
    local valueinfo = PointMetadata(inputsym);

    if (valueinfo)
    {
        for (i=0; i<nbits; i++)
        {
            bitsym = format(outputformat, inputsym, i);
            bitvalue = (value >> i) % 2;
            datahub_write(bitsym, bitvalue, nil, valueinfo.quality,
     valueinfo.timestamp);
        }
    }
}

/* Set up the event handler and initial state for the output points */
method IntToBit.initPoint (inputsym, outputformat, nbits)
{
    local bitsym, i, curvalue;

    if (string_p(inputsym))
        inputsym = symbol(inputsym);

    for (i=0; i<nbits; i++)
    {
        bitsym = format(outputformat, inputsym, i);
        datahub_command (format("(create %s 1)", stringc(bitsym)), 1);
        datahub_command (format("(set_canonical %s BOOL)",
    stringc(bitsym)), 1);
    }
    .OnChange(inputsym, `(@self).processNewValue(this, @outputformat,
       value, @nbits));

    if (!undefined_p(curvalue = eval(inputsym)) && number_p(curvalue))
    {
```

```
        .processNewValue(inputsym, outputformat, curvalue, nbits);
    }
}

/* Any code to be run when the program gets shut down. */
method IntToBit.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (IntToBit);
```

BitsToInt.g

BitsToInt.g — converts a set of boolean data points into an integer point.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called "How to Run a Script" for more information on using scripts.

```
/*
 * Given a list of boolean data points, construct a single integer
 * bit field into a separate output point.  The data point list
 * consists of a point name and the matching bit to set in the
 * output integer. It is not necessary to supply an input data point
 * for each bit in the output.
 */

require ("Application");

class BitsToInt Application
{
}

/*
 * Register the mappings between input points and the output point.
 * You can call .addBitMap as many times as you like.  If the point
 * names follow a pattern you could write a method that constructs
 * the two name and value arrays programmatically and then calls
 * .addBitMap with those arrays.
 */
method BitsToInt.constructor ()
{
    .addBitMap("default:output",
        [ "default:input0", "default:input1", "default:input2",
        "default:input3", "default:input4", "default:input5",
        "default:input6", "default:input7" ],
        [ 0x01, 0x02, 0x04, 0x08, 0x10, 0x20, 0x40, 0x80 ]);
}

/*
 * This class implements the map from input bits to an output integer.
```

```
 * You should not need to change anything below this line.
 */

class BitsToIntMap
{
    pointNames;    // an array of point names, as symbols
    maskValues;    // an array of corresponding masks to apply to the
                   // output when each point value is non-zero
    outputName;    // The name of the output point as a symbol
}

method BitsToIntMap.constructor(outputName, inputNames, inputValues)
{
    .outputName = symbol(outputName);
    .pointNames = inputNames;
    .maskValues = inputValues;

    local i;
    for (i=0; i<length(.pointNames); i++)
    {
        datahub_command(format("(create %s 1)",
                               stringc(.pointNames[i])), 1);
        .pointNames[i] = symbol(.pointNames[i]);
    }
    datahub_command(format("(create %s 1)",
                           stringc(.outputName)), 1);
}

method BitsToIntMap.register(app)
{
    local sym;
    with name in .pointNames do
    {
        app.OnChange(name, `(@self).recompute());
    }
    .recompute();
}

method BitsToIntMap.recompute()
{
    local value = 0, i, len = length(.pointNames), temp;
    for (i=0; i<len; i++)
    {
        if (!undefined_p(temp = number(eval(.pointNames[i])))
            && temp != 0)
            value |= .maskValues[i];
```

```
    }
    set(.outputName, value);
}

method BitsToInt.addBitMap(outputName, inputNames, inputValues)
{
    local bitmap = new BitsToIntMap(outputName, inputNames,
                                    inputValues);
    bitmap.register(self);
    bitmap;
}

/* Start the program by instantiating the class. */
ApplicationSingleton (BitsToInt);
```

MaskedBridge.g

MaskedBridge.g — copies a data point, applying a mask and shift operation.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * Copy a data point to another data point, applying a mask and shift
 * operation during the copy.  The mask is applied before the shift,
 * allowing you to mask any bits and then shift them right or left.
 * A negative shift will shift left, and a positive shift will shift
 * right.  The shift indicates the number of bits to shift, where 0
 * indicates no shift.
 *
 * You can create any number of operations simply by reproducing the
 * .OnChange method call with different pairs of points.  The
 * datahub_command call is simply to ensure that the destination
 * point exists, which may not be necessary depending on your
 * application.
 */

require ("Application");

class MaskedBridge Application
{
}

method MaskedBridge.WriteBits (value, pointname, mask, shift)
{
    if (shift < 0)
        set(pointname, (value & mask) << -shift);
    else
        set(pointname, (value & mask) >> shift);
}

method MaskedBridge.constructor ()
{
    datahub_command("(create DataPid:TwoBits 1)", 1);
```

```
    .OnChange(#$DataPid:PID1.Mv,
        `(@self).WriteBits(value, #$DataPid:TwoBits, 0x03, 0));
}

/* Start the program by instantiating the class. */
ApplicationSingleton (MaskedBridge);
```

ConnectionTrack.g

ConnectionTrack.g — changes a point when a connection is made or broken.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * This script watches the quality on an indicator point and sets
 * an output to 0 if the quality is NOT CONNECTED and 1 otherwise.
 * This effectively produces a synthetic point that changes according
 * to whether a data connection to the source of the indicator point
 * is made or broken.
 *
 * To use this script:
 * 1) Adjust the poll_rate to the desired number of seconds.  This
 *    can be fractional, such as 0.25.
 * 2) Set track_time to t or nil.  If set to t, the time stamp of the
 *    indicator point will be updated on each poll, causing a value
 *    change event to all attached clients, OPC servers, etc.
 * 3) In the constructor, make one or more calls to .BeginTracking
 *    to set up a mapping between the point being watched and the
 *    indicator point.  The watched_point
 *
 * Once this script is running, you can use the output point as a
 * trigger to send email, write to a database, update a PLC, write
 * to Excel or perform some other custom action through scripting.
 */

require ("Application");

class ConnectionTrack Application
{
    poll_rate = 1; // polling rate in seconds
    track_time = nil; // set to t to adjust the output time stamp
                        // on each poll
}

method ConnectionTrack.BeginTracking(indicator_point, output_point)
```

```
{
    datahub_command(format("(create %a 1)", indicator_point), 1);
    datahub_command(format("(create %a 1)", output_point), 1);
    .TimerEvery(.poll_rate, `(@self).CheckQuality(@indicator_point,
        @output_point));
}

method ConnectionTrack.CheckQuality(!indicator_point, !output_point)
{
    local quality = PointMetadata(indicator_point).quality;
    local active = 1;
    if (quality == OPC_QUALITY_NOT_CONNECTED)
        active = 0;
    datahub_write(string(output_point), active, .track_time);
}

method ConnectionTrack.constructor ()
{
    .BeginTracking(#$default:indicator, #$default:active);
    // default:indicator = the point you want to monitor
    // default:active = the point used to trigger the notification
}

ApplicationSingleton (ConnectionTrack);
```

QualityTrack.g

QualityTrack.g — writes the quality of a point as the value of another point.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * This script polls the quality of an "input" point and writes the
 * quality as the value of another "output" point.
 * The input point is typically an actual point from an OPC server.
 * The output point is a synthetic point that can be used to trigger
 * email and ODBC events.
 *
 * To alter this script, just edit the QualityTrack.constructor to
 * change the parameters of the .Track() call.  The parameters are:
 *   poll_secs - the polling rate.  This can be fractional, as in 0.5
 *   input - the name of the input point as a symbol
 *   output - the name of the output point as a symbol
 *
 * You can add as many .Track() calls as you need to monitor
 * multiple points.
 *
 * In an email or ODBC Condition configuration, the quality of a
 * point can be compared to the OPC quality constants:
 *   OPC_QUALITY_BAD
 *   OPC_QUALITY_COMM_FAILURE
 *   OPC_QUALITY_CONFIG_ERROR
 *   OPC_QUALITY_DEVICE_FAILURE
 *   OPC_QUALITY_EGU_EXCEEDED
 *   OPC_QUALITY_GOOD
 *   OPC_QUALITY_LAST_KNOWN
 *   OPC_QUALITY_LAST_USABLE
 *   OPC_QUALITY_LOCAL_OVERRIDE
 *   OPC_QUALITY_MASK
 *   OPC_QUALITY_NOT_CONNECTED
 *   OPC_QUALITY_OUT_OF_SERVICE
 *   OPC_QUALITY_SENSOR_CAL
 *   OPC_QUALITY_SENSOR_FAILURE
```

```
 *   OPC_QUALITY_SUB_NORMAL
 *   OPC_QUALITY_UNCERTAIN
 */

require ("Application");
require ("Time");

class QualityTrack Application
{
}

method QualityTrack.CheckQuality(input, output)
{
    local info = PointMetadata(input);
    set (output, info.quality);
}

method QualityTrack.Track(poll_secs, input, output)
{
    datahub_command(format("(create %a 1)", output));
    .TimerEvery(poll_secs, `(@self).CheckQuality(#@input, #@output));
}

method QualityTrack.constructor ()
{
    // Change the poll_secs and the two point names here.
    // The # in front of the point name is necessary.
    .Track(1, #$default:my_real_opc_point,
           #$default:my_synthetic_trigger);

    // Add more calls to .Track() here
}

ApplicationSingleton (QualityTrack);
```

TagMonitor.g

TagMonitor.g — monitors DataHub points for changes in quality or failure to change value.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * This script monitors tags (or DataHub points) for two conditions:
 *
 * 1) change of quality
 * 2) failure to change within a time period
 *
 * For each of these, the script creates synthetic points
 * (the "target") that hold the result of monitoring the watch points.
 * Email and * database events can then be triggered from the
 * synthetic points.
 *
 * You can modify the constructor function in this script to change
 * the point names, or to add additional watch conditions as needed.
 */

require ("Application");

class TagMonitor Application
{
}

/*
 * Set up a watch tag and a target tag such that the quality of the
 * watch tag is copied into the value of the target tag.
 */
method TagMonitor.copyQuality(poll_seconds, watch, target)
{
    // Ensure that the input and output tags exist.
    datahub_command(format("(create %s 1)", stringc(watch)), 1);
    datahub_command(format("(create %s 1)", stringc(target)), 1);
```

```
    // Periodically copy the quality of the watch point into
    // the value of the target
    .TimerEvery(poll_seconds,
  `set(#@target, PointMetadata(#@watch).quality));
}

/*
 * Set up a watch tag, a target tag and a time such that the target
 * tag will be set to 1 if the watch tag has changed within the timer
 * period, or zero if the watch tag has not changed within the time
 * period.  The time period is specified by dead_seconds, which may
 * be fractional.
 */
method TagMonitor.copyChangeStatus(dead_seconds, watch, target)
{
    // Ensure that the input and output tags exist.
    datahub_command(format("(create %s 1)", stringc(watch)), 1);
    datahub_command(format("(create %s 1)", stringc(target)), 1);

    // Start the watch point off as having changed
    setprop(watch, #has_changed, t);

    // Whenever the watch point changes, set its property
    // "has_changed" to t.
    .OnChange(watch, `(@self).watchHasChanged(#@watch, #@target));
    .TimerEvery(dead_seconds,
  `(@self).checkChange(#@watch, #@target));
}

/*
 * A callback function that checks for a change in a point and puts
 * a 1 or 0 into the target.  Reset the changed flag to zero.
 */
method TagMonitor.checkChange(watch, target)
{
    set(target, getprop(watch, #has_changed) ? 1 : 0);
    setprop(watch, #has_changed, nil);
}

/*
 * A callback whenever a change watch point changes.  We use this to
 * change from 0 to 1 as soon as we see a change in a watch point
 * instead of waiting for the poll delay.
 */
method TagMonitor.watchHasChanged(watch, target)
{
```

```
    setprop(watch, #has_changed, t);
    set(target, 1);
}

/* Write the 'main line' of the program here.
 *
 * As written, the points to watch for quality and change, as well as
 * the target points to modify, are all in the "default" domain,
 * as follows:
 *
 * Point to watch for quality:  default:quality_watch
 * Point to watch for change:   default:change_watch
 * Target point for quality:    default:quality_target
 * Target point for change:     default:change_target
 *
 * You can change these to different domain and point names.  Also,
 * you can add any number of other points to monitor quality and
 * change, following the same syntax.
 *
 * The first argument of .copyQuality is the poll rate in seconds on
 * the quality of the point.  The first argument of .copyChangeStatus
 * is the number of "dead" seconds to wait for a change, before
 * notifiying of a failure.
 */
method TagMonitor.constructor ()
{
    .copyQuality(1, #$default:quality_watch,
                 #$default:quality_target);
    .copyChangeStatus(5, #$default:change_watch,
                      #$default:change_target);
}

/* Any code to be run when the program gets shut down. */
method TagMonitor.destructor ()
{
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (TagMonitor);
```

TimedUpdate.g

TimedUpdate.g — periodically updates the timestamp on a set of DataHub points without changing their values.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to the section called "How to Run a Script" for more information on using scripts.

```
/*
 * This script runs a timer that periodically updates the timestamp on
 * a set of data points without changing their values.
 */

require ("Application");

/*
 * Modify the list of point names here to change which points will be
 * written. Modify the update time (in seconds) to change the write
 * frequency
 */

class TimedUpdate Application
{
 points = [ "default:test1", "default:test2" ];
 updateSecs = 5;
}

/* This is the callback that runs when the timer fires */
method TimedUpdate.doUpdate ()
{
 local current;
 with point in .points do
 {
  current = datahub_read(point);
  if (current[0])
  {
   // preserve the current value and quality,
          // but let the time change to the current
          // system clock time by not specifying
```

```
   // the time argument.  The "1" for the "force"
          // argument indicates that the DataHub
          // instance should emit a change even if
          // the settings would normally cause this
          // change to be ignored.
    datahub_write(point, current[0].value, 1,
          current[0].quality);
  }
 }
}

/* Write the 'main line' of the program here.
   This is where we start the timer. */
method TimedUpdate.constructor ()
{
 // The .TimerEvery function will start counting when the
        // script starts running, so it will not be synchronized with
        // a particular time of day.
 .TimerEvery (.updateSecs, `(@self).doUpdate());

 // If you want to synchronize the update with the time of day,
 // say exactly on each half-hour, you would use the .TimerAt
 // function.  The arguments are .TimerAt(day, month, year,
 // hour, minute, second, callback_function)
 // Specify nil to mean "any".  Specify a list to give
 // multiple values. For example, this will perform the update
 // at (0 and 30 minutes) and 0 seconds past every hour:
 // .TimerAt (nil, nil, nil, nil, list(0, 30), 0,
 //           `(@self).doUpdate());
}

/* Any code to be run when the program gets shut down. */
method TimedUpdate.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (TimedUpdate);
```

FixQuality.g

FixQuality.g — changes point quality for OPC clients that treat bad quality as a disconnection.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/* This application monitors a set of points in the "input domain"
   and copies them to the "output domain".  If the quality of the
   input point is not GOOD, then the script modifies the point value
   to -1 and the quality to GOOD.  This is to handle an OPC client
   that treats bad quality as a disconnection.
 *
 * To configure this application, modify the class variables:
 *    domain_in = the name of the input domain
 *    domain_out = the name of the output domain
 *    value_if_bad = the value to substitute on the point if the
 *                   quality is bad. If this is nil, then do no
 *                   value substitution.
 */
require ("Application");

class FixQuality Application
{
    domain_in = "test";
    domain_out = "test2";
    value_if_bad = -1;
}

/* Monitor a point.  This includes creating the point if it does
   not exist, and then creating the output domain's mirror of the
   point.  This function also sets up an event handler to map any
   future changes of the point into the output domain. */
method FixQuality.Monitor (ptname)
{
    local  outname, ptsym;

    outname = string(.domain_out, ":", ptname);
```

```
    ptname = string(.domain_in, ":", ptname);
    .OnChange(symbol(ptname),
       `(@self).BridgeQuality(#@ptname, #@outname));
    datahub_command(format("(create %s 1)", stringc(ptname)), 1);
    ptsym = symbol(ptname);
    if (!undefined_p(eval(ptsym)))
        .BridgeQuality(ptname, outname);
}

/* This is the function that does the work of mapping from the
   input domain to the output domain. */
method FixQuality.BridgeQuality(ptname, outname)
{
    local  info = PointMetadata(symbol(ptname));
    local  value = info.value;
    if (info.quality != OPC_QUALITY_GOOD && .value_if_bad)
        value = .value_if_bad;
    datahub_write(outname, value, 1,
    OPC_QUALITY_GOOD, info.timestamp);
}

method FixQuality.MonitorDomain(domain)
{
    local  points = datahub_points(domain, nil);
    with point in points do
    {
        .Monitor(point.name);
    }
}

/* This is the mainline of the program.  You can either call
   .Monitor("pointname") for each point, or you can call
   .MonitorDomain(.domain_in) to monitor all existing points in
   the input domain.  If you choose to monitor the whole domain,
   you must re-run this application whenever new points are added
   to the domain. */
method FixQuality.constructor ()
{
    .Monitor("point001");
    .Monitor("point002");
    .MonitorDomain(.domain_in);
}

/* Any code to be run when the program gets shut down. */
method FixQuality.destructor ()
{
```

```
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (FixQuality);
```

OPCItemLoader.g

OPCItemLoader.g — reads a list of OPC DA tags from a CSV file and configures DataHub points for them.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/* This script reads a set of OPC DA item names and point names from
 * a CSV file and updates the Manually Selected Items configuration
 * for an OPC DA connection.  The CSV file format can be one of:
 *     OPC_ITEM_ID
 * or
 *     OPC_ITEM_ID, OPC_DATAHUB_POINT_NAME
 *
 * If the OPC_DATAHUB_POINT_NAME is absent (the line contains only an
 * OPC DA item ID), then the script will create a DataHub point with
 * the same name as the OPC item ID.  The OPC item ID is the item ID
 * defined by the OPC DA server.
 *
 * To use this script, follow these steps:
 *
 * 1) Create the OPC connection that you want to add items to.
 *    Select "Manually Select Items" only in the "Item Selection"
 *    section.  You do not need to configure any items.  Press
 *    OK to save the OPC configuration, the press Apply on the
 *    DataHub properties dialog.
 * 2) Open this script in the editor and change the parameters in the
 *    OPCItemLoader class definition.  These are documented below.
 * 3) Close the OPC DataHub Properties window.
 * 4) Run this script by pressing the run button in the toolbar of
 *    the editor (the right-facing blue arrow).
 * 5) Open the OPC DataHub properties dialog, open the OPC
 *    configuration for your server and verify that the items were
 *    added.
 *
 * If the script has problems, you should see error messages in the
 * "Script Log" window.
 *
```

```
 * You must close the DataHub Properties window before running
 * this script or the changes made by this script may be lost.
 *
 * You do not need to run this script each time a DataHub instance is
 * started.  The configuration produced by this script will be saved
 * in the DataHub configuration file permanently.
 *
 * Editable fields:
 *   connection_name = the name of the OPC connection to be adjusted.
 *       This is the name entered into the box marked "Connection
 *       Name:" in the "Define OPC Server" dialog of the DataHub
 *       Properties dialog.
 *   file_name = the file name containing the OPC DA item names and
 *      point names.  The file name should contain the full path to
 *      the file, either as a literal string or as a function like
 *      this:
 *         file_name = "c:/path/to/file/my_file.csv";
 *         file_name = string(_config_path_, "/scripts/my_file.csv");
 *      If you use the \ character for a path separator,
 *      you must use two of them, like this:
 *         file_name = "c:\\path\\to\\file\\my_file.csv";
 *      The file can contain either one or two strings per line
 *      separated by commas.  If only a single string appears, it is
 *      taken to be the OPC server item name.  The point name is
 *      computed from the item name.  If two strings appear then the
 *      first string is the OPC item and the second string is the
 *      DataHub point name.  The point name will automatically be
 *      broken into components on a "." and a tree hierarchy will be
 *      created as if each component but the last is a tree branch.
 *   trim_spaces = t if you want the item and point names to be
 *       trimmed of all leading and trailing white space and tabs,
 *       otherwise nil.
 *   path_separator = nil if you do not want to split point names
 *       to produce a tree hierarchy, otherwise a string containing
 *       separator characters.  Normally this will be a "." character.
 */

require ("Application");
require ("WindowsSupport");
require ("OPCSupport");

class OPCItemLoader Application
{
    connection_name = "OPC000";
    // Change this to the connection name of the connection to edit
    file_name = "C:/my/file/path/my_items.csv";
```

```
    // Change this to the full path and file name containing
    // the item and point names
    trim_spaces = t;
    // set to nil to preserve leading and trailing spaces in item
    // names
    path_separator = ".";
    // Characters used to split point names into tree components
    file_is_8bit_ansi = t;
    // Set to t if file uses 8-bit extended ANSI, nil if 7-bit ASCII
    // or UTF-8
    opc_connection;
}

method OPCItemLoader.Trim (str)
{
    local i=0, j, len;
    len = strlen(str);
    while (i < len && (str[i] == ' ' || str[i] == '\t'))
        i++;

    j = len - 1;
    while (j >= i && (str[j] == ' ' || str[j] == '\t'))
        j--;

    if (j>=i)
        str = substr(str, i, j-i+1);
    else
        str = "";
    str;
}

method OPCItemLoader.ReadCSVFile (filename)
{
    local  fptr = open (filename, "r", nil);
    local  line, i;
    if (fptr)
    {
        while ((line = read_line(fptr)) != _eof_)
        {
            if (.file_is_8bit_ansi)
                line = strcvt(line);

            if (line != "")
            {
                line = list_to_array(string_split(line, ",",
        0, nil,
```

```
        nil, nil,
        "\\", nil));
                if (.trim_spaces)
                {
                    for (i=0; i<length(line); i++)
                    {
                        line[i] = .Trim(line[i]);
                    }
                }
                if (length(line) == 1)
                    .AddOPCItem(line[0], line[0]);
                else if (length(line) > 1)
                    .AddOPCItem(line[0], line[1]);
            }
        }
        close (fptr);
    }
    else
    {
        local s = strerror(errno());
        princ (class_name(self), ": Could not open file: ",
        filename, ": ", s, "\n");
    }
}

method OPCItemLoader.AddOPCItem(itemname, pointname)
{
    .opc_connection.addItem(pointname, itemname, OPC_NODE_LEAF,
       .path_separator);
}

method OPCItemLoader.LoadFromCSV(opc_conn_name, filename)
{
    local opc = new OPCConnection();
    opc.setServer(opc_conn_name);
    .opc_connection = opc;
    .ReadCSVFile(filename);
    opc.applyConfig();
}

/* Write the 'main line' of the program here. */
method OPCItemLoader.constructor ()
{
    .LoadFromCSV(.connection_name, .file_name);
}
```

```
/* Any code to be run when the program gets shut down. */
method OPCItemLoader.destructor ()
{
}

ApplicationSingleton (OPCItemLoader);
```

OPCReconnect.g

OPCReconnect.g — disconnects and reconnects an OPC DA server.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/* Sample script that disables the OPC DA connection labeled
 * "OPC000", waits 2 seconds, then re-enables the connection.
 * The result will be that the DataHub instance disconnects
 * from the server for 2 seconds and then reconnects.
 */

require ("Application");
require ("OPCSupport");

class OPCReconnect Application
{
}

/* Create an object that references an existing OPC DA connection
 * that we have configured through the user interface.  Its label
 * is the first argument to setServer below.  Once we have the OPC
 * connection object, we can call enable() with t or nil in the
 * argument to enable or disable this connection.
 */
method OPCReconnect.enable(enabled)
{
    local opcclient = new OPCConnection();
    opcclient.setVerbose(t);
    opcclient.setServer("OPC000");
    opcclient.enable(enabled);
}

method OPCReconnect.constructor ()
{
    .enable(nil);
    .TimerAfter(2, `(@self).enable(t));
}
```

```
ApplicationSingleton (OPCReconnect);
```

OPCReload.g

OPCReload.g — requests a reload of OPC DA server data with no disconnect.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to the section called "How to Run a Script" for more information on using scripts.

```
/* This script requests a reload of data from a connected OPC DA
 * server without disconnecting from the server.  It is particularly
 * useful for automatically adding new points, and can poll for new
 * points based on a timer or on a trigger point.
 *
 * You will need to edit the following three variables to run the
 * script on your system:
 *
 *  connection_label: The name given to your OPC DA connection when
 *                    you defined your OPC server.  This appears in
 *                    the "Connection" column in your list of OPC
 *                    Client connections in the Properties window.
 *
 *  poll_time:   The poll rate to check for new points, in seconds.
 *
 *  trigger_point:  The name of the point you will use as a trigger.
 *
 */

require ("Application");
require ("OPCSupport");

class OPCReload Application
{
    connection_label = "OPC002";  // connection label in "Connection"
                                  // column of OPC properties
    poll_time = 30;               // poll rate for new points,
                                  // in seconds
    trigger_point = #$domain_name:point_name;  // name of point
                                               // used as a trigger
}
```

```
/* Transmit a "reload" command to the server, without disconnecting.
 * To disconnect and reload, change the paramter to opc.reload to t
 * instead of nil.
 */
method OPCReload.reload ()
{
    local   opc = new OPCConnection();
    opc.setVerbose(t);
    opc.setServer(.connection_label);
    opc.reload(nil);
}

/* Start the polling timer */
method OPCReload.constructor ()
{
    // To poll for new points periodically, use this line
    .TimerEvery (.poll_time, `(@self).reload());

    // To poll for new points only when a specific data point changes,
    // use this line
    .OnChange (.trigger_point, `(@self).reload());
}

/* Instantiate the class.  This calls the constructor. */
ApplicationSingleton (OPCReload);
```

Built-in Classes

DH_Domain

DH_Domain — the structure of a DataHub domain.

Synopsis

```
class DH_Domain
{
    name;          // the name of the domain, as a string
    auto_created; // 1 if the domain was created implicitly due to
                  // a point reference,
                  // or 0 if the domain was configured in the
                  // General tab
    n_points;     // the number of points in this domain, including
                  // points with values and branches in the
                  // hierarchy tree
    n_assemblies; // Not implemented
    n_attributes; // Not implemented
    n_bridges;    // The number of domain bridges or redundancy pairs
                  // in which this domain is participating
}
```

DH_Item

`DH_Item` — the structure of a DataHub point.

Synopsis

```
class DH_Item
{
    canonical_type;     // number: The canonical VARIANT type
    conf;               // number: confidence (0-100)
    domain;             // string: The domain name
    flags;              // number: flags describing the point
    n_aliases;          // number of aliases for this point
    n_attributes;       // number of attributes this point has
    n_pending;          // number of clients with a change pending
    n_properties;       // number of properties this point has
    n_registered;       // number of clients registered for changes
    n_subassemblies;    // number of subassemblies this point has
    name;               // string: name of the point, without
                        // the domain
    opcaccessrights;    // number: read/write flags
    propid;             // number: property id if applicable
    quality;            // number: OPC item quality
    security;           // number: security level (not used)
    timestamp;          // number: time stamp in Windows epoch time
    value;              // variant: the point value
}
```

Instance Variables

`flags`

This instance variable may be a combination of zero or more of the following flags.

Hex	Constant	Description
0x00001	READABLE	Item is readable.
0x00002	WRITABLE	Item is writable.
0x00004	LOCKED	Item is locked (not used).
0x00008	PROPERTY	Item is a property of another point.
0x00010	SUBASSEMBLY	Item is a subassembly of another point.
0x00020	ASSEMBLY	Item is an assembly.
0x00040	ATTRIBUTE	Item is an attribute of another point.
0x00080	TYPE	Item is an attribute type.

Hex	Constant	Description
`0x00100`	`ACTIVE`	Item is active.
`0x00200`	`PRIVATE_ATTRIBUTE`	Item is a private attribute of a type.
`0x00800`	`HIDDEN`	Item is hidden.
`0x01000`	`AUTO_ID`	Item was assigned a `propid` automatically.
`0x40000`	`TEMP_VALUE`	Item's value is temporary, probably `Not Connected` assigned by an interface becoming disconnected.

Dictionary

`Dictionary` — stores key/value pairs.

Synopsis

```
class Dictionary
{
    keys;
    values;
}
```

Description

This class stores key/value pairs. Keys and values can be any type, with the limitation that a key cannot be `nil`. Comparison uses the `equal` operator, so strings are case-sensitive and numbers of different types with the same value will compare as equal. Insertion and lookup complexity are approximately `O(log2(N))`.

Methods

`add((`*key*, *value*)

Adds a new entry to the dictionary, and returns *value*. Throws an error if the *key* already exists in the dictionary.

`contains(`*key*)

Returns non-`nil` if the *key* is in the dictionary, otherwise `nil`.

`get(`*key*)

Returns the value at the *key*, or throws an error if the *key* does not exist in the dictionary.

`remove(`*key*)

Removes the (*key*,*value*) pair for the *key* and returns non-`nil`. Throws an error if the *key* does not exist in the dictionary.

`set(`*key*, *value*)

Changes the *value* for the *key*, or throws an error if the *key* does not exist in the dictionary.

`dictionary[`*key*]

Retrieves a value in the dictionary at the *key*, using the syntax of array access. Returns the value at the *key*, or `nil` if the *key* does not exist in the dictionary. This access does not throw an error if the *key* does not exist.

`dictionary[`*key*] = *value*

Sets the entry in the dictionary at the *key* to the *value* using the syntax of array assignment. Returns the *value*. If the *key* does not exist, it is added to the dictionary, otherwise the existing *value* is replaced. This assignment does not throw an error if the *key* does not exist.

Instance Variables

`keys`

An array of all keys currently present in the dictionary.

`values`

An array of all values currently present in the dictionary, with the same length and in the same order as *keys*.

Examples

Using methods:

```
--> D = new(Dictionary)
{Dictionary (keys . []) (values . [])}
--> D.add("k1", 5)
5
--> D.add("k2", "value2")
"value2"
--> D.get("k2")
"value2"
--> D.contains("k1")
t
--> D.set("k1", 22)
22
--> D.keys
["k1" "k2"]
--> D.values
[22 "value2"]
```

Using array notation:

```
--> D[44] = "some value"
"some value"
--> D[45] = "another value"
"another value"
--> D["k3"] = 15
15
--> D["k1"]
22
--> D
{Dictionary (keys . [44 45 "k1" "k2" "k3"])
     (values . ["some value" "another value" 22 "value2" 15])}
```

Special Gamma Functions for DataHub Scripting

_

_ — looks up a translation text.

Synopsis

```
_(string)
```

Arguments

string

A string that should be translated.

Returns

The translation of the string.

Description

This function looks up a pre-configured translation text. It is used internally by the DataHub interface programmer to specify which text strings in the interface should be translated when the user selects a language in the Properties window of the DataHub instance. Language selection itself cannot be done within the Gamma engine; it can only be done through the Properties window.

If your language is not available in the DataHub program, you can contact Cogent for instructions on how to add a translation to the Cogent DataHub source code.

The unusual name for this function is based on a convention of GNU's `gettext` function, in which the underscore symbol (_) can be used in place of the `gettext` function name.

add_menu_action

`add_menu_action` — adds a menu action.

Synopsis

```
add_menu_action (menu_id, s_exp)
```

Arguments

menu_id
: A unique ID number for this item.

s_exp
: A Gamma expression that is the action to be taken when a menu item is selected.

Returns

A list:

```
(menu_id s_exp)
```

Where the *s_exp* is in Lisp format.

Description

This function lets you specify what code gets run when a menu item is selected. The code can be removed using `remove_menu_action`

Example

This example is part of the `WindowsExample.g` example program:

```
method WindowsExample.AddSubMenu (parent, pos, label)
{
 local submenu = CreatePopupMenu();
 InsertMenu (traymenu, pos, MF_BYPOSITION | MF_POPUP,
    submenu, label);
 .menu_items = cons (cons (submenu, t), .menu_items);
 submenu;
}

method WindowsExample.AddMenuItem (parent, pos, label, code)
{
 local info = new MENUITEMINFO();

 info.cbSize = 48;
```

```
 info.fMask = MIIM_STRING | MIIM_FTYPE | MIIM_ID;
 info.fType = MFT_STRING;
 info.wID = ++MenuItemID;
 info.dwTypeData = label;
 InsertMenuItem (parent, pos, 1, info);
 local action = add_menu_action (MenuItemID, code);
 .menu_actions = cons (action, .menu_actions);
}

method WindowsExample.AddMenus ()
{
 local  traymenu = get_tray_menu ();

 if (traymenu != 0)
 {
  local submenu = .AddSubMenu (traymenu, 5, "Monitor Functions");

  .AddMenuItem (submenu, -1, "Select Color",
       `(@self).SelectTrayMenuItem (@MenuItemID+1));
  .AddMenuItem (submenu, -1, "Select File",
       `new GFileDialog (1).DoModal(0));
  .AddMenuItem (submenu, -1, "Select Folder",
       `new GFolderDialog ().DoModal(0));
 }
 else
 {
 }
}
```

allow_self_reference

`allow_self_reference` — permits changes to be written back to the point of origin.

Synopsis

```
allow_self_reference (symbol, allow)
```

Arguments

symbol
Any valid Gamma symbol.

allow
1 or any other non-zero value allows self-referential behavior; 0 disallows it.

Returns

The value of the *allow* parameter.

Description

This function tells the Gamma engine not to generate a warning if a change function like on_change causes a sequence of events that changes the original point again.

Example

This example is from LinearXform.g.

```
method LinearXform.AddLinearXform (app, src, dst, mult, add,
                                   bidirectional_p?=nil)
{
    app.OnChange (src, `(@self).cbLinearXform (#@dst, value,
                                               @mult, @add));
    if (bidirectional_p && mult != 0)
    {
        allow_self_reference (src, 1);
        allow_self_reference (dst, 1);
        app.OnChange (dst, `(@self).cbLinearXform (#@src, value,
                                                   1/@mult,
                                                   (@-add)/(@mult)));
    }
}
```

datahub_command

`datahub_command` — sends commands to the DataHub program.

Synopsis

```
datahub_command (command, sync?)
```

Arguments

`command`
A string containing a DataHub configuration command.

`sync`
`1` sends the command synchronously; `0` sends the command asynchronously.

Returns

The result of the command, as a string.

Description

This function sends configuration commands to a DataHub instance, in Lisp format. It returns the result of the command as a string. For more information on DataHub commands, please refer to the Using DataHub Commands chapter of the Cogent DataHub manual.

Setting the *sync* parameter to `1` (synchronous) may slow the execution a tiny bit, but it ensures that the DataHub instance will complete the command before your script continues. Setting the *sync* parameter to `0` will allow your script to continue whether or not the DataHub command has executed. For most cases, we recommend setting it to `1`, just to be on the safe side. This ensures that your script will execute commands in the order expected. The tiny delay for synchronous execution is in micro-milliseconds—insignificant for most applications.

Escaping Characters

Since commands are sent within strings, you probably need to escape certain characters, using the backslash (\). For example, to escape the quote marks delineating the string `"my_string"`, you would enter the string as: `\"my_string\"`.

Windows File Paths

Normally if a command is in a configuration file, you need to escape the backslash in file names, like this:

```
c:\\tmp\\datahub.log
```

But, if you are issuing the command from gamma using **datahub_command** you need to escape each of those two backslashes, like this:

```
c:\\\\tmp\\\\datahub.log
```

So the command would be:

```
datahub_command ("(log_file \"c:\\\\tmp\\\\datahub.log\")")
```

Since the quotes are optional (though recommended) in DataHub commands you could do this:

```
datahub_command ("(log_file c:\\\\tmp\\\\datahub.log)")
```

Fortunately, recent Microsoft operating systems will accept forward slashes in file names, so for those versions you can do this:

```
datahub_command ("(log_file c:/tmp/datahub.log)")
```

Example

This example creates a new point in the DataHub instance, and sets its value to 5.

```
if (undefined_p($default:MyNewPoint))
{
    datahub_command ("(cset default:MyNewPoint 5)", 1);
}
```

datahub_domaininfo

`datahub_domaininfo` — gives information about data domains.

Synopsis

```
datahub_domaininfo(pattern?)
```

Arguments

pattern
: A character string which specifies a search pattern

Returns

An array of instances of the `DH_Domain` class.

Description

This function provides information about all data domains whose names match the *pattern*, or all domains if the *pattern* is left blank. The *pattern* can contain the following special characters:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

Example

```
--> datahub_domaininfo();
[{DH_Domain (auto_created . 1) (n_assemblies . 0) (n_attributes . 0)
     (n_bridges . 0) (n_points . 8) (name . "DataSim")}
 {DH_Domain (auto_created . 0) (n_assemblies . 0) (n_attributes . 0)
     (n_bridges . 0) (n_points . 6) (name . "MySource")}
 {DH_Domain (auto_created . 0) (n_assemblies . 0) (n_attributes . 0)
     (n_bridges . 0) (n_points . 3) (name . "default")}]

--> datahub_domaininfo("*Sim");
[{DH_Domain (auto_created . 1) (n_assemblies . 0) (n_attributes . 0)
```

```
     (n_bridges . 0) (n_points . 8) (name . "DataSim")}
```

datahub_domains

datahub_domains — creates a list of all domains.

Synopsis

```
datahub_domains()
```

Arguments

none

Returns

A list of domain names.

Description

This function creates a list of all domains currently in the DataHub instance, except the default domain.

Example

```
--> datahub_domains();
(DataSim PlantA PlantB)
```

datahub_log

`datahub_log` — writes a string to the Event Log window.

Synopsis

```
datahub_log (trace_level, message)
```

Arguments

`trace_level`
One of: `DHTL_DEBUG`, `DHTL_INFO`, `DHTL_WARNING`, `DHTL_ERROR`.

`message`
Any string.

Returns

`t` on success, otherwise an error message.

Description

This function will write a string to the DataHub Event Log window. The *`trace_level`* parameter corresponds to the level of **Severity** in the Event Log, and the relevant filtering will apply. The **Facility** is always **General**. Messages written with this function will be written to disk if the Event Log is being saved.

datahub_points

datahub_points — shows the points in a data domain.

Synopsis

```
datahub_points (parent, top_level_only? = nil, pattern?)
```

Arguments

parent
: A string containing the name of the parent domain or point name whose child points you wish to list.

top_level_only
: If t, returns only the direct children of the parent. Otherwise, it returns all descendents of the parent.

pattern
: Returns only those points whose full name (the entire point path without the domain: prefix) matches the pattern.

Returns

An array of instances of the DH_Item class.

Description

This function provides an array containing the DataHub points in a given domain. The *pattern* can contain the following special characters:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

Example

```
–> datahub_points("MySource", t);
[{DH_Item (canonical_type . 0) (conf . 0) (domain . "MySource")
    (flags . 307) (n_aliases . 0) (n_attributes . 0) (n_pending . 0)
```

```
   (n_properties . 0) (n_registered . 1) (n_subassemblies . 1)
   (name . "A_Branch") (opcaccessrights . 3) (propid . 0)
   (quality . 0) (security . 0) (timestamp . 0) (value)}]

--> datahub_points("MySource", nil, "*em2");
[{DH_Item (canonical_type . 5) (conf . 0) (domain . "MySource")
    (flags . 579) (n_aliases . 0) (n_attributes . 0) (n_pending . 0)
   (n_properties . 0) (n_registered . 1) (n_subassemblies . 0)
   (name . "A_Branch.Ramp.X_Branch.Item2") (opcaccessrights . 3)
   (propid . 0) (quality . 192) (security . 0)
   (timestamp . 40200.75880280092) (value . 0)}]
```

datahub_read

`datahub_read` — creates a list of all points for a domain.

Synopsis

```
datahub_read (pointnames ...)
```

Arguments

pointnames
A DataHub point name as a string, or a list of such DataHub point names as strings. If the first argument is a list, then it is used for pointnames, and all following arguments are ignored. If not, multiple point names can be passed as individual arguments.

Returns

An array in the same order as the specified point names.

Description

This function reads the point identified by each string in *pointnames*, and returns a `DH_Item` structure for each point, or `nil` if the point does not exist.

datahub_write

`datahub_write` — assigns a value to a DataHub point.

Synopsis

```
datahub_write (pointname, value [, force, quality, timestamp])
```

Arguments

pointname

The name of the point, as a string.

value

The value to be assigned to the point—a number, string, or array.

force

Causes the write to occur even if the value and quality are the same as the value currently in the DataHub instance. This is useful if you are changing only the time stamp of the point. Enter `t` to force, or `nil` to not force.

quality

The quality of a point, as a number. You can use the constants `OPC_QUALITY_*` found in `GetQualityName` by requiring that file like this: `require("Quality.g");`.

timestamp

The time stamp in Windows time. Windows time is a floating point number that can be obtained in the Gamma engine by requiring `Time.g` like this: `require("Time.g");`, then calling the functions `GetCurrentWindowsTime`, `UnixTimeToWindowsTime`, or `PointGetWindowsTime`.

Returns

`t` on success, otherwise an error message.

Description

This function is the same as the Gamma `force` function, but the *pointname* is a string, so the symbol never needs to be created in the Gamma engine. This can be used to reduce Gamma engine load when using a large number of points.

edit_file

`edit_file` — opens a file in the Script Editor.

Synopsis

```
edit_file (filename)
```

Arguments

`filename`
The name of the file you wish to edit, as a string.

Returns

`t` on success, otherwise an error message.

Description

This function opens the Script Editor and loads a requested file. If the requested file cannot be found, it creates a new file with the requested name.

flush_log_file

`flush_log_file` — writes buffered text of Script Log output to the file.

Synopsis

```
flush_log_file ()
```

Returns

`t` on success, otherwise an error message.

Description

This function causes any buffered text of Script Log output to be written to the log file. The log file is block-buffered, so text is held in memory until a full block is available to write or the file is flushed. The block size is operating-system dependent.

See also `set_log_file` and `set_log_size`.

freeze_writes

`freeze_writes` — controls when writes are sent to the DataHub engine.

Synopsis

```
freeze_writes (t|nil)
```

Arguments

t|nil
: Calling this function with a true value (`t`) collects all subsequent `datahub_write` calls in an internal buffer. A `nil` value sends the accumulated calls to the DataHub engine in a single call, and re-enables normal `datahub_write` calls.

Returns

`t` on success, otherwise an error message.

Description

When writing large numbers of points to the DataHub engine the thread context switch adds significant delay. Using this function allows write requests to accumulate in an internal buffer and get sent all at one time. Use like this:

1. Call `freeze_writes(t)`.
2. Call `datahub_write` multiple times as needed (within reason).
3. Call `freeze_writes(nil)`. This will execute all the preceding writes in a single call

See also `datahub_write`.

get_point_queue_count

`get_point_queue_count` — counts the number of DataHub points queued for the Gamma engine.

Synopsis

```
get_point_queue_count ()
```

Arguments

none

Returns

On success, the number of points currently queued, as an integer. Otherwise an error message.

Description

This function queries the DataHub instance for the total number of point changes currently queued to be passed to the Gamma engine. Please refer to `_point_queue_depth` for a description of the queue. See also `get_point_queue_depth`.

get_point_queue_depth

`get_point_queue_depth` — gets the depth of the DataHub instance's per-point queue for the Gamma engine.

Synopsis

```
get_point_queue_depth ()
```

Arguments

none

Returns

On success, the depth of the queue, as an integer. Otherwise an error message.

Description

This function queries the depth of the queue for DataHub changes that get passed to the Gamma engine. Please refer to `set_point_queue_depth` for a description of the queue. See also `get_point_queue_count`.

get_tray_menu

`get_tray_menu` — returns a pointer to the tray menu.

Synopsis

```
get_tray_menu ()
```

Arguments

none

Returns

The ID number for the tray menu.

Description

This function returns a pointer to the tray menu.

on_change

on_change — evaluates an expression when a variable changes value or quality.

Synopsis

```
on_change (symbol, s_exp)
```

Arguments

symbol
: Any Gamma symbol.

s_exp
: Any Gamma expression, usually a function or method call.

Returns

A list of the following items:

```
({class_name } fn_name fn_args...)
```

Where *fn_name* and *fn_args* correspond to the *s_exp* parameter.

Description

This function causes an expression (*s_exp*) to be evaluated when a variable (*symbol*) changes value or quality. It can be undone with a call to remove_change.

Example

```
method AccessData.constructor ()
{
    on_change(#$DataSim:Sine,
              `(@self).print_point($DataSim:Sine));
    after(3, `destroy(@self));
}
```

remove_change

remove_change — removes an on_change function.

Synopsis

```
remove_change (symbol, s_exp)
```

Arguments

symbol
: Any Gamma symbol.

s_exp
: Any Gamma expression, usually a function or method call.

Returns

A list of the following items:

```
(class fn_name fn_args ...)
```

Where *fn_name* and *fn_args* correspond to the *s_exp* parameter.

Description

This function reverses a call to on_change, ending the evaluation of the *s_exp* whenever the *symbol* changes.

Example

```
method AccessData.destructor ()
{
    remove_change(#$DataSim:Sine,
                  `(@self).print_point($DataSim:Sine));
}
```

remove_menu_action

`remove_menu_action` — removes a menu action.

Synopsis

```
remove_menu_action (menu_id, s_exp)
```

Arguments

menu_id
: A unique ID number for this item.

s_exp
: A Gamma expression that is the action to be removed.

Returns

A list:

```
(menu_id s_exp)
```

Where the *s_exp* is in Lisp format.

Description

This function removes a menu action, usually one that was added by `add_menu_action`.

Example

This example is part of the `WindowsExample.g` example program:

```
method MonitorWindow.destructor ()
{
...
    try
    {
        with x in .menu_actions do
            remove_menu_action (car(x), cdr(x));
    }
    catch
    {
        princ ("Error: ", _last_error_, "\n");
        print_stack();
    }
...
```

set_log_file

`set_log_file` — sets the file and open mode for writing Script Log output.

Synopsis

```
set_log_file (filename, mode)
```

Arguments

`filename`
: The full path to the file to write.

`mode`
: The open mode, which can be one of `w`, `w+`, `a`, or `a+`. Other characters might be available, depending on the operating system. Please refer to the documentation for the operating system's `fopen` function.

Returns

`t` on success, otherwise an error message.

Description

This function sets the file and open mode for writing Script Log output. An *open* mode of `w` will overwrite an existing log file, and `a` will append to an existing log file, or start a new file if none currently exists. If *`filename`* is `nil` then the existing log file is closed and logging to file stops. Logging to file adds some delay when writing large amounts of information to the log.

See also `set_log_size` and `flush_log_file`.

set_log_size

`set_log_size` — sets the maximum log file size for Script Log output.

Synopsis

```
set_log_size (nbytes)
```

Arguments

nbytes

The approximate maximum number of bytes to store before rotating the log file.

Returns

`t` on success, otherwise an error message.

Description

This function sets the approximate maximum file size for holding Script Log output. The actual file size will be slightly larger, as the file is rotated at the first line break after the transaction that exceeds the file size. When the log file is rotated, the current file is moved to *filename*.1, and *filename* is recreated. If *filename*.1 exists before rotation, it will be deleted and replaced with the current log file.

See also `set_log_file` and `flush_log_file`.

set_point_flush_flags

`set_point_flush_flags` — determines which data types are not buffered.

Synopsis

```
set_point_flush_flags (flags)
```

Arguments

flags

Any combination of:

VT_EMPTY	=	0
VT_I2	=	2
VT_I4	=	3
VT_R4	=	4
VT_R8	=	5
VT_CY	=	6
VT_DATE	=	7
VT_BSTR	=	8
VT_BOOL	=	11
VT_I1	=	16
VT_UI1	=	17
VT_UI2	=	18
VT_UI4	=	19
VT_I8	=	20
VT_UI8	=	21
VT_INT	=	22
VT_UINT	=	23

`item.conf`

A number from `0` to `100` indicating a confidence factor.

`item.flags`

Any bitwise combination of the following numeric set of flags:

0x01	Turn on un-buffered checking. Always include this with any other of these flags
0x02	Flush on boolean data. If a boolean value changes, transmit all

	queued values.
`0x04`	Flush on integer data. If a boolean value changes, transmit all queued values.
`0x08`	Flush on floating point data. If a floating point value changes, transmit all queued values.
`0x10`	Flush on string data. If a string value changes, transmit all queued values.

Returns

`t` on success, otherwise an error message.

Description

This function sets which data types will cause the point buffer to immediately be transmitted to the Gamma engine. If *`flags`* is `0`, then the transmission is always buffered. For example, to flush all queued data whenever a boolean or string value changes, make this call:

```
set_point_flush_flags(0x01 | 0x02 | 0x10);
```

To return the Gamma engine to fully buffered transmission, use:

```
set_point_flush_flags(0);
```

set_point_queue_depth

`set_point_queue_depth` — sets the depth of the DataHub instance's per-point queue for Gamma.

Synopsis

```
set_point_queue_depth (N)
```

Arguments

N
: An integer defining the depth of the queue.

Returns

`t` on success, otherwise an error message.

Description

The DataHub program has a special queueing mechanism for point changes that get sent to the Gamma engine. If a DataHub instance receives incoming point changes faster than the Gamma engine can process them, it puts the new values into a queue for that point. When the Gamma engine is ready to process the next value of that point, it receives the earliest value from that queue, then the next value, and so on, in time-sequential order.

This function allows you to set the depth of this queue, in other words, the number of values per point that the DataHub instance will store in the queue. The default depth is 3. We recommend setting the queue depth as small as possible, since a deep queue will decrease the Gamma engine's response time. If you want to minimize the response time and always use the very latest value, you can set *N* to `0` or `1`, which effectively eliminates the queueing behavior altogether.

See also `get_point_queue_depth` and `get_point_queue_count`.

show_log

`show_log` — displays the Script Log.

Synopsis

```
show_log ()
```

Arguments

none

Returns

`t` on success, otherwise an error message.

Description

This function displays the Script Log if it is not already open.

symcmp

symcmp — compares symbols to see if they are equal.

Synopsis

```
symcmp (symbol, symbol)
```

Arguments

symbol
: Any valid Gamma symbol.

Returns

A negative number if the first *symbol* is ordinally less than the second *symbol* according to the ASCII character set, a positive number if the first *symbol* is greater than the second, and zero if the two symbol strings are exactly equal.

Description

This function compares symbols to see if they are equal. Neither of the symbols are evaluated when passed to the function. This function can be used as a comparison function for `sort` and `insert`.

Example

This example was done in the Script Log.

```
--> symcmp(a,b);
-1
--> symcmp(a,a);
0
--> symcmp(b,a);
1
-->  y = array(#c, #d, #a);
[c d a]
--> y = sort(y, symcmp);
[a c d]
--> insert(y, symcmp, #b);
b
--> y;
[a b c d]
```

Methods and Functions from `Application.g`

AddCustomMenuItem

`AddCustomMenuItem` — a convenience method for creating a menu item.

Synopsis

```
AddCustomMenuItem (label, code)
```

Arguments

label
The name of the item, as a text string, that will actually appear on the menu.

code
Any piece of code that should be run when the menu item is selected.

Returns

A list containing two members: the ID number for this action, followed by a Gamma expression that is the action to be taken when a menu item is selected.

Description

This method is a convenience method for adding a menu item. It is a wrapper on `AddMenuItem`. It creates an item for a menu created by `AddCustomSubMenu`, allowing any arbitrary code to be attached. This method can be used for modifying the application as it runs. Items to be created by this command must be coded immediately after `AddCustomSubMenu`, and will appear in sequence on that submenu.

Example

```
.AddCustomSubMenu("My Menu", 3);
.AddCustomMenuItem("My First Item, `princ("First Item Activated\n"));
.AddCustomMenuItem("My Second Item, `princ("Second Item Activated\n"));
.AddCustomMenuItem("My Third Item, `princ("Third Item Activated\n"));
...
```

AddCustomSubMenu

AddCustomSubMenu — a convenience method for adding a menu.

Synopsis

```
AddCustomSubMenu (label, pos?=._TrayMenuPosition)
```

Arguments

label
: The name of the menu, as a text string, that will actually appear on the menu.

pos
: An integer desinating the position of this item on the menu. This is an optional argument. If not specified, the value of the `_TrayMenu` class variable will be used.

Returns

The value of the `._CustomSubmenu` class variable, a positive integer.

Description

This method is a convenience method for adding a menu. It is a wrapper on `AddSubMenu` that also automatically assigns the parent menu and arranges its items sequentially as they coded, using the `AddCustomMenuItem` method.

AddMenuItem

`AddMenuItem` — adds a menu item and attaches code to it.

Synopsis

```
AddMenuItem (parent, pos, label, code)
```

Arguments

parent
: The parent menu for this item, such as that returned by a call to `CreateSystemMenu` or `AddSubMenu`.

pos
: An integer desinating the position of this item on the menu.

label
: The name of the item, as a text string, that will actually appear on the menu.

code
: Any piece of code that should be run when the menu item is selected.

Returns

A list containing two members: the ID number for this action, followed by a Gamma expression that is the action to be taken when a menu item is selected.

Description

This method is used to populate a submenu of the DataHub system tray menu with a selectable item that runs user-specified code when selected.

AddPermanentMenuItem

`AddPermanentMenuItem` — should not be used.

Synopsis

```
AddPermanentMenuItem (parent, pos, label, code)
```

Description

This method should not be used.

AddStartMenuItem

`AddStartMenuItem` — should not be used.

Synopsis

```
AddStartMenuItem (label)
```

Description

This method is for internal use only.

AddStopMenuItem

`AddStopMenuItem` — creates a menu item that destroys the running application.

Synopsis

```
AddStopMenuItem (label)
```

Arguments

label
: The name of the item, as a text string, that will actually appear on the menu.

Returns

A list containing two members: the ID number for this action, followed by a Gamma expression that is the action to be taken when a menu item is selected.

Description

This method lets you create an item on a DataHub system tray menu that will exit the application and remove all event handlers and menu items.

AddSubMenu

`AddSubMenu` — creates a submenu on a parent menu.

Synopsis

```
AddSubMenu (parent, pos, label)
```

Arguments

parent
: The parent menu for this submenu, such as that returned by a call to `CreateSystemMenu` or `AddSubMenu`.

pos
: An integer designating the position of this item on the menu.

label
: The name of the submenu, as a text string, that will actually appear.

Returns

The value of the `._CustomSubmenu` class variable, a positive integer.

Description

This method adds a submenu to the DataHub system tray menu. The submenu can then be used for adding menu items or other submenus.

ApplicationMultiple

`ApplicationMultiple` — allows creation of multiple instances of the class.

Synopsis

```
ApplicationMultiple (klass)
```

Arguments

klass

Returns

Description

This function does the opposite of `ApplicationSingleton`. It allows the creation of multiple instances of the `Application` class, giving each new instance the same name but not the exact same definition.

ApplicationSingleton

`ApplicationSingleton` — allows creation of only one instance of the class.

Synopsis

```
ApplicationSingleton (klass)
```

Arguments

klass
The name of a class.

Returns

The instance of the class named by *klass*.

Description

This function creates a singleton based on the name of a class, which in most cases is desirable. This is useful because a class is routinely redefined by reloading its corresponding file, The alternative, `ApplicationMultiple` gives instances of the class the same name but not the same definition.

CreateSystemMenu

`CreateSystemMenu` — adds a submenu to the system tray menu.

Synopsis

```
CreateSystemMenu ()
```

Arguments

none

Returns

The value of the `._CustomSubmenu` class variable, a positive integer.

Description

This method adds a **Scripts** submenu to the DataHub system tray menu, which can then be used for adding submenus or menu items for DataHub scripts.

droptimer

`droptimer` — for internal use only.

Synopsis

```
droptimer (tid)
```

Description

This method is for internal use only.

OnChange

`OnChange` — attaches an event handler to a point change event.

Synopsis

```
OnChange (sym, fn)
```

Arguments

`sym`

Any Gamma symbol.

`fn`

A function or method call.

Returns

A list containing the *`sym`* and *`fn`*.

Description

This method is a wrapper for the on_change function. In addition to applying that function, it adds this change to the class's `_ChangeFunctions` list. For more information, please refer to the section called “Handling Events”.

RemoveAllChanges

`RemoveAllChanges` — removes event handlers from all point change events.

Synopsis

```
RemoveAllChanges ()
```

Arguments

none

Returns

`nil` on success, otherwise an error.

Description

This method removes all changes from the class's `_ChangeFunctions` list, and reassigns the `_ChangeFunctions` variable to `nil`. For more information, please refer to the section called “Handling Events”.

RemoveAllEventHandlers

`RemoveAllEventHandlers` — removes all point change events and all timers.

Synopsis

```
RemoveAllEventHandlers ()
```

Arguments

none

Returns

`nil` on success, otherwise an error.

Description

This method removes all change events and all timers by calling `RemoveAllChanges` and `RemoveAllTimers`.

RemoveAllMenus

`RemoveAllMenus` — removes all script menus, submenus, and menu actions.

Synopsis

```
RemoveAllMenus ()
```

Arguments

none

Returns

`nil` on success, or an error.

Description

This method removes all script menus, submenus, menu items, and actions.

RemoveAllTimers

`RemoveAllTimers` — cancels all timers.

Synopsis

```
RemoveAllTimers ()
```

Arguments

none

Returns

`nil` on success, or an error.

Description

This method cancels all timers and sets the `._TimerIDs` list to `nil`.

RemoveChange

RemoveChange — removes an event handler from a point change event.

Synopsis

```
RemoveChange (chfn)
```

Arguments

chfn
: A change function, as created by OnChange.

Returns

A list of the following items:

```
(class fn_name fn_args ...)
```

Where *fn_name* and *fn_args* are the name and arguments of the removed function.

Description

This method is a wrapper for the remove_change function. In addition to applying that function, it removes this change from the class's _ChangeFunctions list. For more information, please refer to the section called “Handling Events”.

RemoveSystemMenu

`RemoveSystemMenu` — for internal use only.

Synopsis

```
RemoveSystemMenu ()
```

Description

This method is for internal use only.

RemoveTimer

`RemoveTimer` — cancels a timer.

Synopsis

```
RemoveTimer(tid)
```

Arguments

`tid`
: A timer ID number, as assigned by `TimerAt`, `TimerAfter`, or `TimerEvery`.

Returns

The `._TimerIDs` list with the *`tid`* removed.

Description

This method cancels the timer corresponding to *`tid`*, and removes that timer ID number from the `._TimerIDs` list.

TimerAfter

`TimerAfter` — attaches an event handler to an "after" timer.

Synopsis

```
TimerAfter (seconds, fn)
```

Arguments

seconds
: A number of seconds

fn
: A function or method call.

Returns

An integer that is a timer ID number.

Description

This method sets an `after` timer that fires after the number of *seconds* specified, causing the *fn* function or method to execute. This method also creates a unique, sequential ID number for the timer, appends that number to the class's `._TimerIDs` list, and returns that same timer ID number.

Timers created using `TimerAt`, `TimerAfter`, and `TimerEvery` are automatically cancelled when the Application instance is destroyed.

TimerAt

`TimerAt` — attaches an event handler to an "at" timer.

Synopsis

```
TimerAt (day, month, year, hour, minute, second, fn)
```

Arguments

day
: Restriction on the day of the month (1-31), or `nil` for none.

month
: Restriction on the month of the year (1-12), or `nil` for none.

year
: Restriction on the year (1994-2026), or `nil` for none.

hour
: Restriction on the hour of the day (0-23), or `nil` for none.

minute
: Restriction on the minute in the hour (0-59), or `nil` for none.

second
: Restriction on the second in the minute (0-59), or `nil` for none.

fn
: A function or method call.

Returns

Description

This method sets an `at` timer that causes the *fn* function or method to execute at a specific time, or to occur regularly at certain times of the minute, hour, day, month or year. A restriction on a particular attribute of the time will cause the timer to fire only if that restriction is true.

A restriction may be any number in the legal range of that attribute, or a list of numbers in that range. Illegal values for the time will be normalized. For example, a time specified as `July 0, 2008 00:00:00` will be treated as `June 30, 2008 00:00:00`. If `nil` is specified for any attribute of the time, this implies no restriction and the timer will fire cyclically at every legal value for that attribute.

This method also creates a unique, sequential ID number for the timer, appends that number to the class's `._TimerIDs` list, and returns that same timer ID number.

Timers created using `TimerAt`, `TimerAfter`, and `TimerEvery` are automatically cancelled when the Application instance is destroyed.

TimerEvery

`TimerEvery` — attaches an event handler to an "every" timer.

Synopsis

```
TimerEvery (seconds, fn)
```

Arguments

`seconds`
: A number of seconds.

`fn`
: A function or method call.

Returns

An integer that is a timer ID number.

Description

This method sets an `every` timer that that fires periodically every number of *`seconds`*, causing the *`fn`* function or method to execute. This method also creates a unique, sequential ID number for the timer, appends that number to the class's `._TimerIDs` list, and returns that same timer ID number.

Timers created using `TimerAt`, `TimerAfter`, and `TimerEvery` are automatically cancelled when the Application instance is destroyed.

Time Conversion Functions from `Time.g`

The DataHub program works in two different time standards:

- Windows `DATE` (`VT_DATE`) is the number of days, as an 8-byte float since December 30, 1899. The fractional part is unsigned, so 6 a.m. December 29, 1899 would be represented as -1.25.
- Unix time is the number of seconds since 12 a.m. January 1, 1970. It is a signed 4-byte integer. Negative times have no meaning.

In these functions, Unix time uses the traditional Unix time plus a number of nanoseconds. Since this cannot be expressed as a single 4-byte integer, we express it as an 8-byte floating point number where the fractional part adds accuracy. This accuracy is ideally measured down to the nanosecond, but in practise relies on the accuracy of the operating system clock. In Windows, this means milliseconds.

Unix time is important because it is the time format used in the Gamma functions `time`, `mktime`, `localtime` and `date`. It is also the time format used when explicitly specifying a time stamp on a point in Unix.

Windows time is the internal time representation used by DataHub points.

The functions listed here are created in the script `Time.g` located in the `require` folder of your DataHub installation. They are available to any DataHub script that requires or includes the `Time.g` file, using one of these statements:

- `require ("Time");`
- `include ("Time");`

GetCurrentWindowsTime

`GetCurrentWindowsTime` — returns the current clock time in Windows time format.

Synopsis

```
GetCurrentWindowsTime ()
```

Arguments

none

Returns

The current clock time, in Windows time format.

PointGetUnixTime

`PointGetUnixTime` — gets the Unix time stamp from a point.

Synopsis

```
PointGetUnixTime (point)
```

Arguments

`point`
The fully-qualified symbolic point name of a DataHub point.

Returns

The Unix time stamp for the point.

PointGetWindowsTime

`PointGetWindowsTime` — gets the Windows time stamp from a point.

Synopsis

```
PointGetWindowsTime (point)
```

Arguments

point
The fully-qualified symbolic point name of a DataHub point.

Returns

The Windows time stamp.

PointMetadata

`PointMetadata` — queries a point for its metadata structure.

Synopsis

```
PointMetadata (point)
```

Arguments

point
The fully-qualified symbolic point name of a DataHub point.

Returns

Either a `DH_Item` structure, or `nil`.

Description

This function queries a point for its metadata structure, which is a `DH_Item` containing the following fields:

`item.canonical_type`
A number representing the canonical type of the point. See the possible values of VARTYPE in Windows:

```
DH_ITEM_READABLE            0x0001    /* Matches OpcReadable. */
DH_ITEM_WRITABLE            0x0002    /* Matches OpcWritable. */
DH_ITEM_LOCKED              0x0004
DH_ITEM_PROPERTY            0x0008
DH_ITEM_SUBASSEMBLY         0x0010
DH_ITEM_ASSEMBLY            0x0020
DH_ITEM_ATTRIBUTE           0x0040
DH_ITEM_TYPE                0x0080
DH_ITEM_ACTIVE              0x0100
DH_ITEM_PRIVATE_ATTRIBUTE   0x0200
DH_ITEM_PROCESSED           0x0400
DH_ITEM_HIDDEN              0x0800
DH_ITEM_AUTO_ID             0x1000
DH_ITEM_UNINITIALIZED       0x200000  /* The item has been created
                                      but never assigned a value.
```

		`*/`
`DH_ITEM_FIRST_VALUE`	`0x400000`	`/* This is the first value that has been assigned to the point. */`

`item.opcaccessrights`

Any bitwise combination of `1` for `READABLE` and `2` for `WRITABLE`. The same as the first two bits of `item.flags`.

`item.quality`

The OPC quality value. You can get the name associated with the value by using the `GetQualityName` function in the `Quality.g` file. Put the statement:

```
require ("Quality");
```

at the beginning of your script to gain access to this function.

`item.scan_max`

Maximum scan rate on this point. Not in use.

`item.security`

The security level on this point.

`item.timeoffset`

Offset in seconds from local clock time for the originator of this point value. Not in use.

`item.timestamp`

The Windows time stamp of this point.

The point metadata is likely to change in the future, though the actual fields available will remain the same. It would be good practice to wrap access to the metadata within wrapper functions.

UnixLocalToUTC

`UnixLocalToUTC` — converts from local Unix time to UTC.

Synopsis

```
UnixLocalToUTC (secs, offsetsecs)
```

Arguments

secs
: Unix time, in seconds.

offsetsecs
: The offset between local time and UTC, in seconds.

Returns

The UTC time.

UnixTimeToWindowsTime

`UnixTimeToWindowsTime` — converts from Unix time to Windows time.

Synopsis

```
UnixTimeToWindowsTime (secs)
```

Arguments

secs
: Unix time, in seconds.

Returns

A single number representing Windows time.

UnixUTCToLocal

`UnixUTCToLocal` — converts from UTC Unix time to local time.

Synopsis

```
UnixUTCToLocal (secs, offsetsecs)
```

Arguments

secs
: Unix time, in seconds.

offsetsecs
: The offset between local time and UTC, in seconds.

Returns

A local time.

WindowsLocalToUTC

`WindowsLocalToUTC` — converts from local Windows time to UTC.

Synopsis

```
WindowsLocalToUTC (wdate, offsetsecs)
```

Arguments

wdate
: The date, in Windows time.

offsetsecs
: The offset between local time and UTC, in seconds.

Returns

A UTC time.

WindowsTimeToUnixTime

`WindowsTimeToUnixTime` — converts from Windows time to Unix time.

Synopsis

```
WindowsTimeToUnixTime (wdate)
```

Arguments

wdate
: The date, in Windows time.

Returns

The date, in Unix time.

Description

This function converts from Windows time to Unix time. If the *wdate* is prior to January 1, 1970, the function returns `nil`. If *wdate* is after the end of the Unix epoch (03:14:08 UTC on January 19, 2038) then the returned value will be greater than the acceptable input range for Unix date-based functions.

WindowsUTCToLocal

`WindowsUTCToLocal` — converts from UTC Windows time to local time.

Synopsis

```
WindowsUTCToLocal (wdate, offsetsecs)
```

Arguments

wdate
: The date, in Windows time.

offsetsecs
: The offset between local time and UTC, in seconds.

Returns

A local Windows time.

Regular Expression Methods from RegexSupport.g

The RegexSupport.g file provides support for the Perl-Compatible Regular Expression (PCRE) library (http://www.pcre.org/) and includes the PCRS substitution extensions to PCRE.

You must require the Regex support methods before you can use them in a script. At the top of your script, include the following line:

```
require (RegexSupport);
```

The RegexSupport.g file is located in the require folder of your DataHub installation.

The RegexSupport.g file provides three classes:

- Regex, a compiled regular expression pattern. All but one of the methods in this reference are for this class.
- pcrs_job, a compiled substitution expression. There is one method for this class, pcrs_job.Exec.
- pcre_extra, which contains hints for the regular expression Exec function to speed up execution.

Please see the Match and Subst entries for examples.

Compile

`Compile` — compiles a regular expression to a form that is more efficient to evaluate.

Synopsis

```
static Regex.Compile(pattern, options)
```

Arguments

pattern
A string specifying the regular expression pattern.

options
A bitwise OR of zero or more of the following:

```
PCRE_ANCHORED
PCRE_BSR_ANYCRLF
PCRE_BSR_UNICODE
PCRE_CASELESS
PCRE_DOLLAR_ENDONLY
PCRE_DOTALL
PCRE_DUPNAMES
PCRE_EXTENDED
PCRE_EXTRA
PCRE_FIRSTLINE
PCRE_JAVASCRIPT_COMPAT
PCRE_MULTILINE
PCRE_NEWLINE_CR
PCRE_NEWLINE_LF
PCRE_NEWLINE_CRLF
PCRE_NEWLINE_ANYCRLF
PCRE_NEWLINE_ANY
PCRE_NO_AUTO_CAPTURE
PCRE_UNGREEDY
PCRE_UTF8
PCRE_NO_UTF8_CHECK
```

Returns

On success, an instance of `Regex`. On failure, an error list with three elements:

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

See Also

`Match`

CompileSubst

`CompileSubst` — compiles a substitution pattern.

Synopsis

```
static Regex.CompileSubst(pattern)
```

Arguments

pattern
A pattern of the form `s/pattern/substitution/flags`.

Returns

On success, an instance of `pcrs_jobs`. On failure, an error list with three elements:

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

Description

This method compiles a pattern of the form `s/pattern/substitution/flags`.

CompileSubstEx

`CompileSubstEx` — an alternate interface to CompileSubst.

Synopsis

```
static Regex.CompileSubstEx(pattern, substitution, flags?=0)
```

Arguments

pattern
: Normally, a string, but optionally a buffer. If a buffer, it may contain `NUL` characters.

substitution
: Normally, a string, but optionally a buffer. If a buffer, it may contain `NUL` characters.

flags
: A string.

Returns

On success, an instance of `pcrs_job`. On failure, an error list with three elements:

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

Config

`Config` — queries the PCRE library for compiled-in options.

Synopsis

```
static Regex.Config(what)
```

Arguments

what
: The option to query.

Returns

A number.

Description

See the documentation for pcre_config for details.

Exec

Exec — applies a regular expression match to a subject string.

Synopsis

```
Regex.Exec(extra, subject, length, startoffset, options, substrings)
```

Arguments

extra
: An instance of `pcre_extra` returned from `Regex.Study`, or nil.

subject
: The subject string on which to apply the pattern. This may be either a string or a buffer. If the subject is a buffer it may contain `NUL` characters.

length
: The length of the subject, in bytes. If length is `-1`, the length of the subject string is computed automatically .

startoffset
: A byte offset into the subject specifying at which point to start.

options
: Option flags - a bitwise OR of zero or more of these flags:

```
PCRE_ANCHORED
PCRE_NEWLINE_CR
PCRE_NEWLINE_LF
PCRE_NEWLINE_CRLF
PCRE_NEWLINE_ANYCRLF
PCRE_NEWLINE_ANY
PCRE_NOTBOL
PCRE_NOTEOL
PCRE_NOTEMPTY
PCRE_NOTEMPTY_ATSTART
PCRE_NO_START_OPTIMIZE
PCRE_NO_UTF8_CHECK
PCRE_PARTIAL_SOFT
PCRE_PARTIAL_HARD
```

substrings
: An array into which the match substrings are copied. The substrings array cannot be nil. The match substrings will be written into the substrings array starting at position `0`. If the array is not large enough to hold all of the substrings it will be automatically expanded.

Each element of the substrings array is itself an array of 3 elements:

`[0]` - the zero-based starting character of the match
`[1]` - the character position immediately after the match
`[2]` - the string that matched.
This will be returned as a buffer if the subject is a buffer, otherwise it will be a string.

The first element in the substrings array always contains the complete matching string within the subject. Each element after the first corresponds to a positional substring specified within the pattern.

Returns

On success, an array of match specifications as described in the *`substrings`* parameter (above). On failure, an error list with three elements:

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

See Also

`Match`

pcrs_job.Exec

pcrs_job.Exec — applies a compiled pattern substitution to a subject string.

Synopsis

```
pcrs_job.Exec(subject, length?=-1)
```

Arguments

subject
: A subject string for substitution.

length
: The length of the subject string. Entering -1 (the default) for this parameter will cause the length of the subject string to be automatically computed.

Returns

On success, the new string with the substitutions applied. On failure, an error list with three elements:

- car(errlist) = a numeric return code from the failing function
- cadr(errlist) = a character position in the pattern where the error occurred, or 0.
- caddr(errlist) = an error message, as a human-readable string

Description

This method of the pcrs_job class applies a previously compiled pattern substitution to a subject string.

GetStringNumber

`GetStringNumber` — retrieves the index number of named substrings.

Synopsis

```
Regex.GetStringNumber(name)
```

Arguments

name
: The name of a substring.

Returns

On success, a number greater than `1`. On failure, a numeric error code less than `0`.

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

Description

If a pattern contains named substring matches, this method will retrieve the index number (starting at `1`) of the substring corresponding to this name.

Match

`Match` — a convenience function that combines calls to Compile, Study, and Exec.

Synopsis

```
static Regex.Match(pattern, subject, options?=0,
                   length?=-1, startoffset?=0)
```

Arguments

pattern
A string specifying the regular expression pattern.

subject
The subject string on which to apply the pattern. This may be either a string or a buffer. If the subject is a buffer it may contain `NUL` characters.

options
Option flags - a bitwise OR of zero or more of these flags:

```
PCRE_ANCHORED
PCRE_BSR_ANYCRLF
PCRE_BSR_UNICODE
PCRE_CASELESS
PCRE_DOLLAR_ENDONLY
PCRE_DOTALL
PCRE_DUPNAMES
PCRE_EXTENDED
PCRE_EXTRA
PCRE_FIRSTLINE
PCRE_JAVASCRIPT_COMPAT
PCRE_MULTILINE
PCRE_NEWLINE_ANY
PCRE_NEWLINE_ANYCRLF
PCRE_NEWLINE_CR
PCRE_NEWLINE_CRLF
PCRE_NEWLINE_LF
PCRE_NOTBOL
PCRE_NOTEMPTY
PCRE_NOTEMPTY_ATSTART
PCRE_NOTEOL
PCRE_NO_AUTO_CAPTURE
PCRE_NO_START_OPTIMIZE
PCRE_NO_UTF8_CHECK
PCRE_PARTIAL_HARD
```

PCRE_PARTIAL_SOFT
PCRE_UNGREEDY
PCRE_UTF8

length

The length of the subject, in bytes. If length is `-1` (the default), the length of the subject string is computed automatically.

startoffset

A byte offset into the subject specifying at which point to start.

Returns

On success, an array of match specifications equivalent to the substrings argument to `Regex.Exec`. On failure, an error list with three elements:

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

Examples

Find and return all matches of hello, case sensitive:

```
Gamma> Regex.Match ("(hello)", "I say Hello and you say Goodbye");
(-1 0 "No match found")
```

Find and return all matches of hello, case insensitive:

```
Gamma> Regex.Match ("(hello)", "I say Hello and you say Goodbye",
PCRE_CASELESS);
[[0 31 #{I say Hello and you say Goodbye}] [6 11 #{Hello}]]
```

See Also

`Compile`, `Study`, `Exec`, and `Subst`

Study

`Study` — helpful for speeding up repeated applications of a regular expression.

Synopsis

```
Regex.Study(options?=0)
```

Arguments

options
Must be zero in this implementation.

Returns

On success, an instance of `pcre_extra`. On failure, an error list with three elements:

- `car(errlist)` = a numeric return code from the failing function
- `cadr(errlist)` = a character position in the pattern where the error occurred, or 0.
- `caddr(errlist)` = an error message, as a human-readable string

Description

This method evaluates a regular expression to produce hints that can speed up the application of the regular expression in future. This method does not need to be called, but is useful to speed up repeated application of the same regular epxression.

See Also

`Match`

Subst

Subst — applies a substitution pattern to a string of a given length.

Synopsis

```
static Regex.Subst(pattern, subject, length?=-1)
```

Arguments

pattern
: A substitution pattern, in the form s/pattern/substitution/flags.

subject
: The subject string on which the substitution will be made.

length
: The length of the subject string. Entering -1 (the default) for this parameter will cause the length of the subject string to be automatically computed.

Returns

On success, returns the new string with the substitutions applied. On failure, an error list with three elements:

- car(errlist) = a numeric return code from the failing function
- cadr(errlist) = a character position in the pattern where the error occurred, or 0.
- caddr(errlist) = an error message, as a human-readable string

Examples

String replacement:

```
Gamma> x = "This is a test of my test system"
"This is a test of my test system"
Gamma> Regex.Subst("s/test/build/g", x)
"This is a build of my build system"
```

To surround all words with parentheses:

```
Gamma> Regex.Subst ("s/(\\w+)/\\($1\\)/g", "This is a test!");
"(This) (is) (a) (test)!"
```

See Also

Match

Running a Command-Line Program

You can run any command-line program from a Gamma script. Here is an example for a Python program.

Another option for Python users is the DataHub API for Python. This will give you more flexibility in handling the results of a computation. It can be integrated with a DataHub instance using a Gamma script that starts the Python program and then lets it run continuously in the background. Alternatively, using Gamma with a Python script as shown below offers more fine-grained access to the data points, with lower latency.

Code

```
/*
 * Example script to run a Python script and to collect the result
 */

require ("Application");
require ("AsyncRun");

class RunPython Application
{
    python = "python";
    command = "-c \"print(2 + 3)\"";
}

/*
 * Execute python
 *   self in the callback argument is not evaluated with "@", so it
 *   refers to  the AsyncCommand instance, not this script instance.
 *   The AsyncCommand class is defined in
 *   C:\Program Files\Cogent\Cogent DataHub\require\AsyncRun.g
 */
method RunPython.run ()
{
    RunCommandAsync(nil, nil, string(.python, " ", .command),
    _config_path_, `(@self).processResult(self));
}

/*
 * Process the python result.
 */
method RunPython.processResult(command)
{
    princ ("Python command: ", command.cmdline, "\n");
    princ ("   Result code: ", command.exitcode, "\n");
```

```
    princ (" Result string: ", command.resultstring, "\n");
}

/* Write the 'main line' of the program here. */
method RunPython.constructor ()
{
    .run();
}

/* Start the program by instantiating the class. */
ApplicationSingleton (RunPython);
```

Calling OPC UA Methods from DataHub Scripts

OPC UA defines a node type called a Method that allows a client application to synchronously execute a predefined function on the server. The client calls the OPC UA method with zero or more arguments and waits for it to complete. OPC UA servers may use methods as an alternative to executing their internal functions in response to a data value change.

OPC UA methods are synchronous, and normally cannot be executed through a DataHub tunnel, because data flow through a tunnel is always asynchronous. You can, however, use a Gamma script to convert an asynchronous data change into a synchronous OPC UA method call.

Method calls are provided through a class called `OpcUaSupport`. You can include this in your script by adding the following line to the top of your script:

```
require ("OpcUaSupport");
```

The `OpcUaSupport.g` file is located in the `require` folder of your DataHub installation.

In your script, you can now create an instance of the `OpcUaSupport` class:

```
opcua = new OpcUaSupport(self, "UaClientConnectionLabel");
```

You must supply a reference to an instance of a class that derives from `Application`, and the label of an active OPC UA client connection on which the method will be called. This label is configured in the DataHub OPC UA properties option. The instance reference is commonly `self`, referring to your script instance itself.

This instance of `OpcUaSupport` can now be used to attach method calls to data point changes:

```
opcua.AddMethod(triggerPointName, feedbackPointName, parentNode,
                methodName, triggerType, arguments…);
```

where:

`triggerPointName`
: A string containing the fully qualified name of a data point that will cause this method to be called when the point value changes.

`feedbackPointName`
: A string containing the fully qualified name of a data point to which a feedback value will be written. This point will be set to `1` if the method succeeds. If this value is `nil` then no feedback will be provided.

`parentNode`
: A string or list that contains the identification of the OPC UA node that contains this method. It can be one of:

- `NodeId`, a string containing the NodeId of the parent, like `"ns=2;i=253"`.
- `BrowsePath` as a string containing a dot-separated OPC UA browse path, like `""Objects.Refrigerators.Refrigerator #1""`
- `BrowsePath` as a list of browse names forming a BrowsePath, like `("Objects" "Refrigerators" "Refrigerator #1")`

`methodName`

A string containing the name of the method, like `"OpenCloseDoor"`.

`triggerType`

A symbol for the name of a method of the class `OpcUaTriggeredMethod`. This method is called to determine whether to call the OPC UA method according to logic that you supply. Two `triggerType` methods have been supplied for you:

- `risingTrigger(`*`args`*`)`: The OPC UA method will be called only when the `triggerPoint` value changes from any value to 1. This is typically used with boolean trigger points. Before the OPC UA method is called, the value of the `feedbackPoint` is set to 0. If the call to the OPC UA method encounters an error, the `feedbackPoint` will be set to `-1`. Finally, the value of the `triggerPoint` will be set to `0`.
- `toggleTrigger(`*`args`*`)`: The OPC UA method will be called whenever the `triggerPoint` value changes. This will act as a toggle when applied to a boolean trigger point, and as an event generator when applied to a numeric or string point. If the call to the OPC UA method encounters an error, the `feedbackPoint` will be set to `-1`. Otherwise, the `feedbackPoint` will be set to the value of the triggerPoint.

`arguments...`

One or more arguments that will be passed to the OPC UA method. You must provide the number of arguments that the OPC UA method expects. These arguments are limited to numbers and strings. Methods that require complex argument types cannot be called through this mechanism. If an argument is defined a `#eval(expression)` then that expression will be evaluated in the context of the trigger method and supplied as the argument value.

You can add additional trigger methods by adding your own method to `OpcUaTriggeredMethod`, like this:

```
method OpcUaTriggeredMethod.myTriggerFunction(args)
{
    // Implement your logic here.  Somewhere in this code you should
    // call .uaMethod.call(args);
    // The following variables are defined automatically
    // in this method:
    // this - the name of the data point that triggered this method
    // value - the value of the data point that triggered this method
    // previous - the previous value of the data point that
    //            triggered this method
}
```

You can add your trigger method in your own script, so long as the call to `require("OpcUaSupport")` is made before your trigger definition. Do not alter `OpcUaSupport.g`, since it will be overwritten when you upgrade the DataHub application. Look at the definitions of `risingTrigger` and `toggleTrigger` in `OpcUaSupport.g` for examples of how your code can be written.

Example:

The following code will call a method called `OpenCloseDoor` on the OPC UA node `Objects.Refrigerators.Refrigerator #1` whenever the point `default:fridge` changes value. The feedback will be written to `default:fridge_fb`. The trigger function will be `toggleTrigger`, a method defined in `OpcUaSupport.g`. The value of `default:fridge` will be passed to the OPC UA method as the only argument.

```
method MyApp.constructor()
{
local opcua = new OpcUaSupport(self, "UaClientConnectionLabel");
opcua.AddMethod("default:fridge", "default:fridge_fb",
                "Objects.Refrigerators.Refrigerator #1",
                "OpenCloseDoor", #toggleTrigger, #eval(value));
}
```

In addition to `.AddMethod` above, the `OpcUaSupport.g` script also has `.AddMethod2` available, as follows:

```
OpcUaSupport.AddMethod2(triggerPoint, feedbackPoint, parentNodePath,
                        methodName, triggerType, onSuccess,
                        onFailure, args?...=nil)
```

This is similar to the `AddMethod` call, except that it evaluates one of two callbacks depending on whether the method succeeds or fails. The following variables are defined at the time that the callbacks are called:

- `uaMethod` - the method call that was evaluated
- `args` - the arguments that were passed to that method call
- `result` - the array of results from the method call
- `_last_error_` - the error message if the method call failed and an exception was thrown

The result variable contains an array of output values from the OPC UA method call. OPC UA methods can produce multiple output values. The result will always be an array, even if the method only produces one output value. For example, this code will print the array of return values from a method call to add two numbers:

```
opcua.AddMethod2("DataPid:PID1.Sp", "default:results",
                 "Objects.CTT.Methods", "Methods_Add",
                  #toggleTrigger,
                  `princ("Add result = ", result, "\n"),
```

```
                  `princ("Method call failed: ",
                         _last_error_, "\n"), 2, 5);
```

Prints this message whenever DataPid:PID1.Sp changes:

```
Add result = [7]
```

Quality Name Function from `Quality.g`

GetQualityName

`GetQualityName` — converts the quality value of a point to a text string.

Synopsis

```
GetQualityName (quality)
```

Arguments

quality
: A value that indicates the quality of the point, as returned by the function `PointMetaData`.

Returns

A text string corresponding to the *quality*.

Description

This function converts the quality value of a point to a text string. The function is created in the script `Quality.g`, and is available to any DataHub script that requires or includes the `Quality.g` file, using one of these statements:

- `require ("Quality");`
- `include ("Quality");`

The `Quality.g` file is located in the `require` folder of your DataHub installation.

DataHub point information includes a data quality indication that is consistent with the OPC specification. Even if you are not working with OPC data, you may still wish to use the quality in your custom applications and DataHub scripts.

The possible quality strings are:

Quality Flag	Hex	Dec	String
OPC_QUALITY_BAD	0x0	0	Bad
OPC_QUALITY_UNCERTAIN	0x40	16	Uncertain
OPC_QUALITY_GOOD	0xc0	192	Good
OPC_QUALITY_CONFIG_ERROR	0x4	4	Config Error
OPC_QUALITY_NOT_CONNECTED	0x8	8	Not Connected
OPC_QUALITY_DEVICE_FAILURE	0xc	12	Device Failure
OPC_QUALITY_SENSOR_FAILURE	0x10	16	Sensor Failure

Quality Flag	Hex	Dec	String
`OPC_QUALITY_LAST_KNOWN`	`0x14`	`20`	`Last Known`
`OPC_QUALITY_COMM_FAILURE`	`0x18`	`24`	`Comm Failure`
`OPC_QUALITY_OUT_OF_SERVICE`	`0x1c`	`28`	`Out Of Service`
`OPC_WAITING_FOR_INITIAL_DATA`	`0x20`	`32`	`Waiting For Initial Data`
`OPC_QUALITY_LAST_USABLE`	`0x44`	`68`	`Last Usable`
`OPC_QUALITY_SENSOR_CAL`	`0x50`	`80`	`Sensor Cal`
`OPC_QUALITY_EGU_EXCEEDED`	`0x54`	`84`	`EGU Exceeded`
`OPC_QUALITY_SUB_NORMAL`	`0x58`	`88`	`Sub Normal`
`OPC_QUALITY_LOCAL_OVERRIDE`	`0xd8`	`216`	`Local Override`

Classes from `HistorianSupport.g`

The functionality of the DataHub Historian features is made available through a `Historian` class provided in the `HistorianSupport.g` script located in the `require` folder of your DataHub installation..

You must require the Historian support methods before you can use them in a script. At the top of your script, include the following line:

```
require (HistorianSupport);
```

The `HistorianSupport.g` file provides three classes: `Historian`, `HistoryBuffer`, and `HistoryValue`. The `HistTest.g` script provides an example of how these classes are used to query the DataHub Historian.

Historian

`Historian` — encapsulates the Historian facility in the DataHub program.

Synopsis

```
class Historian
{
}
```

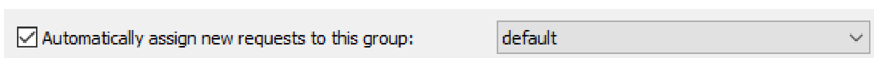
Instance Variables

None.

Methods

`allowAutoHistoryAdds(`*`state`*, *`defaultgroup`*`)`

Configures automatic history addition. The *`state`* should be `nil` to turn off the function and `t` to turn it on. The *`defaultgroup`* is a string naming the History Group to which automatic histories are added. This method corresponds to this setting in the Historian option of the Properties window:



`addGroup(`*`label`*, *`basedir`*, *`cachesize`*`)`

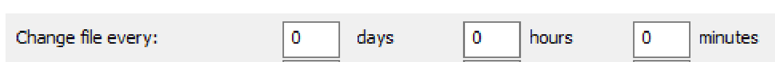
Creates a new History Group with the provided *`label`*, *`basedir`* (base directory) and *`cachesize`* (cache size). This corresponds approximately to pressing the **Add ...** button in the Historian option of the Properties window.

`removeGroup(`*`label`*`)`

Removes the History Group with the given *`label`*.

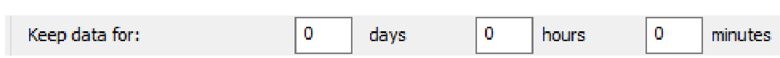
`setFileTimes(`*`labelpattern`*, *`days`*, *`hours`*, *`minutes`*`)`

Assigns the file times for all History Groups whose labels match the *`labelpattern`*. The pattern uses the pattern matching rules documented in the `shell_match` function. This method corresponds to this setting in the Properties window Historian configuration:



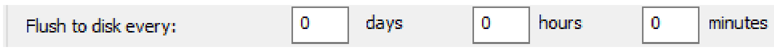
`setRentionTimes(`*`labelpattern`*, *`days`*, *`hours`*, *`minutes`*`)`

Assigns the data retention times for all History Groups whose labels match the *`labelpattern`*. The pattern uses the pattern matching rules documented in the `shell_match` function. This method corresponds to this setting in the Properties window Historian configuration:



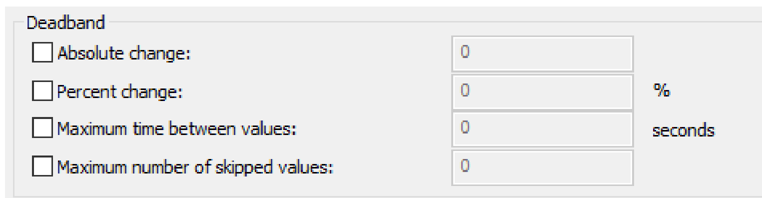
`setFlushTimes(`*`labelpattern`*`, `*`days`*`, `*`hours`*`, `*`minutes`*`)`, ()

Assigns the file flush times for all History Groups whose labels match the *`labelpattern`*. The pattern uses the pattern matching rules documented in the `shell_match` function. This method corresponds to this setting in the Properties window Historian configuration:



`setDeadband(`*`labelpattern`*`, `*`flags`*`, `*`absolute`*`, `*`percent`*`, `*`maxsecs`*`, `*`maxcount`*`)`

Assigns the deadband settings for all History Groups whose labels match the *`labelpattern`*. The pattern uses the pattern matching rules documented in the `shell_match` function. This method corresponds to this section of the Properties window Historian configuration:



The *`flags`* argument is `0` to turn off all deadbands, or any combination of:

`0x0008` - Turn on the percent deadband
`0x0020` - Turn on the absolute deadband
`0x0040` - Turn on the maximum time limit
`0x0080` - Turn on the maximum skip count

`addPoint(`*`pointname`*`, `*`grouplabel`*`?=nil)`

Adds a point to the named History Group. If *`grouplabel`* is `nil` or not specified then the point will be added to the automatic group. If the automatic group is not set and the *`grouplabel`* is not specified, this method will fail silently.

The *`pointname`* is a string specifying the fully qualified point name. That is, the point name must contain the data domain and the full path of the point, for example, `DataPid:PID1.Mv`

`removePoint(`*`pointpattern`*`, `*`grouppattern`*`?="*")`

Removes all points matching the *`pointpattern`* from all groups matching the *`grouppattern`*.

`saveConfig()`

Causes the Historian to save its configuration to disk.

`startConfiguring()`

Tells the Historian to enter configuring mode. In this mode, changes to group configurations are accepted but not applied. This allows a number of configuration commands to be sent without affecting the current state of the Historian. This method must eventually be followed by a call to `endConfiguring` for the configuration changes to be applied.

`endConfiguring()`

Tells the Historian to exit configuring mode, and to apply any changes to the configuration that have been made since the call to `startConfiguring`.

`queryRawData(`*`pointname`*`, `*`start_unixtime`*`, `*`duration_secs`*`)`

Queries the history for a given point, starting at the specified time (*`start_unixtime`*) and running for the specified number of seconds (*`duration_secs`*). The *`pointname`* must be a string containing the fully qualified name of the point. The *`start_unixtime`* must be specified as number of seconds since midnight January 1, 1970 UTC. Both the *`start_unixtime`* and *`duration_secs`* are floating point values and can contain a fractional component.

The return value from this function is either `nil` or an instance of `HistoryBuffer` containing the values that fall within the specified range.

The data returned from this method is the exact data set as stored on disk without modification.

`queryStatistic(`*`pointname`*`, `*`start_unixtime`*`, `*`duration_secs`*`, `*`aggregation_period_secs`*`, `*`stat_name`*`)`

Queries a statistical measure of the history for a given point, starting at the specified time (*`start_unixtime`*) and running for the specified number of seconds (*`duration_secs`*). The *`pointname`* must be a string containing the fully qualified name of the point. The *`start_unixtime`* must be specified as number of seconds since midnight January 1, 1970 UTC. Both the *`start_unixtime`* and *`duration_secs`* are floating point values and can contain a fractional component.

The return value from this function is either `nil` or an instance of `HistoryBuffer` containing the values that fall within the specified range.

The *`aggregation_period_secs`* specifies the number of seconds in each time interval within the overall query on which to produce statistics. For example, a query may request the average value in each 5-second period for a minute. The aggregation period would be 5 seconds, and the duration would be 60 seconds. The result set will contain 12 values, one for each 5-second interval within the duration of the query.

The *`stat_name`* is a string that specifies which statistical measure to query. The statistical measures available are:

Statistic Name	**Description**
`Total`	Retrieve the totalized value (time integral) of the data over the sample interval.
`Average`	Retrieve the average data over the sample interval.
`TimeAverage`	Retrieve the time weighted average data over the sample interval.
`Count`	Retrieve the number of good quality raw values over the sample interval.
`RawCount`	Retrieve the number of raw values over the sample interval.
`StDev`	Retrieve the standard deviation over the sample interval.

Statistic Name	Description
MinimumActualTime	Retrieve the minimum value in the sample interval and the timestamp of the minimum value.
Minimum	Retrieve the minimum value in the sample interval.
MaximumActualTime	Retrieve the maximum value in the sample interval and the timestamp of the maximum value.
Maximum	Retrieve the maximum value in the sample interval.
Start	Retrieve the value at the beginning of the sample interval. The time stamp is the time stamp of the beginning of the interval.
End	Retrieve the value at the end of the sample interval. The time stamp is the time stamp of the end of the interval.
First	Retrieve the first value change within the interval. The time stamp is the time stamp of the first value change.
Last	Retrieve the last value change within the interval. The time stamp is the time stamp of the last value change.
Delta	Retrieve the difference between the first and last value in the sample interval.
RegSlope	Retrieve the slope of the regression line over the sample interval.
RegConst	Retrieve the starting point of the regression line over the sample interval. This is the value of the regression line at the start of the interval.
RegPearsonR	Retrieve Pearson R measure of correlation between Y and Time over the sample interval. This is a number between -1.0 and 1.0.
RegRSquared	Retrieve R-squared measure of regression fitness over the sample interval. This is a number between 0 and 1.0.
Variance	Retrieve the variance over the sample interval .
Range	Retrieve the difference between the minimum and maximum value over the sample interval.
DurationGood	Retrieve the duration (in seconds) of time in the interval during which the data is good.
DurationBad	Retrieve the duration (in seconds) of time in the interval during which the data is bad.
PercentGood	Retrieve the percent of data (1 equals 100 percent) in the interval which has good quality.
PercentBad	Retrieve the percent of data (1 equals 100 percent) in the interval which has bad quality.
WorstQuality	Retrieve the worst quality of data in the interval.

Statistic Name	Description
`ValueSum`	Retrieve the sum of all raw values over the sample interval.

HistoryBuffer

HistoryBuffer — a set of HistoryValues returned from a Historian query.

Synopsis

```
class HistoryBuffer
{
    npoints;
}
```

Instance Variables

npoints
: The number of values (of type HistoryValue) in this data set.

Methods

Result sets from historical queries can be large. Consequently the access methods for a result set come in two types. The first type, named get*Something*, will return a reference to the particular data array or item, without making a copy. This reference is only valid until the HistoryBuffer instance is destroyed, which may happen at any time after all references to the HistoryBuffer instance go out of scope.

If the HistoryValue or array returned from the get method is used after the HistoryBuffer is destroyed, the DataHub instance could crash.

Alternately, you can use the copy*Something* methods to create duplicates of the data requested. These instances will persist after the HistoryBuffer is destroyed. The copy methods are more robust, but increase the CPU usage and memory usage of large queries. In general you should use the copy methods when you are unsure whether the lifetimes of the HistoryValues will exceed the lifetime of the HistoryBuffer.

copyToArray()
: Copy the internal data representation to an array of HistoryValue instances. This method returns the new array. This method is similar to toArray, except that it makes a copy of each HistoryValue instance.

copyValue(*index*)
: Returns a copy of the HistoryValue at the given *index* within the data set. The *index* is a number starting at 0 and less then npoints. This is the safe version of the getValue method.

getCount()
: Returns the number of values in this data set.

`getValue`(*`index`*)

Returns the `HistoryValue` at the given index in the data set. This is the unsafe version of `copyValue`. It will return a reference to the `HistoryValue` within the `HistoryBuffer`. This reference will only be valid until the `HistoryBuffer` is destroyed.

`setValue`(*`index`*, *`histvalue`*)

Modifies the original data in the `HistoryBuffer` at the given *`index`*. This method will result in changes to the original data, and to any `HistoryValue` instances that have been acquired by reference using `getValue` or `toArray`. The *`histvalue`* argument is an instance of `HistoryValue`.

`toArray`()

Returns an array of `HistoryValue` instances as references to the original data. This is equivalent to creating an array by repeatedly calling `getValue`. The resulting data is only valid until the `HistoryBuffer` is destroyed.

HistoryValue

`HistoryValue` — a single value from the Historian, consisting of value, x-axis and quality.

Synopsis

```
class HistoryValue
{
    xaxis;
    value;
    quality;
}
```

Instance Variables

`xaxis`
: The X axis value, generally the time stamp in UNIX time for this value. In some cases, a query can return an Y-vs-X result set instead of a Y-vs-Time result set. Consequently the X axis may not be time in all cases. This is a floating point number that can represent fractional seconds.

`value`
: The data value. This is either a calculated value or a raw value, depending on the type of query.

`quality`
: The quality of this sample. For raw samples this is an OPC DA2 item quality. For computed samples this is `GOOD`, `BAD` or another more precise `BAD` quality (such as `DEVICE FAILURE`) taken from the qualities of the raw values used in the computation.

Methods

None.

HistTest.g

HistTest.g — an example script that demonstrates how to access Historian data.

Code

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

C:\Program Files\Cogent\Cogent DataHub\scripts\

Please refer to the section called “How to Run a Script” for more information on using scripts.

```
/*
 * This script demonstrates how to access the DataHub Historian data
 * both in raw and processed forms.  Generally, a script simply needs
 * to create an instance of the Historian class and then make calls
 * to the methods of that object.  See the documentation for the
 * complete list of methods provided.
 *
 * When you query data from the historian the result is a
 * HistoryBuffer instance.  This encapsulates the result data in an
 * efficient internal representation that is not visible directly to
 * the script.  In order to use the data you must retrieve the data
 * from the HistoryBuffer to produce one or more HistoryValue
 * instances.  Each HistoryValue contains a value, a timestamp and a
 * quality.  The timestamp is called "xaxis" because in some cases a
 * query could return an y-vs-x result instead of a y-vs-time result.
 * The Historian object does not expose a method for a y-vs-x query,
 * but the underlying implementation will support it.
 *
 * A HistoryBuffer holds its data until there are no more references
 * to the HistoryBuffer object.  This means that a HistoryBuffer
 * object that is declared as a local variable in a function will
 * only be valid until the function exits (unless the function
 * returns the HistoryBuffer object).  If you need to hold one or
 * more HistoryValue beyond the lifetime of the HistoryBuffer, use
 * copyToArray or copyValue to make a copy of the data.
 *
 * If a history query produces a large amount of data it will be more
 * memory efficient to avoid making a copy of the data.  You can
 * access individual HistoryValue instances within the HistoryBuffer
 * using the getValue method.  Generally this will take more
 * processing time, but can substantially reduce memory use.
```

```
 *
 * Bear in mind that all scripts run in a single thread.  If you
 * spend a long time processing large historical requests, that will
 * disrupt the timing of other scripts.
 *
 * Statistical queries take substantially longer than raw data
 * queries.
 */

require ("Application");

/* Load the functions for Historian access */

require ("HistorianSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */
class HistTest Application
{
    historian;
}

method HistTest.rawQuery(pointname, starttime, duration)
{
    local histbuffer, data, datacopy;
    local t1, t2, t3, t4;

    t1 = nanoclock();
    histbuffer = .historian.queryRawData(pointname, starttime,
      duration);
    t2 = nanoclock();
    data = histbuffer.toArray();
    t3 = nanoclock();
    datacopy = histbuffer.copyToArray();
    t4 = nanoclock();

    pretty_princ("Raw query produced ",
   histbuffer.npoints, " data values\n");
    pretty_princ("   Query took ", t2 - t1, " seconds\n");
    pretty_princ("   Data access took ", t3 - t2, " seconds\n");
```

```
    pretty_princ("   Data copy took ", t4 - t3, " seconds\n");

    // If we want to use the values outside this method, we need to
    // use a copy, not the raw data. The raw data will be cleaned up
    // when the histbuffer object is no longer referenced. We could
    // also return the histbuffer object from this method, from which
    // we could later query the data using toArray().
    datacopy;
}

method HistTest.statisticalQuery(pointname, starttime, duration,
     aggregation_period_secs, statistic)
{
    local histbuffer, data, datacopy;
    local t1, t2, t3, t4, t5, t6, t7;
    local i, numbad, numbad2;

    t1 = nanoclock();
    histbuffer = .historian.queryStatistic(pointname,
        starttime,
        duration,
        aggregation_period_secs,
        statistic);
    t2 = nanoclock();
    data = histbuffer.toArray();
    t3 = nanoclock();
    datacopy = histbuffer.copyToArray();
    t4 = nanoclock();

    pretty_princ("Statistical query, ", statistic, ", produced ",
   histbuffer.npoints, " data values\n");
    pretty_princ("   Query took ", t2 - t1, " seconds\n");
    pretty_princ("   Data access took ", t3 - t2, " seconds\n");
    pretty_princ("   Data copy took ", t4 - t3, " seconds\n");

    // There are a few ways to process the data.  We can convert the
    // data to an array, as we do with data and datacopy.  We can
    // also walk the data buffer without converting it to an array.
    // The next two examples both do the same thing, walking the data
    // looking for BAD quality.
    numbad = numbad2 = 0;
    t5 = nanoclock();

    // Loop through the data set, having previously converted the
    // buffer data to an array
    with value in data do
```

```
    {
        if (value.quality == OPC_QUALITY_BAD)
            numbad++;
    }
    t6 = nanoclock();

    // Loop through the data set without converting to an array.
    // If the query produces a large amount of data, this will
    // certainly be more memory-efficient since a large array does
    // not have to be created, but the processing cost of querying
    // each value in the data set will be higher.
    for (i=histbuffer.npoints-1; i>=0; i--)
    {
        if (histbuffer.getValue(i).quality == OPC_QUALITY_BAD)
            numbad2++;
    }
    t7 = nanoclock();

    pretty_princ("   Loop through array took ",
   t6 - t5, " seconds\n");
    pretty_princ("   Loop through buffer took ",
   t7 - t6, " seconds\n");
    pretty_princ("      Found ",
   numbad, " (", numbad2, ") Bad quality values\n");

    // Print the last value in the data array, just to show
    // some results.
    if(array_p(data) && length(data) > 0)
    {
        local result = data[length(data) -1];
        pretty_princ("     Query results for most recent value: ",
        date_of(result.xaxis), " : ", result.value,  "\n\n");
    }
}

/* Write the 'main line' of the program here. */
method HistTest.constructor ()
{
    .historian = new Historian();
    princ ("--------------------------------------\n");
    .rawQuery("DataPid:PID1.Mv", nanoclock() - 10, 10);
    .rawQuery("DataPid:PID1.Mv", nanoclock() - 100, 100);
    .rawQuery("DataPid:PID1.Mv", nanoclock() - 1000, 1000);
    .rawQuery("DataPid:PID1.Mv", nanoclock() - 10000, 10000);
    princ ("------\n");
    .statisticalQuery("DataPid:PID1.Mv",
```

```
        nanoclock() - 10, 10, 1, "Average");
    .statisticalQuery("DataPid:PID1.Mv",
        nanoclock() - 100, 100, 1, "StDev");
    .statisticalQuery("DataPid:PID1.Mv",
        nanoclock() - 1000, 1000, 1, "Minimum");
    .statisticalQuery("DataPid:PID1.Mv",
        nanoclock() - 10000, 10000, 1, "RegRSquared");
}

/* Any code to be run when the program gets shut down. */
method HistTest.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (HistTest);
```

Modbus Commands Methods from `ModbusSupport.g`

Access to the DataHub Modbus feature and command set is made available through the `ModbusSupport.g` script located in the `require` folder of your DataHub installation. To use the script, follow these steps:

1. Ensure that the `ModbusSupport.g` file is present in your `Program Files\Cogent\Cogent DataHub\require\` directory.
2. Require the file by adding the following line at the top of your script:
   ```
   require (ModbusSupport);
   ```
3. In your script, create a `ModbusConfig` instance:
   ```
   local x = new ModbusConfig();
   ```

All of the methods in `ModbusSupport.g` are wrappers of a corresponding set of DataHub commands, which are documented in the Cogent DataHub Command Set.

apply

`apply` — applies all scripted changes.

Synopsis

```
.apply()
```

Description

This method is a wrapper for **ModbusApplySettings**.

addPoint

addPoint — configures a Modbus point.

Synopsis

```
.addPoint(slaveName, pointName, blockType, pointType, address,
          allowWrite, xformType, xformArgs, conversion)
```

Description

This method is a wrapper for **ModbusSlaveAddPoint**.

addRange

addRange — configures a range of Modbus points.

Synopsis

```
.addRange(slaveName, pointName, blockType, pointType, address,
          allowWrite, xformType, xformArgs, conversion, itemCount,
          nameStart)
```

Description

This method is a wrapper for **ModbusSlaveAddRange**.

cancel

`cancel` — cancels all scripted changes.

Synopsis

```
.cancel()
```

Description

This method is a wrapper for **ModbusCancelSettings**.

createSlave

`createSlave` — creates a slave connection.

Synopsis

```
.createSlave(slaveName, hostSpec, dataDomain, pollMs, retryMs,
             maxMsgLength, slaveId, supportedFunctions, addressFlags)
```

Description

This method is a wrapper for **ModbusCreateSlave**.

deletePoint

`deletePoint` — deletes point connections.

Synopsis

```
.deletePoint(slaveName, pointNamePattern)
```

Description

This method is a wrapper for **ModbusSlaveDeletePoint**.

deleteSlave

`deleteSlave` — deletes a slave connection.

Synopsis

```
.deleteSlave(slaveNamePattern)
```

Description

This method is a wrapper for **ModbusDeleteSlave**.

enableMaster

`enableMaster` — enables and disables Modbus master functionality.

Synopsis

```
.enableMaster(enable_p?=t)
```

Description

This method is a wrapper for **ModbusEnableMaster**.

enableSlave

`enableSlave` — enables and disables Modbus slave connections.

Synopsis

```
.enableSlave(slaveNamePattern, enable_p?=t)
```

Description

This method is a wrapper for **ModbusEnableSlave**.

reloadSettings

`reloadSettings` — loads all Modbus configuration.

Synopsis

```
.reloadSettings()
```

Description

This method is a wrapper for **ModbusReloadSettings**.

slaveExists

`slaveExists` — checks for the existence of a slave connection.

Synopsis

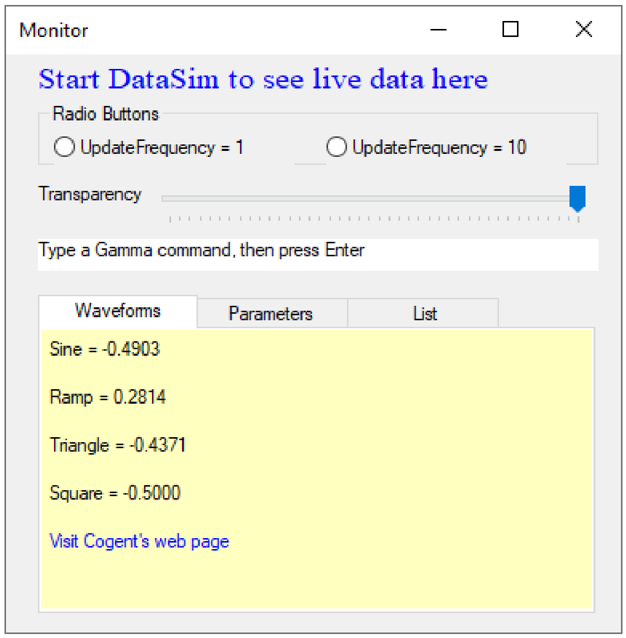
```
.slaveExists(name)
```

Description

This method is a wrapper for **ModbusQuerySlave**.

Appendix A. Basic Troubleshooting

Before doing anything else, you should ensure that a DataHub instance and the Gamma engine are running properly. You can do this by running the `WindowsExample.g` file. Start the DataHub instance, and in the Scripting option of the Properties window, load the `WindowsExample.g` script. (How do I load a script?) When the script is properly loaded, it should display the Monitor window:



This is a demonstration script for DataHub MS Windows Support. If the DataSim program is running, you should be able to see its data and interact with it through this Monitor. If you cannot, you need to check your DataHub program installation and configuration before troubleshooting scripts.

Troubleshooting Scripts

Did the script not run as expected? What happened instead? Here are some suggestions:

- The Script Log displays one or more error messages with relevant line numbers if there are any syntatical or scripting errors, and the Gamma engine will stop executing the script at that point.
- Incorrect output or no output probably means that your script's logic is incorrect. Review your code, correct any errors, and load it again.
- Single expressions, whole lines, or entire blocks of code can be evaluated independently. Highlight the portion of the code text and select **Evaluate Selection** from the **Script** menu.
- You can trace the steps of execution by inserting `princ` statements at strategic points.

Appendix B. License Copyright Information

The following licenses are being used in this product:

License for Scintilla and SciTE

DataHub™ ODBC Scripting

Version 11.0

An implementation of the Gamma scripting language for use in Cogent DataHub™ software that provides ODBC support.

Table of Contents

Introduction

Overview

The Cogent DataHub program has built-in scripting capabilities (see DataHub Scripting), which among other things let you connect the DataHub program to any ODBC-compliant database. This guide assumes a basic understanding of DataHub scripting, and provides the specific information you will need to script connections between the DataHub program and an ODBC database.

DataHub ODBC scripting uses wrapped MSDN functions. Therefore, this documentation often links to and refers to the MSDN documentation. You may need to conduct a search in that documentation to find the corresponding function.

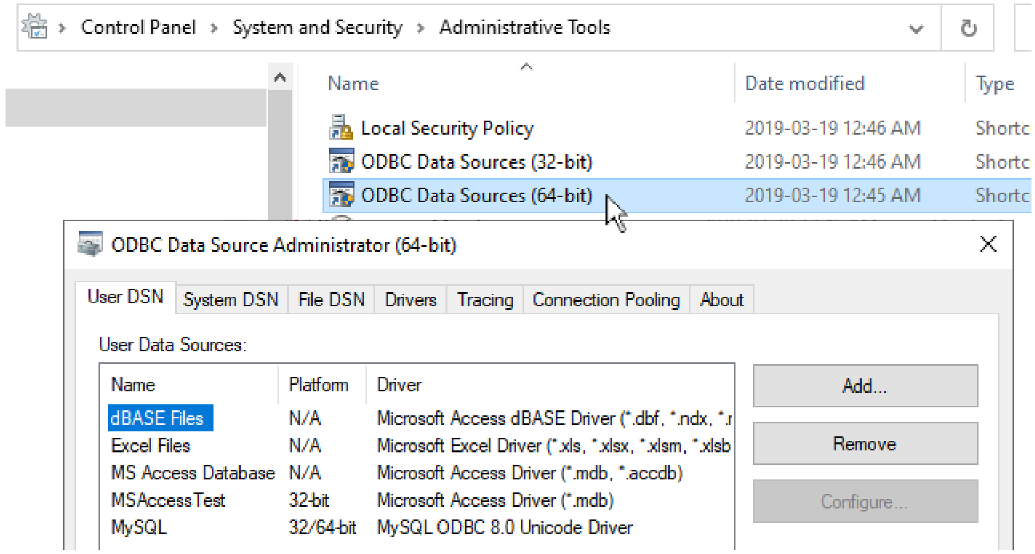
The tutorials in this manual use SQL commands to query the database. The syntax for these commands may vary slightly from one ODBC database to another. If a given tutorial doesn't work right away, check the syntax of the SQL commands in the tutorial against the syntax that your database uses.

Although DataHub Scripting is included with every DataHub license, ODBC scripting requires that the Database feature be licensed as well.

Setting up a DSN (Data Source Name)

To connect an ODBC-compliant database to a DataHub instance, you will need to ensure that you have specified a *DSN* (Data Source Name) for the database. Here's how:

1. From the Windows **Start** menu, choose **Control Panel**, then **Administrative Tools**, and then **Data Sources (ODBC)** to open the ODBC Data Source Administrator window. This is what it looks like in Windows XP:



2. Select the **User DSN** or **System DSN** tab, depending on how you plan to access your database.

   A user DSN is only available to the current user account, while a system DSN is available to any user account on the computer.

3. Now you can add a new database or configure an existing one.

   Add a new database

   1. Click the **Add** button. The Create New Data Source window will open, displaying a list of data source drivers.
   2. Select the data source driver that corresponds to your ODBC database. A data source setup window will open. Each data source setup window is different, but you should be able to find the appropriate entry fields easily enough.
   3. Enter the data source name and select the database.
   4. Enter any other required or optional information such as login name, password, etc. What entries need to be made and where they are entered depends on the particular data source setup window you are using.
   5. Click **OK** to return to the ODBC Data Source Administrator window. You should be able to see the new database and driver listed. If you need to make any changes, you can configure an exiting database, as explained below.

   Configure an existing database

   1. Select a data source name and click the **Configure...** button. This takes you to the data source setup window (explained above) where you can make changes to the configuration.
   2. Make your changes and click **OK** to return to the ODBC Data Source Administrator window. Any time you need to make a change, you can go to this window.

4. When you are satisfied everything is correct, click the **OK** button to exit the ODBC Data Source Administrator.

Working with MS Access

The Microsoft Access database program is a handy tool for MS Office users, but it is not completely ODBC compliant, nor is it a database server. Its design prevents simultaneous updates from outside data sources while the Access program is running, but it can still be used with the DataHub program to collect and store data from real-time systems.

File-based Data Access

MS Access is not a database server like MS SQL Server, MySQL, Oracle, and others. Instead, it accesses a data file (`.mdb` file), reading from and writing data to that file. Other programs like a DataHub instance can also access the file, but *not simultaneously* with Access. You can use the DataHub instance to modify the data file, but any time you open the file in Access, all programs including the DataHub instance are blocked from using it until you close the file in Access.

What this means is that if you are using a DataHub instance to interface to a real-time control or financial system and you want mission critical data stored in an ODBC compliant database, you probably don't want to be using MS Access. However, it could be useful for storing and viewing logged data. And for some it might be a convenient way to start investigating the possibilities of ODBC scripting with the DataHub program.

Queries on Primary Keys

MS Access does not support the ODBC function `SQLPrimaryKeys`, which means you cannot programatically discover the primary keys of an Access database. Thus you will need to identify the primary keys of the tables in the code itself. You will notice in our tutorials that we do just that. Since data table design doesn't change frequently, this should not prove to be a problem in most cases.

Tutorials

Tutorial 1: Writing new rows to a table, based on a trigger - Multi-Threaded Version

This script creates and inserts a new row into a database whenever a trigger point changes value. The data that gets inserted into the row is an ID for the entry (the primary key), the name of a specified point, its value, and a timestamp of the change. The script uses the multi-threaded feature Store and Forward to store data in memory and/or on disk if the database is disconnected or too busy, and then log that data in time-sequential order when the database is available again.

The tutorials in this manual use SQL commands to query the database. The syntax for these commands may vary slightly from one ODBC database to another. If a given tutorial doesn't work right away, check the syntax of the SQL commands used here against the syntax that your database uses.

Although DataHub Scripting is included with every Cogent DataHub license, ODBC scripting requires that the Cogent DataHub Database feature be licensed as well.

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to *An Explanation of the Tutorial Code* for more information about the code.

Getting Started

To run this code or the other tutorials in this manual, you will need to do the following:

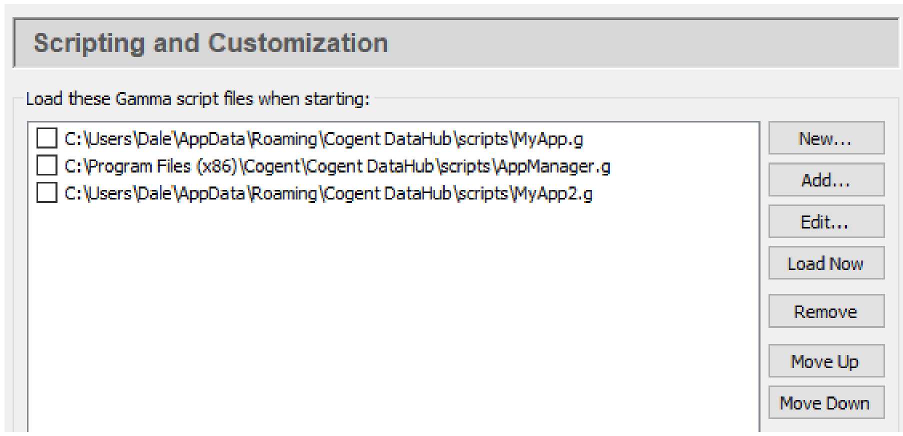
1. Set up a DSN (Data Source Name) called "`DataHubThreadedTest`" and point it to an empty database on your database server.
2. Create a table in the database named "`datatable`" that contains at least four columns with names, data types, and other attributes exactly as specified here:

Column name	**Data type**	**Other attributes**
`ptid`	integer	identity, non-null, counter
`ptname`	text string	null
`ptvalue`	real	non-null
`pttime`	datetime	null

Any other columns in this table must be allowed to take on a null value.

3. Start DataSim.
4. Find the tutorial script `ODBCTutorial1.g` on your system, and run it.

   You can access DataHub scripts and scripting capabilities by pressing the **Scripting** button in the **Properties** window, to display the **Scripting and Customization** screen. The upper half of the screen shows the Gamma files currently configured in the DataHub instance:

   The **Open** button opens a file selector for you to add an existing script to the list. Scripts are kept in a DataHub `scripts` folder. Scripts that come with the DataHub program are installed here (32-bit or 64-bit):

   ```
   C:\Program Files (x86)\Cogent\Cogent DataHub\scripts\
   C:\Program Files\Cogent\Cogent DataHub\scripts\
   ```

   All content in this directory will be replaced by the default content when the DataHub program is re-installed. If you plan to edit one of these scripts, or to write a new script, you should keep it in this folder for user-created scripts:

   ```
   C:\Users\Username\AppData\Roaming\Cogent DataHub\scripts
   ```

   The **Edit** button opens the selected script in the Script Editor for editing.

   You can view error message and printed output from a script in the Script Log. To open the Script Log, right click on the DataHub icon in the system tray, and select **View Script Log**.

   For complete information about DataHub scripting, please refer to the DataHub Scripting Manual

5. Check the database table to see the results. Once you have it working, you can modify the code as explained below.

The Code: `ODBCTutorial1.g`

```
/*
 * This script demonstrates the use of the threaded ODBC interface
```

```
 * to insert data from the DataSim program into a database based on
 * a timer or an event.
 */

require ("Application");
require ("ODBCThreadSupport");
require ("Time");
require ("Quality");

class ODBCTutorial1 Application
{
    DSN = "MySQLLocal";       // The DSN name to use for the database
                              // connection
    username = "test";        // The user name for connecting to
                              // the database
    password = "test";        // The password for connecting to
                              // the database
    tablename = "test";       // The name of the database table
    cachefile = "c:/tmp/testcache.txt";      // Base name for the disk
                                             // cache file
    tableclass;
    thread;
}

/* This method will be called every time the connection is
 * established to the database. If there is something we only want to
 * perform on the first connection, we can test is_first_connect to
 * perform the code only once.
 */
method ODBCTutorial1.onConnect()
{
    princ ("Connection succeeded\n");
    if (.thread.is_first_connect)
    {
        // Start the sequence defined by the AddInitStage calls
        // in the constructor
        .thread.BeginAsyncInit();
    }
}

/* If we get a connection attempt failure, or the connection fails
 * after having been connected, this method is called.
 */
method ODBCTutorial1.onConnectFail()
{
    princ ("Connection closed: ", SQLResult.Description, "\n");
```

```
}

/* Map the table in the set of table definitions that matches the
 * name in .tablename into a Gamma class.  This lets us easily
 ( convert between class instances and rows in the table.
 */
method ODBCTutorial1.mapTable(name, tabledefinitions)
{
    .tableclass = .thread.ClassFromTable(name, tabledefinitions);
}

/* Set up the timer or event handler functions to write to
 * the table.
 */
method ODBCTutorial1.startLogging()
{
     /* You can modify and/or add similar timers or event handlers
      * for each data point that you want to log.  Please refer to
      * the "Methods and Functions from Application.g" section of
      * the documentaton for more details about the timer and event
      * handler funtions.
      */
     // Log a new row of data every 3 seconds.
    .TimerEvery(3, `(@self).writeData(#$DataSim:Sine));

     // Log a new row of data at 20 seconds past each minute of
     // each hour, etc.
    .TimerAt(nil, nil, nil, nil, nil, 20,
      `(@self).writeData(#$DataSim:Triangle));

    // Log a new row of data for the point DataSim:Square when it
    // changes.
    .OnChange(#$DataSim:Square, `(@self).writeData(this));

    // Log a new row of data for the point DataSim:Sine when
    // DataSim:Square changes.
    .OnChange(#$DataSim:Square, `(@self).writeData(#$DataSim:Sine));
}

method ODBCTutorial1.writeData(pointsymbol)
{
    local       row = new (.tableclass);
    local       pttime, ptltime;
    local       timestring;

    /* Generate a timestamp in database-independent format to
```

```
     * the millisecond. Many databases strip the milliseconds from
     * a timestamp, but it is harmless to provide them in case the
     * database can store them.
     */
    pttime =
      WindowsTimeToUnixTime(PointMetadata(pointsymbol).timestamp);
    ptltime = localtime(pttime);
    timestring = format("{ts '%04d-%02d-%02d %02d:%02d:%02d.%03d'}",
   ptltime.year+1900, ptltime.mon+1,
   ptltime.mday, ptltime.hour, ptltime.min,
   ptltime.sec,
   (pttime % 1) * 1000);

    /* Fill the row.  Since we mapped the table into a Gamma class,
     * we can access the columns in the row as member variables of
     * the mapped class.
     */
    row.ptname = string(pointsymbol);
    row.ptvalue = eval(pointsymbol);
    row.pttime = timestring;
    /* Perform the insertion.  In this case we are providing no
     * callback on completion.
     */
    .thread.Insert(row, nil);
}

/* Write the 'main line' of the program here. */
method ODBCTutorial1.constructor ()
{
    // Create and configure the database connection object
    .thread = new ODBCThread();
    .thread.Configure(.DSN, .username, .password,
        STORE_AND_FORWARD, .cachefile, 0);

    /* Use this to delete the table on the first connection after
     * the script starts.
     * BE CAREFUL - re-running the script will start over and delete
     * the table again.
     */
     //.thread.AddInitStage(format("drop table %s", .tablename),
     //     nil, t);

    /* Use this to create the table if it does not exist.
     * Note: this might not work for all databases.
     * When in doubt, create the table manually.  The 't' in the
     * onFail argument says to ignore errors and continue with the
```

```
 * next stage.
 */
.thread.AddInitStage(format("create table %s (ptid int
                     auto_increment primary key, ptname
                     varchar(64),ptvalue double, pttime
                     datetime )", .tablename), nil, t);

/* Query the table and map it to a class for each insertion.We
 * want to run an asynchronous event within the asynchronous
 * initialization stage, so to do that we specify the special
 * method cbInitStage as the callback function of our
 * asynchronous event (GetTableInfo).  We deal with the return
 * from the GetTableInfo in the onSuccess argument of the init
 * stage.
 */
.thread.AddInitStage(`(@.thread).GetTableInfo("", "",
    (@.tablename),
    "TABLE,VIEW",
                                              `(@.thread)
    .cbInitStage()),
                     `(@self).mapTable(@.tablename, SQLTables),
nil);

/* Do not start writing data to the table until we have
 * successfully created and mapped the table to a class.  If we
 * wanted to start writing data immediately, then we would create
 * the table class beforehand instead of querying the database
 * for the table definition.  Then, even if the database were
 * unavailable we could still cache to the local disk until the
 database was ready.
 */
.thread.AddInitStage(nil, `(@self).startLogging(), nil);

/* Set up the callback functions for various events from the
 *database thread
 */
.thread.OnConnectionSucceeded = `(@self).onConnect();
.thread.OnConnectionFailed = `(@self).onConnectFail();
.thread.OnFileSystemError = `princ("File System Error: ",
       SQLResult, "\n");
.thread.OnODBCError = `princ("ODBC Error: ", SQLResult, "\n");
.thread.OnExecuteStored = nil;

/* Now that everything is configured, start the thread and begin
 * connecting.  All of the logic now will be driven through the
 * onConnect callback and then through the init stages.
```

```
     */
    .thread.Start();

    /* Create a menu item in the system tray that allows us to open
     * a window to monitor the performance of the ODBC thread.  The
     * menu strings can be edited as desired.
     */
    .AddCustomSubMenu("ODBC Thread Demo");
    .AddCustomMenuItem("Monitor Performance",
                       `(@.thread).CreateMonitorWindow((@self),
            "ODBC Demo Monitor"));

    /* If we want to open the performance monitor window when the
     * script starts, do it here.
     */
    .thread.CreateMonitorWindow(self, "ODBC Demo Monitor");
}

/* Any code to be run when the program gets shut down. */
method ODBCTutorial1.destructor ()
{
 if (instance_p(.thread))
  destroy(.thread);
}

/* Start the program by instantiating the class. */
ApplicationSingleton (ODBCTutorial1);
```

Modifying the Code

You can modify the `startLogging` method to add your own points by replacing data domains (*domain*), point names (*point*) and/or times (*day*, *month*, *year*, *hour*, *minute*, *second*, etc.) like this:

```
     // Log a new row of data every # seconds.
    .TimerEvery(seconds, `(@self).writeData(#$domain:point));

     // Log a new row of data at # seconds past each minute of each
     // hour, etc.
    .TimerAt(day, month, year, hour, minute, second,
             `(@self).writeData(#$domain:point));

    // Log a new row of data for a point when it changes.
    .OnChange(#$domain:point, `(@self).writeData(this));
```

```
// Log a new row of data for a point when a trigger point changes.
.OnChange(#$domain:point, `(@self).writeData(#$domain:point));
```

Please refer to the documentation for these methods of the `Application` class for more information: `TimerEvery`, `TimerAt`, and `OnChange`.

Tutorial 2: Writing new rows to a table, based on a trigger - Single-Threaded Version

This script creates and inserts a new row into a database whenever a trigger point changes value. The data that gets inserted into the row is an ID for the entry (the primary key), the value of a specified point, the timestamp of the change, and the name and quality of the point. The script also checks the connection to the database, and will attempt to reconnect every 5 seconds if the connection is lost.

The tutorials in this manual use SQL commands to query the database. The syntax for these commands may vary slightly from one ODBC database to another. If a given tutorial doesn't work right away, check the syntax of the SQL commands used here against the syntax that your database uses.

Although DataHub Scripting is included with every Cogent DataHub license, ODBC scripting requires that the Cogent DataHub Database feature be licensed as well.

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

```
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

Please refer to *An Explanation of the Tutorial Code* for more information about the code.

Getting Started

To run this code or the other tutorials in this manual, you will need to do the following:

1. Set up a DSN (Data Source Name) called "`DataHubTest`" and point it to an empty database on your database server.
2. Create a table in the database named "`datatable`" that contains at least five columns with names, data types, and other attributes exactly as specified here:

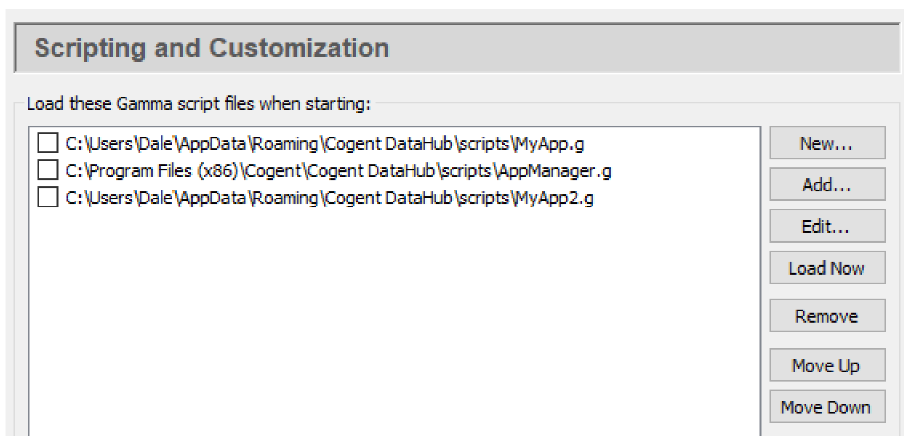
Column name	Data type	Other attributes
`ID`	integer	identity, non-null, counter
`PTVALUE`	real	non-null
`PTTIME`	datetime	null

Column name	Data type	Other attributes
PTNAME	text string	null
PTQUALITY	text string	null

Any other columns in this table must be allowed to take on a null value.

3. Start DataSim.
4. Find the tutorial script `ODBCTutorial2.g` on your system, and run it.

You can access DataHub scripts and scripting capabilities by pressing the **Scripting** button in the **Properties** window, to display the **Scripting and Customization** screen. The upper half of the screen shows the Gamma files currently configured in the DataHub instance:



The **Open** button opens a file selector for you to add an existing script to the list. Scripts are kept in a DataHub `scripts` folder. Scripts that come with the DataHub program are installed here (32-bit or 64-bit):

```
C:\Program Files (x86)\Cogent\Cogent DataHub\scripts\
C:\Program Files\Cogent\Cogent DataHub\scripts\
```

All content in this directory will be replaced by the default content when the DataHub program is re-installed. If you plan to edit one of these scripts, or to write a new script, you should keep it in this folder for user-created scripts:

```
C:\Users\Username\AppData\Roaming\Cogent DataHub\scripts
```

The **Edit** button opens the selected script in the Script Editor for editing.

You can view error message and printed output from a script in the Script Log. To open the Script Log, right click on the DataHub icon in the system tray, and select **View Script Log**.

For complete information about DataHub scripting, please refer to the DataHub Scripting Manual

5. Check the database table to see the results. Once you have it working, you can modify

the code as explained below.

The Code: `ODBCTutorial2.g`

```
/* All user scripts should derive from the base "Application" class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

//require ("WindowsSupport");
require ("ODBCSupport");
require ("Time");
require ("Quality");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */

/*
 * This application assumes that the table specified by the
 * "tablename" member variable exists in the DSN specified by the
 * "DSN" member variable below.
 * The table consists of at least the following columns:
 *    ID - integer, identity, non-null, counter
 *    PTVALUE - real, non-null
 *    PTTIME - datetime, null
 *    PTNAME - text string, null
 *    PTQUALITY - text string, null
 * Any other columns in this table must be allowed to take on a
 * NULL value.
 */

class ODBCTutorial2 Application
{
    /* User-defined values, may be changed as needed. */
    DSN = "DataHubTest";
    user = "test";
    password = "test";
    tablename = "datatable";
```

```
    /* These values get defined by the program.*/
    conn;
    env;
    tableclass;
    is_connected;
    is_connecting;
}

/* Connect to the DSN and create a class that maps the table. */
method ODBCTutorial2.Connect ()
{
    princ ("Connecting to database\n");
    .is_connecting = t;

    protect
    {
        /* Create the ODBC environment and connection */
        if (!.env)
            .env = ODBC_AllocEnvironment();
        if (!.conn)
            .conn = .env.AllocConnection();

        /* Attempt the connection. */
        ret = .conn.Connect (.DSN, .user, .password);
        if (ret != SQL_SUCCESS && ret != SQL_SUCCESS_WITH_INFO)
            error (.conn.GetDiagRec());

        /* Create a class from the table */
        .tableclass = .conn.ClassFromTable (#DataEntry, nil,
         .tablename);

        /* Set the primary key.  This is redundant for MS-SQL and
    MYSQL since they can figure it out themselves, but Access
    requires it. */
        mykey = .conn.SetPrimaryKey (.tableclass, "ID");

        .is_connected = t;
    }
    unwind
    {
        .is_connecting = nil;
        if (.is_connected)
            princ ("    Connection successful\n");
        else
            princ ("    Connection failed\n");
```

```
    }
}

/* Disconnect from the database server */
method ODBCTutorial2.Disconnect ()
{
    if (.conn)
    {
        try
        {
            princ ("Disconnecting database\n");
            .conn.Disconnect();
            destroy(.conn);
        }
        catch
        {
            princ ("Disconnection failed: ", _last_error_, "\n");
        }
        .conn = nil;
    }
    .is_connected = nil;
}

method ODBCTutorial2.Reconnect()
{
    if (!.is_connected && !.is_connecting)
    {
        .Connect();
    }
}

/* Fill a database record with new information from a point change. */
method ODBCTutorial2.FillRecord (record, sym, newvalue)
{
    local   timestamp;

    timestamp = localtime (PointGetUnixTime(sym));
    timestamp = format ("%d-%02d-%02d %02d:%02d:%02d",
        timestamp.year + 1900, timestamp.mon + 1,
        timestamp.mday, timestamp.hour, timestamp.min,
        timestamp.sec);
    record.PTNAME = string (sym);
    record.PTVALUE = number (newvalue);
    record.PTTIME = timestamp;
    record.PTQUALITY = GetQualityName(PointMetadata(sym).quality);
    record;
```

```
}

/* Write a new record into the database based on a point change. */
method ODBCTutorial2.AddRecord (sym, newvalue)
{
    local    record = new (.tableclass);
    .FillRecord (record, sym, newvalue);
    try
    {
        .conn.Insert (record);
    }
    catch
    {
        princ
   ("Write failed. Disconnecting. Record was not written.\n");
        .Disconnect();
    }
    record;
}

/* The mainline.  Connect to the database and begin storing data from
   the DataHub program into the database. */
method ODBCTutorial2.constructor ()
{
    local    ret;

    /* Start a timer that will reconnect to the database
       every 5 seconds if the connection has been lost. */
    .TimerEvery(5, `(@self).Reconnect());

    /* Try connecting now.  If this fails, the timer will
       try again later. */
    .Reconnect();

    /* Add a record when a point changes.  */
    .OnChange (#$DataSim:Square,
        `(@self).AddRecord (#$DataSim:Sine, $DataSim:Sine));

    /* Add more points like this:
     *  .OnChange (#$DataSim:Square,
     *      `(@self).AddRecord
     *      (#$MyDomain:MyPt, $MyDomian:MyPt));
     * Have the trigger point's value get written like this:
     *   .OnChange (#$DataSim:Square,
     *              `(@self).AddRecord
     *              (#$DataSim:Square, $DataSim:Square));
```

```
     */
}

/* Any code to be run when the program gets shut down. */
method ODBCTutorial2.destructor ()
{
    .Disconnect();
    if (.env)
        destroy(.env);
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (ODBCTutorial2);
```

Modifying the Code

There are several ways you can modify the code. These modifications are made in the `ODBCTutorial1.constructor` method, towards the end of the script.

- **Add more DataSim points** using this format:

  ```
  .OnChange (#$DataSim:Square,
             `(@self).AddRecord (#$DataSim:pointname,
                $DataSim:pointname));
  ```

  Where *pointname* is the name of a point in DataSim.

- **Change the trigger point** like this:

  ```
  .OnChange (#$DataSim:pointname,
             `(@self).AddRecord (#$DataSim:Sine, $DataSim:Sine));
  ```

  Where *pointname* is the name of a point in DataSim.

- **Add your own points** You can add your own points using this syntax:

  ```
  .OnChange (#$domain:pointname,
             `(@self).AddRecord (#$domain:pointname,
                                 $domain:pointname));
  ```

  where *domain* is the domain that the point is in, and *pointname* is the name of the point.

Tutorial 3: Updating existing rows, or writing new ones

This tutorial demonstrates how to find a particular row and update it, as well as write new rows, depending on the point.

This tutorial uses the same DSN, database, and table as Tutorial 2. If you haven't done Tutorial 2 yet, please review Getting Started in that section to see how to set up your system for this tutorial.

Although DataHub Scripting is included with every Cogent DataHub license, ODBC scripting requires that the Cogent DataHub Database feature be licensed as well.

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to *An Explanation of the Tutorial Code* for more information about the code.

The Code: `ODBCTutorial3.g`

```
/* All user scripts should derive from the base "Application" class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

//require ("WindowsSupport");
require ("ODBCSupport");
require ("Time");
require ("Quality");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */

/*
 * This application assumes that the table specified by the
 * "tablename" member variable exists in the DSN specified by the
```

```
 * "DSN" member variable below.
 * The table consists of at least the following columns:
 *    ID - integer, identity, non-null, counter
 *    PTVALUE - real, non-null
 *    PTTIME - datetime, null
 *    PTNAME - text string, null
 *    PTQUALITY - text string, null
 * Any other columns in this table must be allowed to take on a
 * NULL value.
 */

class ODBCTutorial3 Application
{
    /* User-defined values, may be changed as needed. */
    DSN = "DataHubTest";
    user = "test";
    password = "test";
    tablename = "datatable";

    /* These values get defined by the program.*/
    conn;
    env;
    tableclass;
}

/* Connect to the DSN and create a class that maps the table. */
method ODBCTutorial3.Connect ()
{
    /* Create the ODBC environment and connection */
    .env = ODBC_AllocEnvironment();
    .conn = .env.AllocConnection();

    /* Attempt the connection. */
    ret = .conn.Connect (.DSN, .user, .password);
    if (ret != SQL_SUCCESS && ret != SQL_SUCCESS_WITH_INFO)
        error (.conn.GetDiagRec());

    /* Create a class from the table */
    .tableclass = .conn.ClassFromTable (#DataEntry, nil, .tablename);

    /* Set the primary key.  This is redundant for MS-SQL and MYSQL
       since they can figure it out themselves, but Access requires
       it. */
    mykey = .conn.SetPrimaryKey (.tableclass, "ID");
}
```

```
/* Fill a database record with new information from a point change */
method ODBCTutorial3.FillRecord (record, sym, newvalue)
{
    local    timestamp;

    timestamp = localtime (PointGetUnixTime(sym));
    timestamp = format ("%d-%02d-%02d %02d:%02d:%02d",
        timestamp.year + 1900, timestamp.mon + 1,
        timestamp.mday, timestamp.hour, timestamp.min,
        timestamp.sec);
    record.PTNAME = string (sym);
    record.PTVALUE = number (newvalue);
    record.PTTIME = timestamp;
    record.PTQUALITY = GetQualityName(PointMetadata(sym).quality);
    record;
}

/* Write a new record into the database based on a point change. */
method ODBCTutorial3.AddRecord (sym, newvalue)
{
    local    record = new DataEntry();
    .FillRecord (record, sym, newvalue);
    .conn.Insert (record);
    record;
}

/* Write a data point into a field of a record.  This is called
   from a DataHub point change event.  This method will replace
   an existing record that is cached with the point at startup.  If
   there was no existing row in the database, this will create one
   and then update it in subsequent calls. */
method ODBCTutorial3.UpdateRecord (sym, newvalue)
{
    local    record = getprop (sym, #dbrecord);
    if (!record)
    {
        record = .AddRecord (sym, newvalue);
        setprop (sym, #dbrecord, record);
    }
    else
    {
        .FillRecord (record, sym, newvalue);
        .conn.Update (record);
    }
}
```

```
/* Find an existing record in the database for this point.  If it
   exists, associate the record with the point. */
method ODBCTutorial3.GetExistingRecord (sym, klass)
{
    local    result = .conn.QueryToClass (klass, string
                                          ("SELECT * FROM ",
                                           klass.__table,
                                           " WHERE PTNAME = '",
        sym, "'"));
    if (array_p(result))
     setprop (sym, #dbrecord, result[0]);
}

/* Start updating the database whenever a point changes.  If the
   overwrite argument is non-nil or absent, then this method will
   cause an existing record in the database to be overwritten each
   time.  If overwrite is nil, every point change will create a
   new row in the database. */
method ODBCTutorial3.WatchPoint (sym, tableclass, overwrite?=t)
{
    /* Grab an existing record for this point if it exists */
    .GetExistingRecord (sym, tableclass);
    if (overwrite)
        .OnChange (sym, `(@self).UpdateRecord (this, value));
    else
        .OnChange (sym, `(@self).AddRecord (this, value));
}

/* The mainline.  Connect to the database and begin storing data from
   the DataHub program into the database. */
method ODBCTutorial3.constructor ()
{
    local    ret;

    /* Connect to the DSN. */
    .Connect();

    /* Register points that we want to save.  The WatchPoint method
       takes an optional third arguement.  If it is nil, every point
       change will add a row to the table.  If it is absent or
       non-nil, then every point change overwrites the existing row
       in the table for that point. */
    .WatchPoint (#$DataSim:Square, .tableclass, nil);
    .WatchPoint (#$DataSim:Sine, .tableclass);
}
```

```
/* Any code to be run when the program gets shut down. */
method ODBCTutorial3.destructor ()
{
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (ODBCTutorial3);
```

Modifying the Code

There are several ways you can modify the code. These modifications are made in the `ODBCTutorial2.constructor` method, towards the end of the script.

- **Overwrite or add rows.** There are two ways the ODBC database can receive the data: by overwriting old values with new values in a single row, or by adding a new row for each new value. These are determined by the last argument in the `.WatchPoint` function.:

  ```
      .WatchPoint (#$DataSim:Square, tableclass, nil);
      .WatchPoint (#$DataSim:Sine, tableclass);
  ```

  The default is to overwrite values. This is what happens for values pertaining to `DataSim:Sine`. To have the DataHub instance write a new line for each change, you can add a final argument, `nil`, such as in `DataSim:Square` above.

- **Add more DataSim points.** To add other points from DataSim, use this format for new rows:

  ```
      .WatchPoint (#$DataSim:pointname, tableclass, nil);
  ```

  or this format for overwriting rows:

  ```
      .WatchPoint (#$DataSim:pointname, tableclass);
  ```

  Where *`pointname`* is the name of a point in DataSim.

- **Add your own points** You can add your own points using this syntax:

  ```
      .WatchPoint (#$domain:pointname, tableclass, nil);
      .WatchPoint (#$domain:pointname, tableclass);
  ```

  where *`domain`* is the domain that the point is in, and *`pointname`* is the name of the point.

Tutorial 4: Writing data from a database to a DataHub instance

This tutorial demonstrates how to keep a DataHub instance updated every second with the latest values in a database.

This tutorial uses the same DSN and database as Tutorial 2, but creates a different table called "`control`" (see below). If you haven't done Tutorial 2 yet, please review Getting Started in that section to see how to set up your system for this tutorial.

Although DataHub Scripting is included with every Cogent DataHub license, ODBC scripting requires that the Cogent DataHub Database feature be licensed as well.

The code for this and other example scripts can be found in the DataHub distribution archive, typically at this location:

`C:\Program Files\Cogent\Cogent DataHub\scripts\`

Please refer to *An Explanation of the Tutorial Code* for more information about the code.

As with Tutorial 2, you will need to create a table in the database. This new table should be named "`control`", and should contain at least three columns with names, data types, and other attributes exactly as specified here:

Column name	Data type	Other attributes
`ID`	integer	identity, non-null, counter
`CTRLNAME`	text string	null
`CTRLVALUE`	real	non-null

Any other columns in this table must be allowed to take on a null value.

Once this script is running, you can enter the name of any existing DataHub point in a row of the database in the `CTRLNAME` column. Make sure you enter the full point name, including the domain name, with the syntax *`domainname`*`:`*`pointname`*. Enter a corresponding value for the point in `CTRLVALUE`. The entered value will appear for that point in the DataHub instance. Any time the value changes in the database, the results get passed to the DataHub instance within a second. The point in the DataHub instance will continue to be updated once every second from the database as long as the two are both running.

The Code: `ODBCTutorial4.g`

```
/* All user scripts should derive from the base "Application" class */

require ("Application");
```

```
/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */

/*
 * This application assumes that the table specified by the
 * "tablename" member variable exists in the DSN specified by the
 * "DSN" member variable below.
 * The table consists of at least the following columns:
 *    ID - integer, identity, non-null, counter
 *    CTRLNAME - text string, null
 *    CTRLVALUE - real, non-null
 * Any other columns in this table must be allowed to take on a
 * NULL value.
 */

class ODBCTutorial4 Application
{
    /* User-defined values, may be changed as needed. */
    DSN = "DataHubTest";
    user = "test";
    password = "test";
    tablename = "Table1";

    /* These values get defined by the program.*/
    conn;
    env;
    tableclass;
    is_connected;
    is_connecting;
}

/* Connect to the DSN and create a class that maps the table. */
method ODBCTutorial4.Connect ()
{
```

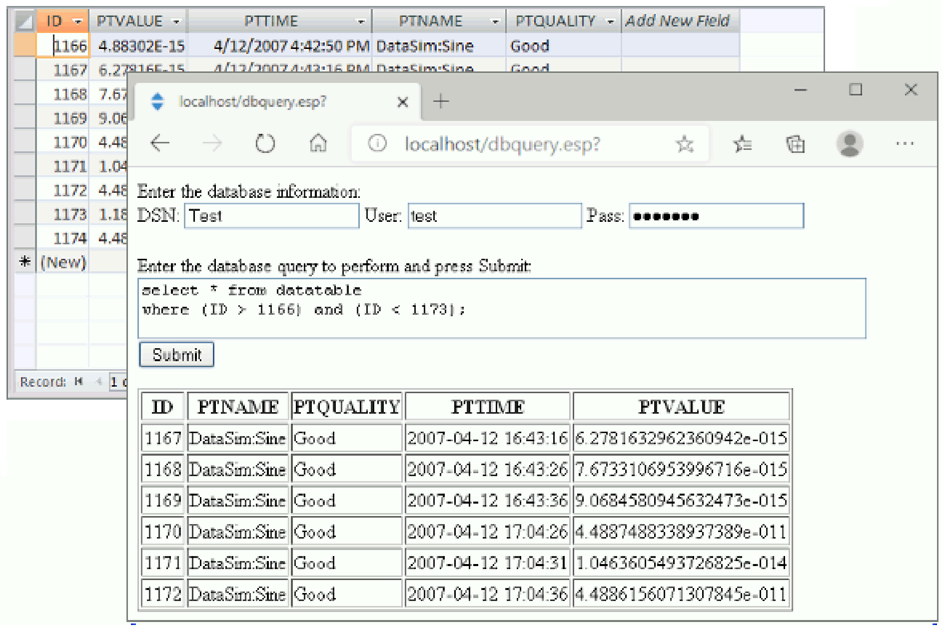
```
    local   ret;
    .is_connecting = t;

    protect
    {
        /* Create the ODBC environment and connection */
        if (!.env)
            .env = ODBC_AllocEnvironment();
        if (!.conn)
            .conn = .env.AllocConnection();

        /* Attempt the connection. */
        ret = .conn.Connect (.DSN, .user, .password);
        if (ret != SQL_SUCCESS && ret != SQL_SUCCESS_WITH_INFO)
            error (.conn.GetDiagRec());

        /* Create a class from the table */
        .tableclass = .conn.ClassFromTable (#DataEntry,
         nil, .tablename);

        /* Set the primary key.  This is redundant for MS-SQL and
    MYSQL since they can figure it out themselves, but Access
    requires it. */
        .conn.SetPrimaryKey (.tableclass, "ID");

      .is_connected = t;
    }
    unwind
    {
        .is_connecting = nil;
        if (.is_connected)
            princ ("    Connection successful\n");
        else
            princ ("    Connection failed\n");
    }
}

/* Disconnect from the database server */
method ODBCTutorial4.Disconnect ()
{
    if (.conn)
    {
        try
        {
            princ ("Disconnecting database\n");
            .conn.Disconnect();
```

```
            destroy(.conn);
        }
        catch
        {
            princ ("Disconnection failed: ", _last_error_, "\n");
        }
        .conn = nil;
    }
    .is_connected = nil;
}

/* Try to reconnect to the database if it's not currently
   connected. */
method ODBCTutorial4.Reconnect()
{
    if (!.is_connected && !.is_connecting)
    {
        .Connect();
    }
}

/* Reload information from a database record into the DataHub
   program.  This is being called on a timer.  We re-query the
   database for the given record, then update the DataHub points
   simply by assigning them. */
method ODBCTutorial4.Update ()
{
    local  result;

    if (.is_connected)
    {
        try
        {
            result = .conn.QueryToClass (.tableclass,
      string ("select * from ", .
       tablename));
            with x in result do
            {
               datahub_write (x.CTRLNAME, x.CTRLVALUE);
            }
        }
        catch
        {
            /* If the query fails then disconnect and do not try
        again until a successful connection has been made
        based on the reconnect timer. */
```

```
            princ("Query failed.  Disconnecting - ",
    _last_error_, "\n");
            .Disconnect();
        }
    }
}

/* The mainline.  Connect to the database and begin storing data from
   the DataHub program into the database. */
method ODBCTutorial4.constructor ()
{
    /* Every second, read the 'control' database, and update the
       values.  This keeps the value in the DataHub instance always
       in sync with the database.  The timer value can be fractional,
       such as 0.5 for twice per second.  */
    .TimerEvery (1, `(@self).Update ());

    /* Start a timer that will reconnect to the database
       every 5 seconds if the connection has been lost. */
    .TimerEvery(5, `(@self).Reconnect());

    /* Try connecting now.  If this fails, the timer will try again
       later. */
    .Reconnect();

}

/* Any code to be run when the program gets shut down. */
method ODBCTutorial4.destructor ()
{
    .Disconnect();
    if (.env)
        destroy(.env);
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (ODBCTutorial4);
```

Viewing data from a web browser

Using the DataHub Web Server, it is possible to send an SQL query from a web page to a database, and view the results in the web page.



Please refer to the Web Server documentation in the Cogent DataHub manual for more information.

An Explanation of the Tutorial Code

The DataHub program interacts with relational databases through ODBC (Open Data Base Connectivity). Every database acts a little differently, and each person's requirements are specific to the their own application. Consequently, the DataHub program offers its ODBC support through scripts, written in the Gamma language.

A DataHub script consists of four parts:

- Define the application object
- Interactions with the database
- Set up event handlers
- Shut down

Define the Application Object

A DataHub script defines an object called an `Application` object. This object is a class derived from the class `Application`. All of the functions that you define should be methods of this class. Variables should be members of this class wherever possible.

```
class MyODBCScript Application
{
  env;    // store the ODBC environment here
  conn;   // store the ODBC connection here
}
```

This defines the application object.

The application object requires a constructor. The constructor acts as the main line of your program. To start your program, you just create an instance of the application class, causing the constructor to run.

```
method MyODBCScript.constructor ()
{
  // This is the program main line
}
```

The job of the constructor is to define event handlers. An event handler is program code attached to a particular event. An event can be one of:

- A change in a DataHub point value
- A timer
- A Microsoft Windows event

The constructor runs to completion. Once the constructor completes, the script engine begins processing events, and executes the program code attached to those events.

The script engine will continue to process events until the application object is destroyed. You may optionally provide a destructor for the object to clean up any specific data or open any files or timers that your application has created.

```
method MyODBCScript.destructor ()
{
  // This is where you clean up open files and connections
}
```

You can add other methods to the application object as you need them. Only the constructor is necessary.

Interactions with the Database

Connecting to the Database

Connecting to an ODBC database is a three-step process:

1. Create an `ODBCEnvironment` object.
2. Create an `ODBCConnection` object.
3. Connect to a DSN (Data Source Name).

```
    .env = ODBC_AllocEnvironment();
    .conn = .env.AllocConnection();

    /* Attempt to connect. */
    ret = .conn.Connect ("DSN name", "user name", "password");
    if (ret != SQL_SUCCESS && ret != SQL_SUCCESS_WITH_INFO)
        error (.conn.GetDiagRec());
```

If the connection fails, the return value will be something other than `SQL_SUCCESS` or `SQL_SUCCESS_WITH_INFO`. You can query the database for details of the failure by calling the `GetDiagRec` method of the `ODBCConnection`.

Creating a Gamma Class from a Database Table

The tutorial code connects to an existing database table. If you would like the script create a table for you, please refer to the section called “Creating a Database Table” below.

ODBC tables are mapped as classes into the Gamma engine. This means that most interactions with the database will be through convenient method calls rather than SQL queries. The Gamma engine is able to automatically determine the structure of a table in your database and to create a class from it:

```
tableclass = .conn.ClassFromTable (#ClassName, nil, "table_name");
```

This statement will look up the table named `table_name` in your database, and create a class whose name is `ClassName` from it. It will also return the class definition into the variable `tableclass`.

The Gamma engine attempts to determine the primary key field from your table. Some databases, such as Microsoft Access, do not provide a facility to do this. In that case, you need to assign the primary key for the table:

```
.conn.SetPrimaryKey (tableclass, "id");
```

The resulting class will have a number of special data members, like `__table`, the name of the table, as well as a data member for each column of the database table.

Querying Rows from the Database

Once you have mapped your database table to a Gamma class, you can query the database by constructing a `select` SQL call:

```
allrows = .conn.QueryToClass (tableclass,
                              string ("select * from ",
                                      tableclass.__table));
```

This statement will query all of the rows in the table attached to `tableclass`, and return them as an array in `allrows`. Each element of the array will be a class instance.

Inserting Rows into a Database

To insert a row, first create a member of the class associated with the table, and then use `ODBCConnection.Insert` to insert it:

```
local   timestamp;
local   record;

record = new (tableclass);
timestamp = localtime (clock());
timestamp = format ("%d-%02d-%02d %02d:%02d:%02d",
        timestamp.year + 1900, timestamp.mon + 1,
        timestamp.mday, timestamp.hour, timestamp.min,
        timestamp.sec);
record.ptname = "point name";
record.ptvalue = point_value;
record.pttimestamp = timestamp;
record.ptquality = point_quality;
.conn.Insert (record);
```

This code creates a record to be inserted, assigns a value to each column in the record, and then inserts it into the database. The Gamma engine will attempt to convert the values in each column to the type required by the database. If an error occurs, the `Insert` method will throw an error that can be handled by a `try/catch` block.

You can also insert rows by constructing your own SQL statement and submitting it using the ODBCConnection.QueryAndStore method.

Updating Existing Rows in a Database

To update an existing row in a database, you must know the primary key for the row you wish to update. Normally you find this key by performing a query on the database:

```
local   result = .conn.QueryToClass (tableclass, string
                                      ("select * from ",
                                       tableclass.__table,
                                       " where name = '",
                                       "the_point_name", "'"));
local   record = result[0];
```

The primary key column of the record will identify the row in the database. You can now modify the record:

```
record.ptvalue = new_point_value;
```

and update the record in the database:

```
.conn.Update (record);
```

If an error occurs, the `Update` method will throw an error that can be handled by a `try/catch` block.

Creating a Database Table

In most cases, you will create the database table using your database management software. This gives you a more convenient interface to the creation process. Different databases use different syntax to create a table. However, if you need to create a table within your script, there are two options:

1. Call the ODBCConnection.CreateTable method.
2. Call the ODBCConnection.QueryAndStore method.

The `CreateTable` method helps to construct the query, but it still requires you to understand the SQL syntax of table creation for your database.

```
.conn.CreateTable ("table name",
                   "id int PRIMARY KEY IDENTITY",
                   "ptname VARCHAR(20) NOT NULL",
                   "ptvalue DOUBLE NOT NULL",
                   "pttimestamp DATETIME NOT NULL",
                   "ptquality VARCHAR(20) NOT NULL"
                   );
```

The `CreateTable` arguments consist of the table name followed by any number of definitions for the columns in the table. The column definitions depend on the database being used. In particular, the primary key field (in this example, `id`) is very different from one database to another. The primary key must be integer, unique and auto-incrementing. In the case of Microsoft Access, you must issue an additional query to create a primary key:

```
.conn.CreateTable ("table_name",
                   "id COUNTER",
                   "ptname VARCHAR(20) NOT NULL",
                   "ptvalue DOUBLE NOT NULL",
                   "pttimestamp DATETIME NOT NULL",
                   "ptquality VARCHAR(20) NOT NULL"
                   );
.conn.QueryAndStore ("create unique index p_id on table_name (id)
                      with primary disallow null");
```

The alternative to using `ODBCConnection.CreateTable` is to construct your own complete SQL statement and submit it to the database using `ODBCConnection.QueryAndStore`:

```
.conn.QueryAndStore ("create table table_name
                      (id COUNTER, ptname VARCHAR(20) NOT NULL,
                                   ptvalue DOUBLE NOT NULL,
                                   pttimestamp DATETIME NOT NULL,
                                   ptquality VARCHAR(20) NOT NULL)");
.conn.QueryAndStore ("create unique index p_id on table_name (id)
                      with primary disallow null");
```

If any call to `CreateTable` or `QueryAndStore` generates an error, then the error will be thrown. You can catch the error using a `try/catch` block within your script.

Set up Event Handlers

The Gamma application will normally define functions to be called when an event occurs. In ODBC applications, this is most commonly to write live data into the relational database. Another word for an event is a "trigger". It is up to you to decide the best trigger for writing data into the database.

An event handler will look something like this:

```
.OnChange (#$DataSim:Sine, `(@self).AddRecord (this, value));
```

This statement says that when the DataHub point `DataSim:Sine` changes, we want to call our application's `AddRecord` method with two arguments. The special variables `this` and `value` are always defined to be the point name and the point value respectively when running an `OnChange` handler. We might define our `AddRecord` method like this:

```
method MyODBCScript.AddRecord (pointname, newvalue)
{
    local  record = new (tableclass);
```

```
    local  timestamp;

    timestamp = localtime (PointGetUnixTime(pointname));
    timestamp = format ("%d-%02d-%02d %02d:%02d:%02d",
        timestamp.year + 1900, timestamp.mon + 1,
        timestamp.mday, timestamp.hour, timestamp.min,
        timestamp.sec);
    record.ptname = string (pointname);
    record.ptvalue = number (newvalue);
    record.pttimestamp = timestamp;
    record.ptquality =
                  GetQualityName(PointMetadata(pointname).ptquality);
    .conn.Insert (record);
    record;
}
```

If you would like to add a record at a specific interval rather than on a value change, you could create a timer:

```
timerid = every (0.5, `(@self).AddRecord (#$DataSim:Sine,
                                          $DataSim:Sine));
```

This statement will add a new record to the database every ½ second. In this case, we need to specify the name of the point, `$DataSim:Sine`, as part of the `AddRecord` call because the special variables `this` and `value` are not defined during a timer call. The first reference to `$DataSim:Sine` is protected from evaluation during the call using the # modifier, so its name is passed to the first argument when the expression is evaluated (when the timer occurs). The second reference is not protected from evaluation, so its value is passed to the second argument.

You need to keep track of outstanding timers so that you can clean them up during the destructor:

```
method MyODBCScript.destructor ()
{
  cancel (timerid);
}
```

Shut Down

Normally an `Application` is not started and stopped repeatedly. The application is normally started when the DataHub instance starts, and continues until the DataHub instance is stopped.

To shut down your application, you need to destroy the application instance. This will cause the destructor to be called. Your clean-up code should be located in the destructor. The `Application` class automatically cleans up event handlers created using `OnChange`. You can detach from the ODBC database in your destructor:

```
method MyODBCScript.destructor ()
{
    .conn.Disconnect();
    cancel (timerid);
}
```

If you do not disconnect from the database in the destructor, the Gamma engine will disconnect from the database when its garbage collector destroys the `ODBCConnection` object.

You can destroy the application instance by calling the `destroy` function. This can be triggered by a data point change or some other method. For example:

```
.OnChange (#$default:kill_application, `destroy(@self));
```

This statement would wait for a change to the DataHub point named `default:kill_application` and then destroy the application. The application could then be restarted from the Scripting option in the DataHub Properties window.

Multi-Threaded ODBC Interface

The Cogent DataHub program includes a scripting interface to multi-threaded database access. This comes in addition to the existing single-threaded ODBC implementation. A multi-threaded interface is substantially different from a single-threaded interface, and offers a number of advantages:

1. **Non-blocking** A single-threaded interface can block when attempting to communicate with a database that is no longer available. While blocked, all other Gamma scripts are halted until the database responds or the connection times out. This has a particularly substantial impact when attempting to communicate with more than one database at a time, since blocking on one database will also halt communication to the other database.

   With a multi-threaded interface, a separate thread is spawned to communicate with each database. If a communication problem occurs, only the database thread blocks. All other Gamma scripts continue to run normally.
2. **Store-and-forward** A single-threaded interface must be willing to drop data when the database becomes temporarily too busy to handle incoming data, or when the database is disconnected for some reason, such as a network failure.

   A multi-threaded interface can store data to disk when the database is unresponsive or unavailable. When the database recovers, the stored data can be transmitted to the database. Some multi-threaded implementations do not preserve operation order. The Gamma implementation guarantees that every operation will be performed in the same order that it was originally attempted.
3. **Time-delayed write** The multi-threaded implementation can store data to disk, to be written to the database at a later time or in batches as defined intervals. This is particularly useful if bandwidth is limited at certain times of day, or where the database connection is expensive to maintain at all times. For example, a database connection using satellite Internet could be charged based on connection time. It is much more efficient to store data temporarily and then connect at a predefined interval to update the database.

How-To

To ensure that the primary script thread does not block when there is a communication problem with the the database, all communication to the database must be asynchronous. This means that a database command will normally not produce an immediate result. The result will be delivered at some time in future by triggering a "callback" function in the script. This is a different way of thinking about a script, and takes a little getting used to. The Gamma language provides a number of functions to make this as simple as possible.

Create an ODBCThread Instance

All communication with the database is performed through an instance of the class `ODBCThread`. For example:

```
mysql = new ODBCThread();
flags = STORE_AND_FORWARD;
cachefile = "C:/temp/mysql.cache";
mysql.Configure ("myDSN", "username", "password", flags, cachefile);
```

This code is sufficient to create the database connection. At this point, the database is not connected, and the thread that handles the database has not yet been started.

Attach Event Callbacks

The next step is to attach the callback functions that will alert the script to various events from the database thread. Whenever a callback function is executed, a special variable called `SQLResult` will be defined for the duration of the callback. This contains information about the result of the SQL command, a description of the command and error codes. This information is stored in an instance of the class `ODBCThreadResult`.

A callback is attached by simply assigning the code to run to the callback member of the `ODBCThread` object. For example, to print information when the connection fails, you could do this:

```
method MyApp.onConnectionFail()
{
    princ ("Connection closed: ", SQLResult.Description, "\n");
}
```

and then in the application constructor, do this:

```
thread.OnConnectionFailed = `(@self).onConnectFail();
```

The following callbacks are defined:

`OnConnectionSucceeded`
: Called when the connection to the database transitions from not connected to connected.

`OnConnectionFailed`
: Called when the connection to the database transitions from connected to not connected, or when a connection attempt fails. The `Description` member of the `SQLResult` contains information about the reason for the event.

`OnExecuteStored`
: Called when a stored transaction is successfully forwarded to the database. The `SQLResult` contains information about the transaction.

`OnFileSystemError`
: Called when a file system error occurs when reading or writing to the disk. The `Description` member for the `SQLResult` has details about the error.

`OnODBCError`
: Called when an ODBC error occurs that cannot be reported as part of the result set from a successful transaction. Typically this would be a failure generated by an attempt to execute a stored transaction.

Configure Startup Actions

One of the most difficult concepts of using an asynchronous interface is the idea that a sequence of steps must be performed in order during startup, even though the script code cannot be executed sequentially. At each step, there could be an asynchronous request/event pair that breaks up the sequence into disjoint code fragments.

The `ODBCThread` class defines a startup state machine that helps to sequence these steps. As a script developer, you define the steps that will be performed by creating a series of initialization steps, or "stages" that will be performed after a successful database connection. These stages will not automatically be executed. It is up to you to initiate them. This allows you to choose whether to execute these stages on each connection, or only on the first connection, or to start executing the stages at a stage other than the first.

To create initialization stages, make repeated calls to the method "addInitStage":

```
AddInitStage(sqlCommand, onSuccess, onFailure);
```

The *`sqlCommand`* argument contains either a string containing valid SQL, or inline code to be executed. If the *`sqlCommand`* is a string, it is passed to the database thread for execution. If it is inline code, it will be executed immediately.

The *`onSuccess`* and *`onFailure`* arguments are inline code that will be executed when the *`sqlCommand`* has returned a result. Only one of these two will be executed for each execution of *`sqlCommand`*. The return value from *`onSuccess`* is ignored. If the return value from *`onFailure`* is `nil`, then the initialization sequence is aborted. It is sufficient to supply `nil` to *`onFailure`* to abort the sequence on any error, and to supply `t` to *`onFailure`* to continue the sequence if there is an error.

For example, the following sequence could be used:

```
// Drop the existing table.  If we get an error, continue
   thread.AddInitStage("drop table mytable", nil, t);

// Create a new table.  Once the table is created, set up an
// auto-incrementig primary key.  If either the table creation or
// the key definition fails, abort.
thread.AddInitStage("create table mytable ( myid counter,
                                            myvalue number,
                                            tstamp number )",
```

```
                     nil, nil);
thread.AddInitStage("create unique index p_myid on mytable (myid)
                     with primary disallow null", nil, nil);

// Make a call to getTableInfo to look up all tables in the
// database.  Since getTableInfo is asynchronous, we must use its
// callback to resume the initialization sequence by calling the
// special method "cbInitStage()" in the callback, and then
// letting the initialization sequencer call the real callback
// mapTable is an example of user-created code.
thread.AddInitStage(`(@thread).getTableInfo("", "", "", "TABLE",
                    `(@thread).cbInitStage()),
                    `(@self).mapTable(@thread, "mytable",
                                      SQLTables), nil);

// We happen to know that the database we use does not provide
// primary key information so we have to set the primary key
// manually after the table has been mapped to  class.
thread.AddInitStage(nil, `(@self).SetClassKey((@self).tableclass,
                                               #myid),
                    nil);

// Finally, we have passed through all the initialization steps,
// so we begin storing data.  beginDataStream in this example is
// user-generated code, which might set up timers or data event
// handlers that cause the script to write data to the database.
thread.AddInitStage(nil, `(@self).beginDataStream(@thread), nil);
```

Notice that the final two stages do not define the *sqlCommand* at all. This will cause their success code to run immediately and then to move on to the next initialization stage. If an initialization stage has no *sqlCommand*, it cannot fail.

At this point, the initialization stages are defined but have not run. They will not be run until the script calls:

```
thread.beginAsyncInit();
```

Commonly, you only want to run the initialization once, so you might handle it in the `OnConnectionSuccess` handler like this:

```
method MyApp.onConnect(thread)
{
    princ ("Connection succeeded\n");
    if (thread.is_first_connect)
    {
        thread.beginAsyncInit();
    }
}
```

Start the Database Thread

Once you have defined the parameters for the database connection, defined the callback handlers and defined the initialization code, the connection is completely defined, but still is not running. To start the thread and begin connecting, call the `Start` method:

```
thread.Start();
```

At this point the thread is started and begins trying to connect to the database. As the thread runs it may call your callback functions in any order to indicate successes, failures, and errors.

Store and Forward

Store and Forward is a term used to describe a database connection where the data is stored locally to disk and then later forwarded to the database. The `ODBCThread` object performs an advanced form of store and forward that does more than simply store data for later delivery.

For any SQL statement given to the `ODBCThread.ExecDirect` method, you can optionally specify that this particular statement should be stored for later forwarding. Normally these will be `INSERT` or `UPDATE` statements, but they could be an SQL statement that must be executed at the database, such as stored procedures or `ALTER` statements. The `ODBCThread` guarantees that all storable SQL commands will be executed in the order in which they are specified, even if they are first stored to file.

The `ODBCThread` object uses a sophisticated store and forward technique that only writes to disk if the database is not connected, or has been paused. If the database is available, the commands will be transmitted directly to the database. This means that there is no penalty to using store and forward during normal operation.

`ODBCThread` also maintains an in-memory queue of pending operations. This queue helps to avoid writing to disk during busy periods or during short database or network outages. You can modify the depth of this queue to reduce the chance of involving the disk during busy periods. The queue depth defaults to 100 messages, but it can be modified by setting the `MaxTransactions` member of the ODBCThread. For example:

```
thread.MaxTransactions = 200;
```

For the thread to perform store and forward, the flag `STORE_AND_FORWARD` must be specified when initially configuring the thread, and the flag `STORE_AND_FORWARD` must also be specified for any call to `ExecDirect` that should be a candidate for store and forward treatment.

Time Delayed Writes

Time delayed writing is used to avoid maintaining a continuous connection to the database, or to make use of times of day where the network utilization is low. You can call the `Pause` and `Disconnect` methods at any time to cause the thread to pause output to the database, then disconnect. All further transactions will be written to the local disk cache until the database is reconnected. To resume writing to the database, the script just needs to call the `Resume` method. The database thread will automatically reconnect to the database when it can.

You can periodically test to see whether the disk cache has been transmitted by running a repeating timer that calls `CacheIsEmpty`. When `CacheIsEmpty` returns non-nil, the disk cache has been consumed. At this point the script can once again `Pause` and `Disconnect` the thread.

Using this method, the script can transmit the cached data based on the time of day, a process event, or even input from an operator.

Example

```
/*
 * This script demonstrates the use of the threaded ODBC interface
 * to insert data into a database based on a timer.
 */

require ("Application");
require ("ODBCThreadSupport");
require ("Time");
require ("Quality");

class ODBCThreadDemo Application
{
    DSN = "MySQLLocal";         // The DSN name to use for the
                                // database connection
    username = "test";          // The user name for connecting to
                                // the database
    password = "test";          // The password for connecting to
                                // the database
    tablename = "table1";       // The name of the database table
    cachefile = "c:/tmp/testcache.txt";     // Base name for the
                                            // disk cache file

    tableclass;
    thread;
}

/* This method will be called every time the connection is
 * established to the database. If there is something we only want
 * to perform on the first connection, we can test is_first_connect
 * to perform the code only once.
 */
method ODBCThreadDemo.onConnect()
```

```
{
    princ ("Connection succeeded\n");
    if (.thread.is_first_connect)
    {
        // Start the sequence defined by the AddInitStage calls in
        // the constructor
        .thread.BeginAsyncInit();
    }
}

/* If we get a connection attempt failure, or the connection fails
 * after having been connected, this method is called.
 */
method ODBCThreadDemo.onConnectFail()
{
    princ ("Connection closed: ", SQLResult.Description, "\n");
}

/* Map the table in the set of table definitions that matches the
 * name in .tablename into a Gamma class.  This lets us easily
 * convert between class instances and rows in the table.
 */
method ODBCThreadDemo.mapTable(name, tabledefinitions)
{
    .tableclass = .thread.ClassFromTable(name, tabledefinitions);
}

/* Set up the timer or event handler functions to write to the table.
 */
method ODBCThreadDemo.startLogging()
{
 /* You can modify and/or add similar timers or event handlers
  * for each data point that you want to log.  Please refer to
  * the "Methods and Functions from Application.g" section of
  * the documentaton for more details about the timer and event
  * handler funtions.
  */
 // Log a new row of data every 3 seconds.
    .TimerEvery(3, `(@self).writeData(#$DataSim:Sine));

 // Log a new row of data at 20 seconds past each minute
        // of each hour, etc.
    .TimerAt(nil, nil, nil, nil, nil, 20,
      `(@self).writeData(#$DataSim:Triangle));

    // Log a new row of data for the point DataSim:Square when
```

```
    // it changes.
    .OnChange(#$DataSim:Square, `(@self).writeData(this));

    // Log a new row of data for the point DataSim:Sine when
    // DataSim:Square changes.
    .OnChange(#$DataSim:Square, `(@self).writeData(#$DataSim:Sine));
}

method ODBCThreadDemo.writeData(pointsymbol)
{
    local       row = new (.tableclass);
    local       pttime, ptltime;
    local       timestring;

    /* Generate a timestamp in database-independent format to the
     * millisecond. Many databases strip the milliseconds from a
     * timestamp, but it is harmless to provide them in case the
     * database can store them.
     */

    pttime = WindowsTimeToUnixTime(PointMetadata(pointsymbol).
       timestamp);
    ptltime = localtime(pttime);
    timestring = format("{ts '%04d-%02d-%02d %02d:%02d:%02d.%03d'}",
   ptltime.year+1900, ptltime.mon+1,
   ptltime.mday, ptltime.hour,
   ptltime.min, ptltime.sec,
   (pttime % 1) * 1000);

    /* Fill the row.  Since we mapped the table into a Gamma class,
     * we can access the columns in the row as member variables of
     * the mapped class.
     */
    row.ptname = string(pointsymbol);
    row.ptvalue = eval(pointsymbol);
    row.pttime = timestring;

    /* Perform the insertion.  In this case we are providing no
     * callback on completion.
     */
    .thread.Insert(row, nil);
}

/* Write the 'main line' of the program here. */
method ODBCThreadDemo.constructor ()
{
```

```
    // Create and configure the database connection object
    .thread = new ODBCThread();
    .thread.Configure(.DSN, .username, .password,
        STORE_AND_FORWARD, .cachefile, 0);

    /* Use this to delete the table on the first connection after
     * the script starts. BE CAREFUL - re-running the script will
     * start over and delete the table again.
     */
    // .thread.AddInitStage(format("drop table %s", .tablename),
    //                      nil, t);

    /* Use this to create the table if it does not exist.  Note: this
     * might not work for all databases. When in doubt, create the
     * table manually.  The 't' in the onFail argument says to ignore
     * errors and continue with the next stage.
     */
     // thread.AddInitStage(format
     //    ("create table %s (ptid int
     //                     auto_increment primary key, ptname
     //                     varchar(64), ptvalue double, pttime
     //                     datetime )", .tablename), nil, t);

    /* Query the table and map it to a class for eash insertion.
     * We want to run an asynchronous event within the asynchronous
     * initialization stage, so to do that we specify the special
     * method cbInitStage as the callback function of our asynchronous
     * event (GetTableInfo).  We deal with the return from the
     * GetTableInfo in the onSuccess argument of the init stage.
     */
    .thread.AddInitStage(`(@.thread)
    .GetTableInfo("", "",
           (@.tablename),
           "TABLE,VIEW",
           `(@.thread).cbInitStage()),
    `(@self).mapTable(@.tablename,
        SQLTables),
    nil);

    /* Do not start writing data to the table until we have
     * successfully created and mapped the table to a class.  If we
     * wanted to start writing data immediately, then we would create
     * the table class beforehand instead of querying the database
     * for the table definition.  Then, even if the database were
     * unavailable we could still cache to the local disk until the
     *database was ready.
```

```
     */
    .thread.AddInitStage(nil, `(@self).startLogging(), nil);

    /* Set up the callback functions for various events from the
     * database thread
     */
    .thread.OnConnectionSucceeded = `(@self).onConnect();
    .thread.OnConnectionFailed = `(@self).onConnectFail();
    .thread.OnFileSystemError = `princ("File System Error: ",
           SQLResult, "\n");
    .thread.OnODBCError = `princ("ODBC Error: ", SQLResult, "\n");
    .thread.OnExecuteStored = nil;

    /* Now that everything is configured, start the thread and begin
     * connecting.  All of the logic now will be driven through the
     * onConnect callback and then through the init stages.
     */
    .thread.Start();

}

/* Any code to be run when the program gets shut down. */
method ODBCThreadDemo.destructor ()
{
}

/* Start the program by instantiating the class. */
ApplicationSingleton (ODBCThreadDemo);
```

Classes

DATE_STRUCT

DATE_STRUCT — contains dates (y,m,d).

Synopsis

```
class DATE_STRUCT
{
    day;
    month;
    year;
}
```

Description

This structure contains dates. For more information, please refer to C Data Types.

ODBCColumn

`ODBCColumn` —

Synopsis

```
class ODBCColumn
{
    columnsize;
    datatype;
    decimaldigits;
    name;
    nullable;
}
```

Description

Not yet documented.

ODBCConnection

`ODBCConnection` — allocates a connection handle.

Synopsis

```
class ODBCConnection ODBCHandle
{
    __stmt;
    h;
    handle;
    type;
}
```

Base Classes

`ODBCHandle` <-- `ODBCConnection`

Description

This class allocates a connection handle. It corresponds to using the value `SQL_HANDLE_DBC` for the *`HandleType`* of the `SQLAllocHandle` function.

Conversion Functions

This class provides conversion functions (`QueryToClass`, `QueryToTempClass` and `ClassFromColumns`, details below) to map an ODBC response into a Gamma class. They are all variations on constructing a list of class instances, where each row in the ODBC result maps to an instance of the class. Each column name maps to a member variable in the class, and each value in the row maps to the value of the member variable matching the corresponding column name.

For example, if this is the ODBC result:

```
Name       | Value        | Timestamp
point1     | 1            | 2025-01-22 12:00:00
point2     | 2            | 2025-01-22 12:00:01
```

and this is the class definition:

```
class MyDataClass
{
Name;
Value;
Timestamp;
}
```

then the goal of these functions is to create 2 instances of `MyDataClass`, where their `Name`, `Value` and `Timestamp` values are the corresponding values from each row of the query result.

The implementation of these functions can be found in `C:\Program Files\Cogent \Cogent DataHub\require\ODBCSupport.g`

Class Members

These functions are identical to the corresponding C or C++ functions, as noted.

We have attempted to link to Microsoft function documentation for these, but you may need to search.

`AddColumn (tablename, column, type, default_val, allow_null)`
: corresponds to AddColumn.

`AllocDescriptor ()`
: corresponds to AllocDescriptor.

`AllocStatement ()`
: corresponds to SQLAllocStmt.

`ClassFromColumns (symclassname, superclass, columns)`
: This method is used by `QueryToTempClass` (see below) to construct the class based on the column definitions returned from an ODBC query. `symclassname` is a symbol that will be the name of the temporary class. This name does not need to be unique. `superclass` is the same as for `QueryToTempClass`. `columns` is the column set as returned from the ODBC query. See also Conversion Functions, above.

`ClassFromTable (symclassname, superclass, tablename)`
: corresponds to ClassFromTable.

`ClassesFromTables (superclass, verbose?=nil)`
: corresponds to ClassesFromTables.

`Connect (ServerName, UserName, Authentication)`
: corresponds to SQLConnect.

`CreateTable (tablename, columns...)`
: corresponds to CreateTable.

`Delete (row)`
: corresponds to Delete.

`Disconnect ()`
: corresponds to SQLDisconnect.

`DropTable (tablename)`
: corresponds to DropTable.

`EndTran (CompletionType)`
: corresponds to SQLEndTran.

`Error ()`
: corresponds to SQLError.

`GetOneColumn (query_string)`
: corresponds to GetOneColumn.

`GetOneValue (query_string)`
: corresponds to GetOneValue.

`Insert (row)`
: corresponds to Insert.

`MakeClass (symclassname, superclass, ivars, tablename, primary_key)`
: corresponds to MakeClass.

`MapClassFromResponse (klass, response)`
: corresponds to MapClassFromResponse.

`Query (query_string)`
: corresponds to Query.

`QueryAndStore (query_string)`
: corresponds to QueryAndStore.

`QueryToClass (klass, query_string)`
: This method will produce an array of instances of `klass`, where the values from the query are mapped to the member variables of the class. See also Conversion Functions, above. Example:

```
local instanceArray = conn.QueryToClass(MyDataClass,
                           "select * from mytable");
```

`QueryToTempClass (superclass, query)`
: This method will create a temporary class on the fly, such that the member variables of the class match the column names of the query result. If superclass is non-nil then it must be a class. The newly created class will be derived from the superclass. The return value is an array of instances of the newly created class. See also Conversion Functions, above. Example:

```
local instanceArray = conn.QueryToTempClass(nil,
                          "select * from mytable");
```

`ReQuery (row)`
: corresponds to ReQuery.

`Statement ()`
: corresponds to Statement.

`StoreResult ()`
: corresponds to StoreResult.

`Update (row)`
: corresponds to Update.

(The following functions are inherited from: ODBCHandle)

`GetDiagRec ()`
: corresponds to SQLGetDiagRec.

ODBCDescriptor

`ODBCDescriptor` — allocates a descriptor handle.

Synopsis

```
class ODBCDescriptor ODBCHandle
{
    h;
    handle;
    type;
}
```

Base Classes

`ODBCHandle` <-- `ODBCDescriptor`

Description

This class allocates a descriptor handle. It corresponds to using the value `SQL_HANDLE_DESC` for the *`HandleType`* of the `SQLAllocHandle` function.

ODBCEnvironment

`ODBCEnvironment` — allocates an environment handle.

Synopsis

```
class ODBCEnvironment ODBCHandle
{
    h;
    handle;
    type;
}
```

Base Classes

`ODBCHandle` <-- `ODBCEnvironment`

Description

This class allocates an environment handle. It corresponds to using the value `SQL_HANDLE_ENV` for the *`HandleType`* of the `SQLAllocHandle` function.

Class Members

These functions are identical to the corresponding C or C++ functions, as noted.

We have attempted to link to Microsoft function documentation for these, but you may need to search.

`AllocConnection ()`
: corresponds to SQLAllocConnect.

(The following functions are inherited from: ODBCHandle)

`GetDiagRec ()`
: corresponds to SQLGetDiagRec.

ODBCHandle

`ODBCHandle` — a parent class for connections, descriptors, environments, and statements.

Synopsis

```
class ODBCHandle
{
    handle;
    type;
}
```

Description

This class is a parent class for `ODBCConnection`, `ODBCDescriptor`, `ODBCEnvironment`, and `ODBCStatement` handles. Together, these classes provide the functionality of `SQLAllocHandle`.

Class Members

These functions are identical to the corresponding C or C++ functions, as noted.

We have attempted to link to Microsoft function documentation for these, but you may need to search.

`GetDiagRec ()`
: corresponds to SQLGetDiagRec.

ODBCResult

`ODBCResult` —

Synopsis

```
class ODBCResult
{
    columns;
    rows;
}
```

Description

Not yet documented.

Class Members

These functions are identical to the corresponding C or C++ functions, as noted.

We have attempted to link to Microsoft function documentation for these, but you may need to search.

`ColumnIndex (column_name)`
: corresponds to ColumnIndex.

ODBCStatement

ODBCStatement — allocates a statement handle.

Synopsis

```
class ODBCStatement ODBCHandle
{
    h;
    handle;
    type;
}
```

Base Classes

ODBCHandle <-- ODBCStatement

Description

This class allocates a statement handle. It corresponds to using the value SQL_HANDLE_STMT for the *HandleType* of the SQLAllocHandle function.

Class Members

These functions are identical to the corresponding C or C++ functions, as noted.

We have attempted to link to Microsoft function documentation for these, but you may need to search.

`Cancel ()`
: corresponds to SQLCancel.

`CloseCursor ()`
: corresponds to SQLCloseCursor.

`Columns (CatalogName, SchemaName, TableName, ColumnName)`
: corresponds to SQLColumns.

`ExecDirect (StatementText)`
: corresponds to SQLExecDirect.

`Execute ()`
: corresponds to SQLExecute.

`Fetch ()`
: corresponds to SQLFetch.

`FetchScroll (FetchOrientation, FetchOffset)`
: corresponds to SQLFetchScroll.

`FreeStmt (Option)`
: corresponds to SQLFreeStmt.

`GetResultData ()`
: corresponds to SQLGetData.

`Prepare (StatementText)`
: corresponds to SQLPrepare.

`PrimaryKeys (CatalogName, SchemaName, TableName)`
: corresponds to SQLPrimaryKeys.

`RowCount (StatementText)`
: corresponds to SQLRowCount.

`Tables (CatalogName, SchemaName, TableName, TableType)`
: corresponds to SQLTables.

(The following functions are inherited from: ODBCHandle)

`GetDiagRec ()`
: corresponds to SQLGetDiagRec.

ODBCThread

`ODBCThread` — configures the multi-threaded ODBC interface.

Synopsis

```
class ODBCThread
{
    Commands;                 // Internal variable
    Callbacks;                // Internal variable
    OnExecuteStored;          // callback
    OnConnectionSucceeded;    // callback
    OnConnectionFailed;       // callback
    OnFileSystemError;        // callback
    OnODBCError;              // callback
    NCached;                  // Internal variable
    NUncached;                // Internal variable
    NStoredPrimary;           // Number of transactions written to
                              // level 1 cache
    NStoredSecondary;         // Number of transactions written to
                              // level 2 cache
    NForwarded;               // Number of transactions read from cache
    NStoreFailPrimary;        // Number of failures while writing to
                              // level 1 cache
    NStoreFailSecondary;      // Number of failures while writing to
                              // level 1 cache
    NForwardFail;             // Number of failures while writing to
                              // the database from cache
    NCommands;                // Number of commands ever queued to
                              // thread
    NResults;                 // Number of commands results ever
                              // returned from thread
    NRejected;                // Number of commands that were rejected
                              // without queueing
    ReconnectSecs;            // Number of seconds to wait between
                              // database reconnection attempts
    ForwardDelay;             // Delay in milliseconds between
                              // transactions written from cache to
                              // database
    MaxTransactions;          // Maximum number of transactions to hold
                              // on queue
}
```

Description

As of this writing, the ForwardDelay member is not implemented.

The script developer should only modify the following members:

```
OnExecuteStored
OnConnectionSucceeded
OnConnectionFailed
OnFileSystemError
OnODBCError
ReconnectSecs
ForwardDelay
MaxTransactions
```

Methods

`ODBCThread.CacheIsEmpty()`

returns non-nil if both the level 1 and level 2 cache files are empty.

`ODBCThread.Columns (`*`catalog, schema, tablename, columnname, callback`*`)`

queries the database table for its column definitions. The *catalog*, *schema*, *tablename* and *columnname* are all strings. Some of these may accept wildcard patterns depending on the database being used. When the call completes, the callback code will be executed. The result is available in the `SQLResult` for the duration of the callback.

`ODBCThread.Configure (`*`DSN, username, password, flags, storagefile, maxfilesize`*`)`

sets the initial configuration for the database connection. The *flags* parameter can be either `0` or `STORE_AND_FORWARD`. If `STORE_AND_FORWARD` is not specified then no command on this connection will be stored, even if the individual command specifies the `STORE_AND_FORWARD` flag. The *storagefile* parameter specifies the name of a file to store the level 1 cache information for store and forward operation. The level 2 cache file name will be created from this file name.

The *maxfilesize* specifies the maximum number of bytes that a cache file can grow to. There can in fact be 3 cache files, each of this size, at any one time. The *maxfilesize* may be exceeded by the length of a single transaction for any file. If you set *maxfilesize* to `0`, then 2.1 GB will be used. If the size exceeds this amount then it will be truncated to 2.1 GB. You may wish to intentionally limit the file size to a lower number. In a system where the data rate is always too high for the database to handle, a smaller cache file size will cause the `ODBCThread` to go through periods where its data is discarded while the cache file is caught up. A smaller file will make this discard/catch-up cycle faster.

Flags can be any combination of:

- `STORE_AND_FORWARD` - If this flag is not set, then no file storage will take place. Any transactions that cannot be written to the thread immediately will be rejected. Any transactions in the queue that cannot be delivered to the database will be discarded.
- `NO_STORE_TO_SECONDARY` - This tells the `ODBCThread` to only use the level 1 cache. If the queue between the script and the database thread becomes full, further transactions will be rejected until there is space in the queue. However, any transactions in the queue that cannot be delivered to the database will be stored in level 1 cache.
- `STORE_ALWAYS` - This flag tells the `ODBCThread` to always store a transaction to disk before sending it to the database. This will normally cause the thread to read its queue faster, and write the transactions to disk more frequently. In case of a system crash, those transactions are more likely to be recoverable when the script re-starts. This option imposes a speed penalty if the disk is slow. On systems with fast disks, this penalty is normally minimal.
- `ALLOW_CACHE_RESTART` - In case of a system or application crash, the `ODBCThread` will resume reading any disk files at the point where it left off when the application restarts. This flag tells the `ODBCThread` not to track its position in the disk file, and to restart at the beginning of the file during a crash recovery. This improves speed on systems with a slow disk, but means that some transactions may be sent to the database more than once. This should only be used if disk access is slow.
- `NO_FLUSH_ON_WRITE` - The `ODBCThread` normally tries to update files as soon as possible after a write to disk. This is not efficient, but it improves the chance that more transactions will be recoverable in the case of a system or application crash. Specifying this flag will cause the `ODBCThread` to store data in memory longer and write to disk in larger blocks. This may improve performance for systems with a slow file system, but it increases the chance that transactions will be lost if the system crashes or shuts down.

  We recommend using either:

  ```
  STORE_AND_FORWARD
  ```

  or

  ```
  STORE_AND_FORWARD | STORE_ALWAYS
  ```

  unless the impact of disk access is unacceptably high on the system.

`ODBCThread.Connect ()`

forces a connection attempt, even if the thread connection timer has not expired.

`ODBCThread.DataSources (`*`type`*`)`

lists all data sources (DSNs). The type parameter can be one of:

- `SQL_FETCH_FIRST` - retrieve all DSNs.
- `SQL_FETCH_FIRST_USER` - retrieve only user DSNs.
- `SQL_FETCH_FIRST_SYSTEM` - retrieve only system DSNs.

The return value is an array of lists of the form: `("dsn_name" . "dsn_driver")`

`ODBCThread.Disconnect ()`
: forces the thread to disconnect from the database. If the thread is not paused then it will attempt to reconnect to the database on the next reconnect timer cycle.

`ODBCThread.ExecDirect (`*`flags, sql, callback`*`)`
: executes an SQL statement on the database. Flags can be either `0` or `STORE_AND_FORWARD`. If the command cannot be executed immediately, and `STORE_AND_FORWARD` is set, and `STORE_AND_FORWARD` is also set on the thread, then the command will be stored to file and executed later. The SQL statement is a string. When the statement is executed, the callback will be called. The result is available in the `SQLResult` for the duration of the callback.

`ODBCThread.GetFlags ()`
: retrieves the flags set by the `.Configure` method.

`ODBCThread.GetMessageCount ()`
: retrieves the number of messages currently queued to the database thread.

`ODBCThread.GetResultCount ()`
: retrieves the number of results currently queued from the database thread to the script thread.

`ODBCThread.Insert (`*`row, callback`*`)`
: performs a database `INSERT` given an instance of a class that has been mapped to a column set in the database. The row must be an instance of a class returned from `.ClassFromResultSet`, `.ClassFromTable`, or `.ClassFromThreadResult`. When the insertion is complete, the callback is executed.

`ODBCThread.QueueIsFull ()`
: returns non-nil if the message queue is full.

`ODBCThread.IsPaused ()`
: returns non-nil if the thread is paused. See the information in `ODBCThread.Pause()`.

`ODBCThread.NoOp (`*`callback`*`)`
: sends a message to the database thread, and do nothing. When the message has arrived at the database thread, the method returns and runs the callback. This is a mechanism to synchronize execution in the script with actions that are queued on the database thread.

`ODBCThread.Pause ()`
: pauses the thread. A paused thread will continue to store data to disk to be forwarded later, but it will not perform transactions on the database. If the database is disconnected and paused, the thread will not attempt to reconnect until the thread is resumed.

`ODBCThread.PrimaryKeys (`*`catalog, schema, tablename, callback`*`)`
: queries the database for the primary keys for the given *`catalog`*, *`schema`* and *`tablename`*. The result is available in the `SQLResult` when the callback is executed.

`ODBCThread.QuoteConversion (`*`head, tail, character, replacement`*`)`
: is used internally.

`ODBCThread.Resume ()`

resumes a thread that has been previously paused by `.Pause()`.

`ODBCThread.SlowInsert (`*`row, callback`*`)`

is an alternate (slower) method to insert data. It acts the same as the `.Insert` method, except that it recomputes the SQL statement on each insert. The `.Insert` method computes the SQL statement ahead of time.

`ODBCThread.SlowUpdate (`*`row, callback`*`)`

is an alternate (slower) method to update data. It acts the same as the `.Update` method, except that it recomputes the SQL statement on each update. The `.Update` method computes the SQL statement ahead of time.

`ODBCThread.Start ()`

starts the thread and begins attempting to connect.

`ODBCThread.Stop ()`

closes the connection to the database and stops the thread.

`ODBCThread.Tables (`*`catalog, schema, tablename, tabletype, callback`*`)`

queries the database for all tables matching the *`catalog`*, *`schema`*, *`tablename`* and *`tabletype`*. It calls the *`callback`* when the transaction completes. Specifying an empty string (`""`) for any argument indicates no preference. The tabletype must be one of `"TABLE"`, `"VIEW"` or `"TABLE,VIEW"`. The result of this call is available in `ODBCResult`.

`ODBCThread.Update (`*`row, callback`*`)`

performs a database `UPDATE` given an instance of a class that has been mapped to a column set in the database. The row must be an instance of a class returned from `.ClassFromResultSet`, `.ClassFromTable` or `.ClassFromThreadResult`. When the update is complete, the callback is executed. The result of this call is available in `ODBCResult`.

`ODBCThread.ValueString (`*`value`*`)`

is used internally.

`ODBCThread.AddInitStage (`*`sqlString, onSuccess, onFailure`*`)`

adds an initialization stage to the sequential set of steps to be executed as part of the initialization after the database connections is made. See the section Configure Startup Actions above. The return value from this function is an index that can be given to `.BeginAsyncInit`.

`ODBCThread.BeginAsyncInit (`*`stage`*`?=0)`

starts executing the initialization stages in the order in which they were specified. If the stage argument is non-zero, being executing from that index in set. This index is provided as the return value from `.AddInitStage`.

`ODBCThread.cbInitStage ()`

is a provided callback that can be used to trigger the next initialization stage in the initialization sequence. If the stage specifies user-defined code instead of a string for the *`sqlString`* argument of `.AddInitStage`, that code must at some point call

`.cbInitStage` in order for the sequence to continue.

`ODBCThread.ClassFromResultSet (`*`columnresult, keyresult, superclass`*`?=nil,` *`symclassname`*`?=#UnboundODBCThreadTableClass)`

creates a class from the table defined in the given result sets. The *`columnresult`* is the column definition for the table, and the *`keyresult`* is the result from calling `.PrimaryKeys` on the table, or the result from querying the table through the `.Tables` method. If the *`superclass`* is non-nil, the class will be derived from *`superclass`*, otherwise it will have no parent class. If *`symclassname`* is provided, that class name will be used instead of the default *`UnboundODBCThreadTableClass`*. The class produced by this call maps each column in the *`columnresult`* to a member variable in the class. In addition, information about the primary key and the source table is held in the class. Instances of this class are suitable for use with the `.Insert` method. If the table has a primary key, then instances of this class can also be used in the `.Update` method.

`ODBCThread.ClassFromTable (`*`tablename, tables, superclass`*`?=nil,` *`symclassname`*`?=#UnboundODBCThreadTableClass)`

creates a class from the table named *`tablename`* from the table set defined in *`tables`*. The *`tables`* argument is the value of `SQLTables` from a call to the `.GetTableInfo` method. See the discussion in `.ClassFromResultSet` for more information.

`ODBCThread.ClassFromThreadResult (`*`threadresult, superclass`*`?=nil,` *`symclassname`*`?=#UnboundODBCThreadTableClass)`

creates a class from an `ODBCThreadResult` instance. This instance is usually obtained from a call to `.GetTableInfo` or `.Columns`. See the discussion in `.ClassFromResultSet` for more information.

`ODBCThread.constructor ()`

is the constructor for this class. Do not override the constructor for `ODBCThread` in your own code. Instead, derive a new class from `ODBCThread` and then define a constructor for your derived class.

`ODBCThread.CreateClass (`*`symclassname, superclass, ivars, tablename, primary_key`*`)`

is the low-level call made from `.ClassFromResultSet`, `.ClassFromTable` and `.ClassFromThreadResult`. It constructs the necessary code to define a class that maps its member variables to columns in a result set.

`ODBCThread.EvalSafe (`*`code`*`)`

is used internally.

`ODBCThread.GetDataSources (`*`direction`*`?=SQL_FETCH_FIRST)`

queries the ODBC subsystem for the names of all DSNs. The type parameter can be one of:

- `SQL_FETCH_FIRST` - retrieve all DSNs.
- `SQL_FETCH_FIRST_USER` - retrieve only user DSNs.
- `SQL_FETCH_FIRST_SYSTEM` - retrieve only system DSNs.

The return value is an array of lists of the form: `("dsn_name" . "dsn_driver")`

This method is the only method that calls synchronously into the ODBC subsystem. The result is available as the return value from this function. The ODBC definition states that this call will be entirely satisfied by the driver manager, and so cannot block on the database. The database does not need to be connected, and the database thread does not have to be started for this method to succeed.

`ODBCThread.GetInsertFormat` (*klass*)

constructs the SQL statement that will be issued when the `.Insert` method is called. If you change the definition of the table by calling `.SetClassKey`, then you must also issue `.GetInsertFormat` and `.GetUpdateFormat` after `.SetClassKey` completes.

`ODBCThread.GetTableInfo` (*catalog*, *schema*, *tablename*, *tabletype*, *callback*)

produces a result that will be available in the special variable `SQLTables` for the duration of the callback. `SQLTables` is an array of arrays. Each element of the result is an array of two elements containing the table name and an instance of `ODBCThreadResult` corresponding to a call to `.Columns` for that table.

`ODBCThread.GetUpdateFormat` (*klass*)

constructs the SQL statement that will be issued when the `.Update` method is called. If you change the definition of the table by calling `.SetClassKey`, then you must also issue `.GetInsertFormat` and `.GetUpdateFormat` after `.SetClassKey` completes.

`ODBCThread.HandleColumnInfo` (*tablename*, *results*, *callback*)

is used internally.

`ODBCThread.HandleFinalInfo` (*results*, *callback)*

is used internally.

`ODBCThread.HandleTableInfo` (*results*, *callback)*

is used internally.

`ODBCThread.NextInitStage` ()

is used internally.

`ODBCThread.SetClassKey` (*klass*, *keysym*, *ignore_if_set*?=t)

sets the primary key for the class specified by *klass*. The class is the result of a call to `.ClassFromResultSet`, `.ClassFromTable` and `.ClassFromThreadResult`. Some databases (MS-Access in particular) do not provide information about the primary keys in a table. In order for `.Update` calls to work on this type of class, the `.SetClassKey` method must be called to tell the table which column is its primary key.

ODBCThreadResult

`ODBCThreadResult` — the results of an SQL command.

Synopsis

```
class ODBCThreadResult
{
    Result;         // The SQL result set, or nil.
    KeyResult;      // The SQL result set describing the primary
                    // keys, for those commands that produce a
                    // primary key set.
    Diagnostic;     // The complete ODBC diagnostic set, if any.
    KeyDiagnostic;  // The diagnostic set for the primary key query.
    Description;    // A description of the command or result.
    ReturnCode;     // A numeric SQLRESULT for an SQL command, or an
                    // "errno" return code for a file system error.
    AffectedRows;   // The number of affected rows for an SQL command,
                    // if available.
}
```

Description

The `Diagnostic` and `KeyDiagnostic` each consist of an array, where the elements of the array are themselves arrays:

- `element[0]` = the database diagnostic message, as a string.
- `element[1]` = the ODBC diagnostic state code, as a string.
- `element[2]` = the ODBC native error code, as a number.

There can be more than one diagnostic message returned by a single SQL call.

The `Result` and `KeyResult` contain the column and row definitions resulting from an SQL command. This definition is shared with the single-threaded ODBC implementation. The complete definition for `ODBCResult`is:

```
class ODBCResult
{
    columns;
    rows;
}
```

The `columns` member is an array of instances of the `ODBCColumn` class:

```
class ODBCColumn
{
    columnsize;      // A numeric column width.
```

```
    datatype;       // A number representing the ODBC data type.
    decimaldigits;  // The number of decimal digits, or 0.
    name;           // The column name.
    nullable;       // 0 if not nullable, 1 if nullable.
}
```

The `rows` member is an array of values, each of which corresponds to the column definition in the same position in the `columns` array.

SQLGUID

`SQLGUID` — holds ID strings.

Synopsis

```
class SQLGUID
{
}
```

Description

This structure is used to hold ID strings. For more information, please refer to C Interval Structure.

SQL_DAY_SECOND_STRUCT

`SQL_DAY_SECOND_STRUCT` — contains time data for `SQL_INTERVAL_STRUCT`.

Synopsis

```
class SQL_DAY_SECOND_STRUCT
{
    day;
    fraction;
    hour;
    minute;
    second;
}
```

Description

This structure contains time data for `SQL_INTERVAL_STRUCT`. For more information, please refer to C Interval Structure.

SQL_INTERVAL_STRUCT

SQL_INTERVAL_STRUCT — contains interval data for SQL queries.

Synopsis

```
class SQL_INTERVAL_STRUCT
{
    interval_sign;
    interval_type;
}
```

Description

This structure contains interval data for SQL queries. For more information, please refer to C Interval Structure.

SQL_INTERVAL_STRUCT_intval

`SQL_INTERVAL_STRUCT_intval` — contains year/month or day/second info for `SQL_INTERVAL_STRUCT`.

Synopsis

```
class SQL_INTERVAL_STRUCT_intval
{
    day_second;
    year_month;
}
```

Description

This structure contains year/month or day/second info for `SQL_INTERVAL_STRUCT`. For more information, please refer to C Interval Structure.

SQL_NUMERIC_STRUCT

`SQL_NUMERIC_STRUCT` — specifies number precision and sign.

Synopsis

```
class SQL_NUMERIC_STRUCT
{
    precision;
    sign;
}
```

Description

This structure specifies number precision and sign. For more information, please refer to C Data Types.

SQL_YEAR_MONTH_STRUCT

`SQL_YEAR_MONTH_STRUCT` — contains year and month data for `SQL_INTERVAL_STRUCT`.

Synopsis

```
class SQL_YEAR_MONTH_STRUCT
{
    month;
    year;
}
```

Description

This structure contains year and month data for `SQL_INTERVAL_STRUCT`. For more information, please refer to C Interval Structure.

TIMESTAMP_STRUCT

`TIMESTAMP_STRUCT` — contains timestamp data (y,m,d,h,m,s, etc.).

Synopsis

```
class TIMESTAMP_STRUCT
{
    day;
    fraction;
    hour;
    minute;
    month;
    second;
    year;
}
```

Description

This structure contains timestamp data. For more information, please refer to C Data Types.

TIME_STRUCT

`TIME_STRUCT` — contains time data (h,m,s).

Synopsis

```
class TIME_STRUCT
{
    hour;
    minute;
    second;
}
```

Description

This structure contains time data. For more information, please refer to C Data Types.

Global Functions

ODBC_AllocEnvironment

ODBC_AllocEnvironment — creates an ODBCEnvironment.

Synopsis

```
ODBC_AllocEnvironment ()
```

Description

This function is used to create an ODBCEnvironment class, the first step in creating an ODBC database. When you allocate the ODBC environment in your script, you can optionally specify the ODBC version that you want. To do this, give the version number (2 or 3) to ODBC_AllocEnvironment, like this: ODBC_AllocEnvironment(2);

ODBC_ValueString

`ODBC_ValueString`

Synopsis

```
ODBC_ValueString (value)
```

Description

Not yet documented.

Constants

ODBCVER
SQL_ACCESSIBLE_PROCEDURES
SQL_ACCESSIBLE_TABLES
SQL_ALL_TYPES
SQL_ALTER_TABLE
SQL_AM_CONNECTION
SQL_AM_NONE
SQL_AM_STATEMENT
SQL_API_SQLALLOCCONNECT
SQL_API_SQLALLOCENV
SQL_API_SQLALLOCHANDLE
SQL_API_SQLALLOCSTMT
SQL_API_SQLBINDCOL
SQL_API_SQLBINDPARAM
SQL_API_SQLCANCEL
SQL_API_SQLCLOSECURSOR
SQL_API_SQLCOLATTRIBUTE
SQL_API_SQLCOLUMNS
SQL_API_SQLCONNECT
SQL_API_SQLCOPYDESC
SQL_API_SQLDATASOURCES
SQL_API_SQLDESCRIBECOL
SQL_API_SQLDISCONNECT
SQL_API_SQLENDTRAN
SQL_API_SQLERROR
SQL_API_SQLEXECDIRECT
SQL_API_SQLEXECUTE
SQL_API_SQLFETCH
SQL_API_SQLFETCHSCROLL
SQL_API_SQLFREECONNECT
SQL_API_SQLFREEENV
SQL_API_SQLFREEHANDLE
SQL_API_SQLFREESTMT
SQL_API_SQLGETCONNECTATTR
SQL_API_SQLGETCONNECTOPTION
SQL_API_SQLGETCURSORNAME
SQL_API_SQLGETDATA
SQL_API_SQLGETDESCFIELD
SQL_API_SQLGETDESCREC
SQL_API_SQLGETDIAGFIELD
SQL_API_SQLGETDIAGREC
SQL_API_SQLGETENVATTR
SQL_API_SQLGETFUNCTIONS
SQL_API_SQLGETINFO
SQL_DIAG_SERVER_NAME
SQL_DIAG_SQLSTATE
SQL_DIAG_SUBCLASS_ORIGIN
SQL_DIAG_UNKNOWN_STATEMENT
SQL_DIAG_UPDATE_WHERE
SQL_DOUBLE
SQL_DROP
SQL_ERROR
SQL_FALSE
SQL_FETCH_ABSOLUTE
SQL_FETCH_DIRECTION
SQL_FETCH_FIRST
SQL_FETCH_LAST
SQL_FETCH_NEXT
SQL_FETCH_PRIOR
SQL_FETCH_RELATIVE
SQL_FLOAT
SQL_GETDATA_EXTENSIONS
SQL_HANDLE_DBC
SQL_HANDLE_DESC
SQL_HANDLE_ENV
SQL_HANDLE_STMT
SQL_IC_LOWER
SQL_IC_MIXED
SQL_IC_SENSITIVE
SQL_IC_UPPER
SQL_IDENTIFIER_CASE
SQL_IDENTIFIER_QUOTE_CHAR
SQL_INDEX_ALL
SQL_INDEX_CLUSTERED
SQL_INDEX_HASHED
SQL_INDEX_OTHER
SQL_INDEX_UNIQUE
SQL_INSENSITIVE
SQL_INTEGER
SQL_INTEGRITY
SQL_INVALID_HANDLE
SQL_IS_DAY
SQL_IS_DAY_TO_HOUR
SQL_IS_DAY_TO_MINUTE
SQL_IS_DAY_TO_SECOND
SQL_IS_HOUR
SQL_IS_HOUR_TO_MINUTE
SQL_IS_HOUR_TO_SECOND

SQL_API_SQLGETSTMTATTR
SQL_API_SQLGETSTMTOPTION
SQL_API_SQLGETTYPEINFO
SQL_API_SQLNUMRESULTCOLS
SQL_API_SQLPARAMDATA
SQL_API_SQLPREPARE
SQL_API_SQLPUTDATA
SQL_API_SQLROWCOUNT
SQL_API_SQLSETCONNECTATTR
SQL_API_SQLSETCONNECTOPTION
SQL_API_SQLSETCURSORNAME
SQL_API_SQLSETDESCFIELD
SQL_API_SQLSETDESCREC
SQL_API_SQLSETENVATTR
SQL_API_SQLSETPARAM
SQL_API_SQLSETSTMTATTR
SQL_API_SQLSETSTMTOPTION
SQL_API_SQLSPECIALCOLUMNS
SQL_API_SQLSTATISTICS
SQL_API_SQLTABLES
SQL_API_SQLTRANSACT
SQL_ARD_TYPE
SQL_ATTR_APP_PARAM_DESC
SQL_ATTR_APP_ROW_DESC
SQL_ATTR_AUTO_IPD
SQL_ATTR_CURSOR_SCROLLABLE
SQL_ATTR_CURSOR_SENSITIVITY
SQL_ATTR_IMP_PARAM_DESC
SQL_ATTR_IMP_ROW_DESC
SQL_ATTR_METADATA_ID
SQL_ATTR_OUTPUT_NTS
SQL_CATALOG_NAME
SQL_CB_CLOSE
SQL_CB_DELETE
SQL_CB_PRESERVE
SQL_CHAR
SQL_CLOSE
SQL_CODE_DATE
SQL_CODE_TIME
SQL_CODE_TIMESTAMP
SQL_COLLATION_SEQ
SQL_COMMIT
SQL_CURSOR_COMMIT_BEHAVIOR
SQL_CURSOR_SENSITIVITY
SQL_DATA_AT_EXEC
SQL_DATA_SOURCE_NAME
SQL_IS_MINUTE
SQL_IS_MINUTE_TO_SECOND
SQL_IS_MONTH
SQL_IS_SECOND
SQL_IS_YEAR
SQL_IS_YEAR_TO_MONTH
SQL_MAXIMUM_CATALOG_NAME_LENGTH
SQL_MAXIMUM_COLUMNS_IN_GROUP_BY
SQL_MAXIMUM_COLUMNS_IN_INDEX
SQL_MAXIMUM_COLUMNS_IN_ORDER_BY
SQL_MAXIMUM_COLUMNS_IN_SELECT
SQL_MAXIMUM_COLUMN_NAME_LENGTH
SQL_MAXIMUM_CONCURRENT_ACTIVITIES
SQL_MAXIMUM_CURSOR_NAME_LENGTH
SQL_MAXIMUM_DRIVER_CONNECTIONS
SQL_MAXIMUM_IDENTIFIER_LENGTH
SQL_MAXIMUM_INDEX_SIZE
SQL_MAXIMUM_ROW_SIZE
SQL_MAXIMUM_SCHEMA_NAME_LENGTH
SQL_MAXIMUM_STATEMENT_LENGTH
SQL_MAXIMUM_TABLES_IN_SELECT
SQL_MAXIMUM_USER_NAME_LENGTH
SQL_MAX_CATALOG_NAME_LEN
SQL_MAX_COLUMNS_IN_GROUP_BY
SQL_MAX_COLUMNS_IN_INDEX
SQL_MAX_COLUMNS_IN_ORDER_BY
SQL_MAX_COLUMNS_IN_SELECT
SQL_MAX_COLUMNS_IN_TABLE
SQL_MAX_COLUMN_NAME_LEN
SQL_MAX_CONCURRENT_ACTIVITIES
SQL_MAX_CURSOR_NAME_LEN
SQL_MAX_DRIVER_CONNECTIONS
SQL_MAX_IDENTIFIER_LEN
SQL_MAX_INDEX_SIZE
SQL_MAX_MESSAGE_LENGTH
SQL_MAX_NUMERIC_LEN
SQL_MAX_ROW_SIZE
SQL_MAX_SCHEMA_NAME_LEN
SQL_MAX_STATEMENT_LEN
SQL_MAX_TABLES_IN_SELECT
SQL_MAX_TABLE_NAME_LEN
SQL_MAX_USER_NAME_LEN
SQL_NAMED
SQL_NC_HIGH
SQL_NC_LOW
SQL_NEED_DATA

SQL_DATA_SOURCE_READ_ONLY
SQL_DATETIME
SQL_DATE_LEN
SQL_DBMS_NAME
SQL_DBMS_VER
SQL_DECIMAL
SQL_DEFAULT
SQL_DEFAULT_TXN_ISOLATION
SQL_DESCRIBE_PARAMETER
SQL_DESC_ALLOC_AUTO
SQL_DESC_ALLOC_TYPE
SQL_DESC_ALLOC_USER
SQL_DESC_COUNT
SQL_DESC_DATA_PTR
SQL_DESC_DATETIME_INTERVAL_CODE
SQL_DESC_INDICATOR_PTR
SQL_DESC_LENGTH
SQL_DESC_NAME
SQL_DESC_NULLABLE
SQL_DESC_OCTET_LENGTH
SQL_DESC_OCTET_LENGTH_PTR
SQL_DESC_PRECISION
SQL_DESC_SCALE
SQL_DESC_TYPE
SQL_DESC_UNNAMED
SQL_DIAG_ALTER_DOMAIN
SQL_DIAG_ALTER_TABLE
SQL_DIAG_CALL
SQL_DIAG_CLASS_ORIGIN
SQL_DIAG_CONNECTION_NAME
SQL_DIAG_CREATE_ASSERTION
SQL_DIAG_CREATE_CHARACTER_SET
SQL_DIAG_CREATE_COLLATION
SQL_DIAG_CREATE_DOMAIN
SQL_DIAG_CREATE_INDEX
SQL_DIAG_CREATE_SCHEMA
SQL_DIAG_CREATE_TABLE
SQL_DIAG_CREATE_TRANSLATION
SQL_DIAG_CREATE_VIEW
SQL_DIAG_DELETE_WHERE
SQL_DIAG_DROP_ASSERTION
SQL_DIAG_DROP_CHARACTER_SET
SQL_DIAG_DROP_COLLATION
SQL_DIAG_DROP_DOMAIN
SQL_DIAG_DROP_INDEX
SQL_DIAG_DROP_SCHEMA
SQL_NONSCROLLABLE
SQL_NO_DATA
SQL_NO_NULLS
SQL_NTS
SQL_NULLABLE
SQL_NULLABLE_UNKNOWN
SQL_NULL_COLLATION
SQL_NULL_DATA
SQL_NULL_HDBC
SQL_NULL_HDESC
SQL_NULL_HENV
SQL_NULL_HSTMT
SQL_NUMERIC
SQL_OJ_CAPABILITIES
SQL_ORDER_BY_COLUMNS_IN_SELECT
SQL_OUTER_JOIN_CAPABILITIES
SQL_PC_NON_PSEUDO
SQL_PC_PSEUDO
SQL_PC_UNKNOWN
SQL_PRED_BASIC
SQL_PRED_CHAR
SQL_PRED_NONE
SQL_REAL
SQL_RESET_PARAMS
SQL_ROLLBACK
SQL_ROW_IDENTIFIER
SQL_SCOPE_CURROW
SQL_SCOPE_SESSION
SQL_SCOPE_TRANSACTION
SQL_SCROLLABLE
SQL_SCROLL_CONCURRENCY
SQL_SEARCH_PATTERN_ESCAPE
SQL_SENSITIVE
SQL_SERVER_NAME
SQL_SMALLINT
SQL_SPECIAL_CHARACTERS
SQL_STILL_EXECUTING
SQL_SUCCESS
SQL_SUCCESS_WITH_INFO
SQL_TC_ALL
SQL_TC_DDL_COMMIT
SQL_TC_DDL_IGNORE
SQL_TC_DML
SQL_TC_NONE
SQL_TIMESTAMP_LEN
SQL_TIME_LEN

SQL_DIAG_DROP_TABLE
SQL_DIAG_DROP_TRANSLATION
SQL_DIAG_DROP_VIEW
SQL_DIAG_DYNAMIC_DELETE_CURSOR
SQL_DIAG_DYNAMIC_FUNCTION
SQL_DIAG_DYNAMIC_FUNCTION_CODE
SQL_DIAG_DYNAMIC_UPDATE_CURSOR
SQL_DIAG_GRANT
SQL_DIAG_INSERT
SQL_DIAG_MESSAGE_TEXT
SQL_DIAG_NATIVE
SQL_DIAG_NUMBER
SQL_DIAG_RETURNCODE
SQL_DIAG_REVOKE
SQL_DIAG_ROW_COUNT
SQL_DIAG_SELECT_CURSOR
SQL_TRANSACTION_CAPABLE
SQL_TRANSACTION_ISOLATION_OPTION
SQL_TRUE
SQL_TXN_CAPABLE
SQL_TXN_ISOLATION_OPTION
SQL_TYPE_DATE
SQL_TYPE_TIME
SQL_TYPE_TIMESTAMP
SQL_UNBIND
SQL_UNKNOWN_TYPE
SQL_UNNAMED
SQL_UNSPECIFIED
SQL_USER_NAME
SQL_VARCHAR
SQL_XOPEN_CLI_YEAR

DataHub™ Windows Scripting

Version 11.0

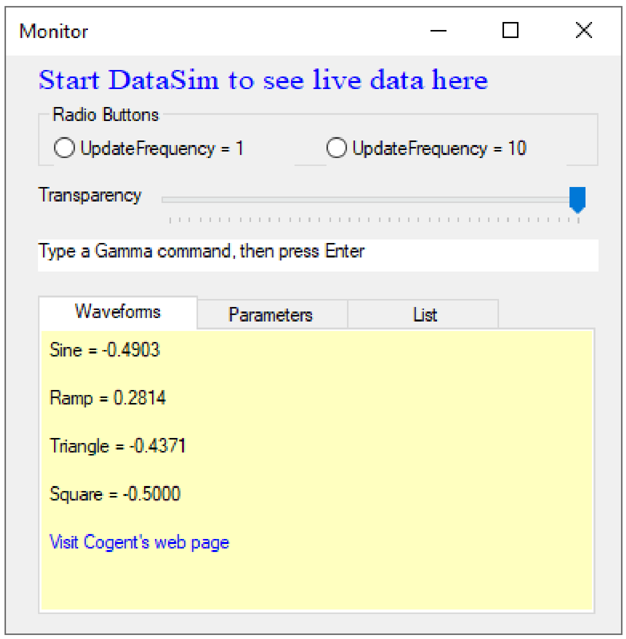
An implementation of the Gamma scripting language for use in Cogent DataHub™ software that provides Windows support.

Table of Contents

Introduction

Overview

The DataHub program has built-in scripting capabilities based on Cogent's Gamma language, which among other things let you create Windows interfaces with DataHub scripts. This guide assumes a basic understanding of DataHub scripting, and provides the specific information you will need to create windows, buttons, frames, tabs, entry fields, and so on—all animated with live data.



DataHub Windows scripting combines two APIs:

- WTL-based widget classes
- Windows Platform SDK functions, structures and constants

Auto-Generation

The API is machine-generated, so some of the less common Windows functions are not supported. We plan to add those functions by hand on a case-by-case basis as they are identified as necessary. In all, there are 46 widget classes, 400+ common structures, 1700+ functions and 6000+ constants included. We do not plan to fully document it, but instead list the functions we support and rely on the reader to search the Microsoft documentation for details.

We have added some functions to make it convenient to set colors and fonts, and to anchor widgets for resizing support, but for the most part the functions we support are faithful to the Microsoft documentation.

Documentation

In addition to the API itself, about 95% of the reference sections of this documentation are automatically generated. In a few instances we have not been able to automatically extract all of the documentation from the code. The most notable example is when there is more than one calling sequence for the member function of a widget. Each of these functions has an argument list that looks like this: `(args?...)`. Until we are able to extract the correct calling sequences and their syntaxes, you will have to search and read the Windows documentation and do a little trial and error to determine what the possibilities are.

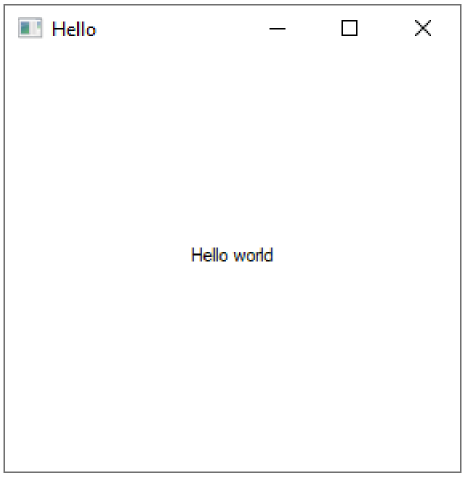
Tutorials

The tutorials given here show how to create a window where you can display and interact with live data. These tutorials build on the tutorials in the DataHub Scripting manual and assume you have some knowledge of the Gamma language.

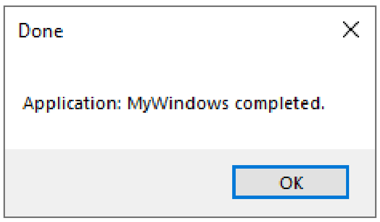
Making a Window

This first tutorial is repeated from the DataHub Scripting manual.

1. Open the Properties window, select the **Scripting** option, and click the **New** button to create a new script.
2. In the New Script File dialog, name the main class '`MyWindows`' and select the **Windows** option. More details.
3. Add the file to your list of files, and load it now. Here's how. A new window will open:



4. Click the close icon in the top right corner. The window will close, and you will see this dialog box:



The Code

The code that gets written to the `MyWindows.g` file is as follows:

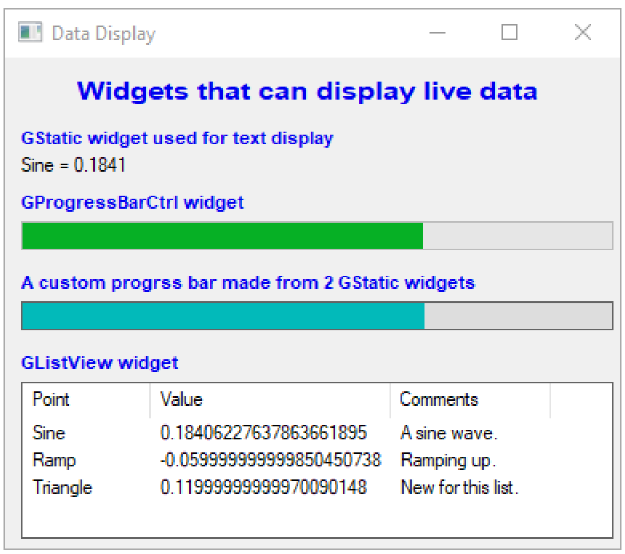
```
/* All user scripts should derive from the base "Application" class */

require ("Application");

/* Get the Gamma library functions and methods for ODBC and/or
 * Windows programming.  Uncomment either or both. */

require ("WindowsSupport");
//require ("ODBCSupport");

/* Applications share the execution thread and the global name
 * space, so we create a class that contains all of the functions
 * and variables for the application.  This does two things:
 *   1) creates a private name space for the application, and
 *   2) allows you to re-load the application to create either
 *      a new unique instance or multiple instances without
 *      damaging an existing running instance.
 */
class MyWindows Application
{
 window;
}

/* Use methods to create functions outside the 'main line'. */
method MyWindows.samplemethod ()
{
}

/* Write the 'main line' of the program here. */
method MyWindows.constructor ()
{
 local rect = CreateRect (0, 0, 300, 300), txt;
 .window = new GWindow();

 .window.Create (0, rect, "Hello", WS_OVERLAPPEDWINDOW, 0);
 .window.CenterWindow();
 txt = .window.CreateControl (GStatic, 0, 0, 280, 22, "Hello world", SS_CENTER);
 txt.CenterWindow();
 .window.MessageHandler (WM_DESTROY, `(!destroyed_p(@self) ? destroy(@self) : nil)
 .window.ShowWindow (SW_SHOW);
}

/* Any code to be run when the program gets shut down. */
method MyWindows.destructor ()
{
```

```
 // The WM_DESTROY message could come before or after this destructor depending
 // on whether the application instance is destroyed or the window is closed
 // first.  We protect against the case where the window is closed first.
 if (instance_p(.window) && .window.GetHwnd() != 0)
  .window.SendMessage (WM_CLOSE, 0, 0);
 MessageBox(0, string ("Application: ", class_name(self), " completed."), "Done",
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (MyWindows);
```

Displaying Data

This tutorial illustrates four ways to display live data in a window: as text, with a progress bar, with a custom progress bar, or in a list.

Output



Code

```
require ("Application");
require ("WindowsSupport");
```

```
class MyDataDisplay Application
{
    window;
}

/* Adds items to a GListView widget. */
method MyDataDisplay.AddPoint (name, val, comment)
{
    local        n = lv.GetItemCount();
    lv.InsertItem (n, name);
    lv.SetItemText (n, 1, val);
    lv.SetItemText (n, 2, comment);
}

/* Changes the 2nd value of a GListView item. */
method MyDataDisplay.ChangeVal (name, val)
{
    local finfo = new LVFINDINFO();
    finfo.flags = LVFI_STRING;
    finfo.psz = name;
    local item = lv.FindItem (finfo, -1);
    lv.SetItemText (item, 1, string(val));
}

/* Formats a label for convenience. */
function format_label (win, letterh, letterw, font, color)
{
    win.SetForeground (0, 0, color);
    win.SetFontEx (letterh, letterw, 0, 0, 0, 0, 0, 0, 0,
                                     0, 0, 0, 0, font);
}

/* Updates a value on a GStatic widget. */
function update (win, point)
{
    local        val, i;
    if (!undefined_p (val = eval(point)))
    point = string (point);
    if ((i = strchr (point, ':')) != -1)
        point = substr (point, i+1, -1);
    win.SetWindowText (format ("%s = %.4f", point, val));
}

/* Calculates the resize dimensions for a GStatic widget. */
function xrect (ptpos, low, high, pixels)
```

```
{
    local ret = int (((ptpos - low)/(high - low)) * (pixels));
}

/* The 'main line' of the program. */
method MyDataDisplay.constructor ()
{
    local    rect = CreateRect (0, 0, 300, 300), txt;
    local    x = 10, y = 10, w = 370, h = 20;

    /* Create the window, size and position it. */
    .window = new GWindow();
    .window.Create (0, rect, "Data Display", WS_OVERLAPPEDWINDOW, 0);
    .window.MoveWindow(20, 200, 400, 345);

    /* Set the same background color for the window
     * and its children. */
    .window.SetBackground(0, GetSysColor (COLOR_3DFACE), 0);
    .window.SetChildBackground(0, GetSysColor (COLOR_3DFACE), 0);

    /* Allow for the possibility that DataSim isn't running.
     * Use the datahub_command function to send a cset command so
     * that the point will get created if it doesn't already exist. */
    $DataSim:Sine := 0;
    datahub_command("(cset DataSim:Sine 0)");
    datahub_command("(cset DataSim:Ramp 0)");
    datahub_command("(cset DataSim:Triangle 0)");

    /* Set a frequency and update rate for DataSim that suits
     * this demo. */
    datahub_command("(cset DataSim:Frequency 0.02)");
    datahub_command("(cset DataSim:UpdateFrequency 5)");

    /* Create all labels. */
    txt = .window.CreateControl (GStatic, x, 12, w, h,
                    "       Widgets that can display live data");
    format_label (txt, 18, 9, "Arial Bold", 0xee0000);
    txt = .window.CreateControl (GStatic, x, 43, w, h,
                         "GStatic widget used for text display");
    format_label (txt, 14, 5, "Arial Bold", 0xee0000);
    txt = .window.CreateControl (GStatic, x, 83, w, h,
                             "GProgressBarCtrl widget");
    format_label (txt, 14, 5, "Arial Bold", 0xee0000);
    txt = .window.CreateControl (GStatic, x, 133, w, h,
             "A custom progrss bar made from 2 GStatic widgets");
    format_label (txt, 14, 5, "Arial Bold", 0xee0000);
```

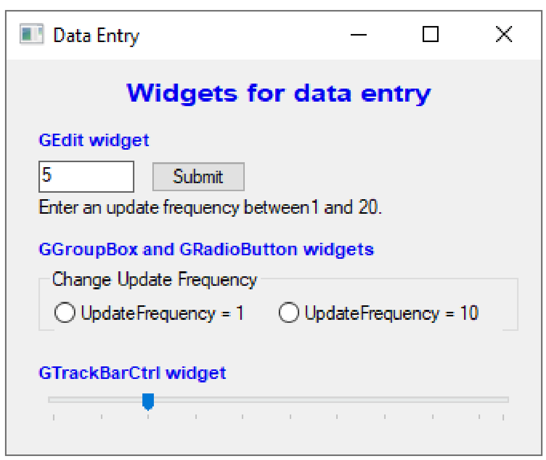
```
    txt = .window.CreateControl (GStatic, x, 183, w, h,
                                 "GListView widget");
    format_label (txt, 14, 5, "Arial Bold", 0xee0000);

    /* Create a text display for live Sine data. */
    stSine = .window.CreateControl (GStatic, x, 60, w, h, "Sine");
    .window.onChange (#$DataSim:Sine, `update (@stSine, this));

    /* Create a progress bar widget to display live Sine data. */
    pgSine = .window.CreateControl (GProgressBarCtrl, x, 100, w,
                                                    h, "Sine");
    pgSine.SetRange(0, 100);
    .window.onChange (#$DataSim:Sine,
                      `((@pgSine).SetPos(($DataSim:Sine +.5) * 100)));
    pgSine.SetPos(($DataSim:Sine +.5) * 100);

    /* Create a custom progress bar out of two GStatic widgets
     * for live Sine data. */
    rectSine = .window.CreateControl (GStatic, x, 150, w, h, "",
                                      WS_BORDER);
    rectSine.SetBackground(0, 0xdddddd, 0);
    fillSine = .window.CreateControl (GStatic, x + 1, 151, w/2,
                                               h - 2, "");
    fillSine.SetBackground(0, 0xbbbb00, 0);
    .window.onChange (#$DataSim:Sine,
            `((@fillSine).ResizeClient(xrect($DataSim:Sine, -.5,
                                             .5, @w), 18, 1)));

    /* Create a list view widget for live Sine, Ramp,
     * and Triangle data. */
    lv = .window.CreateControl (GListViewCtrl, x, 200, w, h * 5,
                                             "lv", WS_BORDER);
    lv.SetViewType (1);
    lv.SetExtendedListViewStyle (LVS_EX_FULLROWSELECT |
                                 LVS_EX_ONECLICKACTIVATE,
                                 LVS_EX_FULLROWSELECT /*|
                                 LVS_EX_ONECLICKACTIVATE*/);

    lv.InsertColumn (0, "Point", 0, 80, 0);
    lv.InsertColumn (1, "Value", 0, 150, 0);
    lv.InsertColumn (2, "Comments", 0, 100, 0);
    lv.SetBackground (0, 0xffffff, 0);

    .AddPoint ("Sine", "No change" ,"A sine wave.");
    .AddPoint ("Ramp", "No change","Ramping up.");
    .AddPoint ("Triangle", "No change", "New for this list.");
```

```
    .window.onChange (#$DataSim:Sine,
                      `((@self).ChangeVal("Sine", $DataSim:Sine)));
    .window.onChange (#$DataSim:Ramp,
                      `((@self).ChangeVal("Ramp", $DataSim:Ramp)));
    .window.onChange (#$DataSim:Triangle,
                      `((@self).ChangeVal("Triangle",
                                          $DataSim:Triangle)));

    .window.MessageHandler (WM_DESTROY, `destroy(@self));
    .window.ShowWindow (SW_SHOW);
}

ApplicationSingleton (MyDataDisplay);
```

Entering Data

This tutorial illustrates three ways to enter data from a window: in a text entry field, using radio buttons, or with a track bar. All of the widgets are linked to the `DataSim:UpdateFrequency` point. They each change the value of the point. The text entry and track bar widgets also change to indicate the value of the point whenever the point changes.

Output



Code

```
require ("Application");
require ("WindowsSupport");

class MyDataEntry Application
```

```
{
    window;
}

/* Sets a DataHub point to the position of a scrolling widget. */
method MyDataEntry.Scrolled (tb)
{
    $DataSim:UpdateFrequency = tb.GetPos();
}

/* Formats a label for convenience. */
method MyDataEntry.format_label (win, letterh, letterw, font, color)
{
    win.SetForeground (0, 0, color);
    win.SetFontEx (letterh, letterw,
     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, font);
}

/* Sets a DataHub point to the value of a widget.*/
method MyDataEntry.SubmitEval (txt)
{
    local x;
    if (!undefined_p(x = eval_string (txt.GetWindowText())))
    {
        if (number_p(x) && (x >= 1) && (x <= 20))
            $DataSim:UpdateFrequency = x;
        else
            txt.SetWindowText("Try again");
    }
    else
        txt.SetWindowText("Try again");
    nil;
}


/* The 'main line' of the program. */
method MyDataEntry.constructor ()
{
    local    rect = CreateRect (0, 0, 300, 300), txt, btn;
    local    x = 20, y = 10, w = 300, h = 20;

    /* Create the window, set its size, position, and colors. */
    .window = new GWindow();
    .window.Create (0, rect, "Data Entry", WS_OVERLAPPEDWINDOW, 0);
    .window.MoveWindow(20, 200, 350, 285);
    .window.SetBackground(0, GetSysColor(COLOR_3DFACE), 0);
```

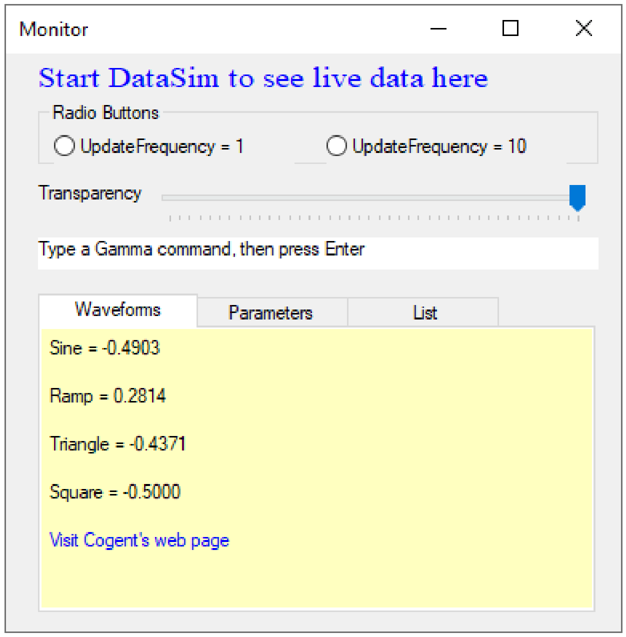
```
    .window.SetChildBackground(0, GetSysColor(COLOR_3DFACE), 0);

    /* Allow for the possibility that DataSim isn't running
     * or that UpdateFrequency isn't defined. */
    $DataSim:UpdateFrequency := 5;
    datahub_command("(cset DataSim:UpdateFrequency 5)");

    /* Create labels. */
    txt = .window.CreateControl (GStatic, x, 12, w, h,
                                 "            Widgets for data entry");
    .format_label (txt, 18, 9, "Arial Bold", 0xee0000);
    txt = .window.CreateControl (GStatic, x, 43, w, h,
                                 "GEdit widget");
    .format_label (txt, 14, 6, "Arial Bold", 0xee0000);
    txt = .window.CreateControl (GStatic, x, 85, w, h,
                                 "Enter an update frequency
                                 between1 and 20.");
    txt = .window.CreateControl (GStatic, x, 111, w, h,
                                "GGroupBox and GRadioButton widgets");
    .format_label (txt, 14, 6, "Arial Bold", 0xee0000);
    txt = .window.CreateControl (GStatic, x, 188, w, h,
                                 "GTrackBarCtrl widget");
    .format_label (txt, 14, 6, "Arial Bold", 0xee0000);

    /* Create a data entry field for Update Frequency. */
    txt = .window.CreateControl (GEdit, x, 63, 60, 20,
                                 string($DataSim:UpdateFrequency),
                                 WS_BORDER);
    txt.SetBackground (0, GetSysColor (COLOR_WINDOW), 0);
    .window.onChange (#$DataSim:UpdateFrequency,
                      `(@txt).SetWindowText (string(value)));

    btn = .window.CreateControl (GButton, x + 60 + 10,
                                 63, 60, 20, "Submit");
    .window.CommandHandler(BN_CLICKED, btn.GetDlgCtrlID(),
                           `(@self).SubmitEval(@txt));

    /* Create a control group and two radio buttons for
     * Update Frequency. */
    b0 = .window.CreateControl (GGroupBox, x, 130, w, 40,
                                "Change Update Frequency");
    b = b0.CreateControl (GRadioButton, 10, 15, 140, 25,
                          "UpdateFrequency = 1");
    b2 = b0.CreateControl (GRadioButton, 150, 15, 140, 25,
                           "UpdateFrequency = 10");
    b0.CommandHandler (BN_CLICKED, b.GetDlgCtrlID(),
```

```
                       `((@b0).IsDlgButtonChecked((@b).GetDlgCtrlID())
                         == 0 ? nil :
                         $DataSim:UpdateFrequency = 1));
    b0.CommandHandler (BN_CLICKED, b2.GetDlgCtrlID(),
                       `((@b0).IsDlgButtonChecked((@b2).GetDlgCtrlID())
                          == 0 ? nil :
                          $DataSim:UpdateFrequency = 10));
    .window.onChange (#$DataSim:UpdateFrequency,
                      `(@b).SetCheck (value == 1 ? 1 : 0));
    .window.onChange (#$DataSim:UpdateFrequency,
                      `(@b2).SetCheck (value == 10 ? 1 : 0));

    /* Create a track bar control for Update Frequency. */
    tb = .window.CreateControl (GTrackBarCtrl, x, 205, w, h, "");
    tb.SetRange (1, 20, 1);
    tb.ModifyStyle (0, TBS_AUTOTICKS, 0);
    tb.SetTicFreq (2);
    .window.MessageHandler (WM_HSCROLL, `(@self).Scrolled(@tb));
    .window.onChange (#$DataSim:UpdateFrequency,
                      `(@tb).SetPos (value));
    if (!undefined_p($DataSim:UpdateFrequency))
        tb.SetPos ($DataSim:UpdateFrequency);

    .window.MessageHandler (WM_CLOSE, `destroy(@self));
    .window.ShowWindow (SW_SHOW);
}

method MyDataEntry.destructor ()
{
    if (instance_p(.window))
        destroy(.window);
}

ApplicationSingleton (MyDataEntry);
```

A complete demo program: `WindowsExample.g`

This tutorial demonstrates more widgets and useful features.

Output



Code

```
require ("Application");
require ("WindowsSupport");

class WindowsExample Application
{
 menu_actions;
 menu_items;
 win;
}

method WindowsExample.constructor ()
{
 local win = new GWindow();
 local rect = CreateRect(10, 10, 400, 400);
 local b, tb, txt;

 win.Create (0, rect, "Monitor", WS_OVERLAPPEDWINDOW, 0);
 .win = win;

 win.SetBackground (0, GetSysColor (COLOR_3DFACE), 0);
 win.SetChildBackground (0, GetSysColor (COLOR_3DFACE), 0);
 win.MessageHandler (WM_DESTROY, `destroy (@self));
```

```
txt = win.CreateControl (GStatic, 20, 5, 350, 20,
               "Start DataSim to see live data here");
txt.SetForeground (0, 0, 0xff0000);
txt.SetFontEx (20, 8, 0, 0, 1, 0, 0, 0,
        0, 0, 0, 0, 0, "Times");
win.onChange (#$DataSim:Sine,
       `(@txt).SetWindowText(format
        ("%a = %.4f",
         this, value)));

b0 = win.CreateControl (GGroupBox, 20, 30, 350, 40,
   "Radio Buttons");
win.AddControlResizeFlags (b0.GetDlgCtrlID(), DLSZ_SIZE_X);
b = b0.CreateControl (GRadioButton, 10, 15, 150, 25,
        "UpdateFrequency = 1");
b2 = b0.CreateControl (GRadioButton, 180, 15, 150, 25,
         "UpdateFrequency = 10");
b0.AddControlResizeFlags (b2.GetDlgCtrlID(), DLSZ_MOVE_X);

b0.CommandHandler (BN_CLICKED, b.GetDlgCtrlID(),
 `((@b0).IsDlgButtonChecked((@b).GetDlgCtrlID())
   == 0 ? nil :
   $DataSim:UpdateFrequency = 1));
b0.CommandHandler (BN_CLICKED, b2.GetDlgCtrlID(),
 `((@b0).IsDlgButtonChecked((@b2).GetDlgCtrlID())
   == 0 ? nil :
   $DataSim:UpdateFrequency = 10));

win.onChange (#$DataSim:UpdateFrequency,
       `(@b).SetCheck (value == 1 ? 1 : 0));
win.onChange (#$DataSim:UpdateFrequency,
       `(@b2).SetCheck (value == 10 ? 1 : 0));

txt = win.CreateControl (GStatic, 20, 80, 70, 25,
    "Transparency");
tb = .win.CreateControl (GTrackBarCtrl, 90, 80, 280, 25,
    "Transparency");
tb.SetRange (50, 255, 5);
tb.ModifyStyle (0, TBS_AUTOTICKS, 0);
tb.SetTicFreq (5);
tb.SetPos (255);
.win.MessageHandler (WM_HSCROLL,
      `(@self).SetTransparency((@tb).GetPos()));

// Make a field for entering Gamma commands
txt = win.CreateControl (GammaEntry, 20, 115, 350, 20,
```

```
     "command");
 txt.SetBackground (0, GetSysColor (COLOR_WINDOW), 0);
 win.AddControlResizeFlags (txt.GetDlgCtrlID(), DLSZ_SIZE_X);
 txt.SetWindowText ("Type a Gamma command, then press Enter");

 // Make a tab control.

 tab = win.CreateControl (GTabCtrl, 20, 150, 350, 200, "tabs");
 tab.ModifyStyle (TCS_TABS |
    TCS_RAGGEDRIGHT,
    TCS_FOCUSONBUTTONDOWN |
    TCS_FIXEDWIDTH);
 tab.SetChildBackground (0, 0xc0ffff, 0);

 tab.AddWindow (0, "Waveforms", .
        CreateDialog1 (tab.GetHwnd(), ""));
 tab.AddWindow (1, "Parameters", .
        CreateDialog2 (tab.GetHwnd(), ""));
 tab.AddWindow (2, "List", .
        CreateDialog3 (tab.GetHwnd(), ""));
 win.AddControlResizeFlags (tab.GetDlgCtrlID(),
       DLSZ_SIZE_X | DLSZ_SIZE_Y);
 win.NotifyHandler (TCN_SELCHANGE,
      tab.GetDlgCtrlID(),
      `(@tab).SelChange());
 tab.SetCurSel (0);
 .AddMenus();

 win.ShowWindow (SW_SHOW);
}

method WindowsExample.destructor ()
{
 local  id, count, traymenu, i, item;

 try
 {
  with x in .menu_actions do
   remove_menu_action (car(x), cdr(x));
 }
 catch
 {
  princ ("Error: ", _last_error_, "\n");
  print_stack();
 }
```

```
 with x in .menu_items do
{
 try
 {
  id = car(x);
  traymenu = get_tray_menu();
  count = GetMenuItemCount (traymenu);
  item = new MENUITEMINFO;
  item.cbSize = 48;
  item.fMask = MIIM_ID | MIIM_SUBMENU;

  if (cdr(x)) // id is a submenu hmenu
  {
   for (i=0; i<count; i++)
   {
    if (GetMenuItemInfo
        (traymenu, i, 1, item)
        != 0
        && item.hSubMenu == id)
      DeleteMenu (traymenu,
           i,
           MF_BYPOSITION);
   }
  }
  else // id is a menu item command id
  {
   for (i=0; i<count; i++)
   {
    if (GetMenuItemInfo
        (traymenu, i, 1, item)
        != 0
        && item.wID == id)
      DeleteMenu (traymenu,
           i,
           MF_BYPOSITION);
   }
  }
 }
 catch
 {
  princ ("Error: ", _last_error_, "\n");
  print_stack();
 }
}
if (!destroyed_p (.win))
 .win.DestroyWindow();
```

```
}

method WindowsExample.SetTransparency (alpha)
{
 // This bit of code makes the window translucent.
 .win.ModifyStyleEx (0, WS_EX_LAYERED);
 SetLayeredWindowAttributes (.win.GetHwnd(), 0,
        alpha, LWA_ALPHA);
}

/* ======= An entry field that evaluates its input as Gamma ======= */

class GammaEntry GEdit
{
}

method GammaEntry.constructor ()
{
 .MessageHandler (WM_CHAR, `(@self).SubmitEval ());
}

method GammaEntry.Typing ()
{
 local str = .GetWindowText();
 princ (str, "\n");
}

method GammaEntry.SubmitEval ()
{
 if (wParam == VK_RETURN)
 {
  local str = .GetWindowText();
  princ (str, "\n");
  local x = eval_string (string(str,";"), t);
  princ ("    ");
  pretty_print (x);
  terpri();
 }
 nil;
}

/* ======= Print something when the user selects a file ====== */
/* This is an example of how to use the global hook on
   a file dialog to act on any file selection. */

method GFileDialog.OnSelChange ()
```

```
{
 local buf = make_buffer(256);
 .GetFilePath (buf, 256);
 princ ("Selection changed: ", buffer_to_string(buf), "\n");
}

/* =========== Add sample menu items to the tray menu ========= */

MenuItemID := 10000;

method WindowsExample.SelectTrayMenuItem (id)
{
 local  win = new GColorDialog();
 princ ("HWND: ", win.m_hWnd, " = ", win.GetHwnd(), "\n");
 local  result = win.DoModal(0);
 if (result == 1)
 {
  princ ("You chose the color: ",
         hex(win.GetColor()), "\n");
 }
}

method WindowsExample.AddSubMenu (parent, pos, label)
{
 local submenu = CreatePopupMenu();
 InsertMenu (traymenu, pos, MF_BYPOSITION | MF_POPUP,
    submenu, label);
 .menu_items = cons (cons (submenu, t), .menu_items);
 submenu;
}

method WindowsExample.AddMenuItem (parent, pos, label, code)
{
 local info = new MENUITEMINFO();

 info.cbSize = 48;
 info.fMask = MIIM_STRING | MIIM_FTYPE | MIIM_ID;
 info.fType = MFT_STRING;
 info.wID = ++MenuItemID;
 info.dwTypeData = label;
 InsertMenuItem (parent, pos, 1, info);
 local action = add_menu_action (MenuItemID, code);
 .menu_actions = cons (action, .menu_actions);
}

method WindowsExample.AddMenus ()
```

```
{
 local  traymenu = get_tray_menu ();

 if (traymenu != 0)
 {
  local submenu = .AddSubMenu (traymenu,
             5,
             "Monitor Functions");

  .AddMenuItem (submenu, -1, "Select Color",
       `(@self).SelectTrayMenuItem
         (@MenuItemID+1));
  .AddMenuItem (submenu, -1, "Select File",
         `new GFileDialog (1).DoModal(0));
  .AddMenuItem (submenu, -1, "Select Folder",
         `new GFolderDialog ().DoModal(0));
 }
 else
 {
 }
}

/* ==== A dialog within the first tab in the tab control ==== */

class Dialog1 GWindow
{
 win;
 stHeader;
 stSine;
 stRamp;
 stTriangle;
 stSquare;
}

method WindowsExample.CreateDialog1 (parent, str)
{
 local win = new Dialog1();
 win.Init (parent, str);
 win;
}

method Dialog1.Init (parent, str)
{
 local  rect = CreateRect(10, 10, 10, 10);
 local  row = 5, drow = 30, w = 290, h = 20;
```

```
.win = self;
.win.Create (parent, rect, "tab", WS_CHILDWINDOW, 0);

.stSine = .win.CreateControl (GStatic, 5, row, w, h, "Sine");
.win.onChange (#$DataSim:Sine, `WindowsExample_update
        (@.stSine, this));
WindowsExample_update (.stSine, #$DataSim:Sine);

.stRamp = .win.CreateControl (GStatic, 5, row += drow,
         w, h, "Ramp");
.win.onChange (#$DataSim:Ramp, `WindowsExample_update
        (@.stRamp, this));
WindowsExample_update (.stRamp, #$DataSim:Ramp);

.stTriangle = .win.CreateControl (GStatic, 5, row += drow,
      w, h, "Triangle");
.win.onChange (#$DataSim:Triangle, `WindowsExample_update
        (@.stTriangle, this));
WindowsExample_update (.stTriangle, #$DataSim:Triangle);

.stSquare = .win.CreateControl (GStatic, 5, row += drow,
    w, h, "Square");
.win.onChange (#$DataSim:Square, `WindowsExample_update
        (@.stSquare, this));
WindowsExample_update (.stSquare, #$DataSim:Square);

link = .win.CreateControl (GHyperLink, 5, row += drow,
      w, h, "http://www.cogent.ca");
link.SetHyperLink ("http://www.cogent.ca");
link.SetLabel ("Visit Cogent's web page");
link.SetLinkFont (GetStockObject (DEFAULT_GUI_FONT));
link.ShowWindow (SW_SHOW);

.win.onChange (#$DataSim:Square,
      `progn {
 if (value < 0)
 {
  (@win).SetBackground (0, 0xc0ffff, 0);
  (@win).SetChildBackground (0, 0xc0ffff, 0);
 }
 else
 {
  (@win).SetBackground (0, 0xffffff, 0);
  (@win).SetChildBackground (0, 0xffffff, 0);
 }
 (@win).Invalidate();
```

```
 });

 win;
}

/* ==== A dialog within the second tab in the tab control ==== */

class Dialog2 GWindow
{
 win;
 stHeader;
 stAmplitude;
 stFrequency;
 stOffset;
 stUpdateFrequency;
}

method WindowsExample.CreateDialog2 (parent, str)
{
 local win = new Dialog2();
 win.Init (parent, str);
 win;
}

method Dialog2.Init (parent, str)
{
 local  rect = CreateRect(10, 10, 10, 10);
 local  row = 5, drow = 30, w = 290, h = 20;

 .win = self;
 .win.Create (parent, rect, "tab", WS_CHILDWINDOW, 0);

 .stAmplitude = .win.CreateControl (GStatic, 5, row,
        w, h, "Amplitude");
 .win.onChange (#$DataSim:Amplitude,
         `WindowsExample_update(@.stAmplitude, this));
 WindowsExample_update (.stAmplitude, #$DataSim:Amplitude);

 .stFrequency = .win.CreateControl (GStatic, 5, row += drow,
        w, h, "Frequency");
 .win.onChange (#$DataSim:Frequency,
         `WindowsExample_update(@.stFrequency, this));
 WindowsExample_update (.stFrequency, #$DataSim:Frequency);

 .stOffset = .win.CreateControl (GStatic, 5, row += drow,
     w, h, "Offset");
```

```
 .win.onChange (#$DataSim:Offset,
         `WindowsExample_update(@.stOffset, this));
 WindowsExample_update (.stOffset, #$DataSim:Offset);

 .stUpdateFrequency = .win.CreateControl (GStatic, 5,
       row += drow,
       w, h,
       "UpdateFrequency");
 .win.onChange (#$DataSim:UpdateFrequency,
         `WindowsExample_update(@.stUpdateFrequency,
           this));
 WindowsExample_update (.stUpdateFrequency,
                               #$DataSim:UpdateFrequency);

 local tb = .win.CreateControl (GTrackBarCtrl, 5,
      row += drow, w, h,
      "FreqBar");

 tb.SetRange (0, 20, 1);
 tb.ModifyStyle (0, TBS_AUTOTICKS, 0);
 tb.SetTicFreq (2);
 .win.MessageHandler (WM_HSCROLL, `(@self).Scrolled(@tb));
 .win.onChange (#$DataSim:UpdateFrequency,
       `(@tb).SetPos (value));
 if (!undefined_p($DataSim:UpdateFrequency))
  tb.SetPos ($DataSim:UpdateFrequency);
 win;
}

method Dialog2.Scrolled (tb)
{
 $DataSim:UpdateFrequency = tb.GetPos();
}

/* ==== A dialog containing a List box ==== */

class Dialog3 GWindow
{
 win;
 lv;
}

method WindowsExample.CreateDialog3 (parent, str)
{
 local win = new Dialog3();
 win.Init (parent, str);
```

```
 win;
}

method Dialog3.AddPet (name, owner, species)
{
 local  n = .lv.GetItemCount();
 .lv.InsertItem (n, name);
 .lv.SetItemText (n, 1, owner);
 .lv.SetItemText (n, 2, species);
}

method Dialog3.Init (parent, str)
{
 local  rect = CreateRect(10, 10, 10, 10);
 local  w = 10, h = 10;

 .win = self;

 .win.SetBackground (0, GetSysColor (COLOR_3DFACE), 0);
 .win.Create (parent, rect, "tab", WS_CHILDWINDOW, 0);

 .lv = .CreateControl (GListViewCtrl, 0, 0, w, h, "lv");

 .lv.SetViewType (1);
 .lv.SetExtendedListViewStyle (LVS_EX_FULLROWSELECT |
          LVS_EX_ONECLICKACTIVATE,
          LVS_EX_FULLROWSELECT
          /*| LVS_EX_ONECLICKACTIVATE*/
          );

 .lv.InsertColumn (0, "Pet", 0, 100, 0);
 .lv.InsertColumn (1, "Owner", 0, 100, 0);
 .lv.InsertColumn (2, "Species", 0, 100, 0);
 .lv.SetBackground (0, 0xffffff, 0);
 .AddPet ("Fluffy","Harold","cat");
 .AddPet ("Claws","Gwen","cat");
 .AddPet ("Buffy", "Harold", "dog");
 .AddPet ("Fang", "Benny", "dog");
 .AddPet ("Bowser", "Diane", "dog");
 .AddPet ("Chirpy", "Gwen", "bird");
 .AddPet ("Whistler", "Gwen", "bird");
 .AddPet ("Slim", "Benny", "snake");
 .AddPet ("Blob", "Benny", "slug");

 /* One way to modify the list after it has been created is
    to search for an entry by its column-zero text and then
```

```
    modify the sub-items. */
 local finfo = new LVFINDINFO();
 finfo.flags = LVFI_STRING;
 finfo.psz = "Chirpy";
 local item = .lv.FindItem (finfo, 0);
 .lv.SetItemText (item, 1, "Nobody");

 .win.AddControlResizeFlags (.lv.GetDlgCtrlID(),
        DLSZ_SIZE_X | DLSZ_SIZE_Y);

 .win.NotifyHandler (LVN_ITEMACTIVATE,
       .lv.GetDlgCtrlID(),
       `(@self).SelectedItems(@(.lv)));
 .win;
}

method Dialog3.SelectedItems (lv)
{
 local  i, n = lv.GetItemCount(), state, items;
 for (i=0; i<n; i++)
 {
  if ((state = lv.GetItemState (i, LVIS_SELECTED)) != 0)
   items = cons (i, items);
 }
 princ (reverse(items), "\n");
 reverse (items);
}

/* ======================= Support functions ==================== */

function WindowsExample_update (win, point)
{
 local  val, i;
 if (!undefined_p (val = eval(point)))
 {
  point = string (point);
  if ((i = strchr (point, ':')) != -1)
   point = substr (point, i+1, -1);
  win.SetWindowText (format ("%s = %.4f", point, val));
 }
}

/* ============================ Run It ========================= */

ApplicationSingleton (WindowsExample);
```

Sample Code: `ShowImage.g`

This tutorial demonstrates how to add a BMP image using the GStatic control.

Code

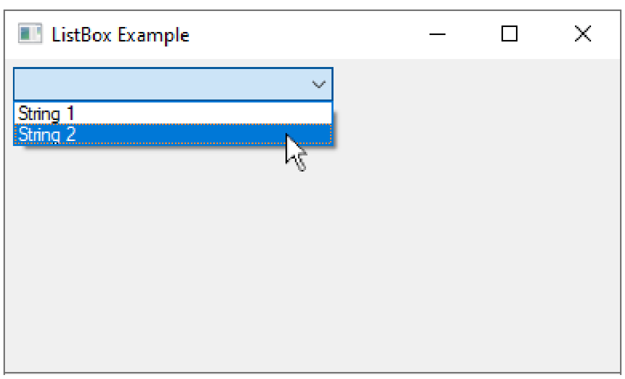
```
require ("Application");
require ("WindowsSupport");

class ShowImage Application
{
 window;
 imageFile = "c:/tmp/Capture.bmp";
 imageHandles;
}

/*
 * This creates a GStatic and populates it with an image from a file.
 * The image must be in Windows BMP format.  You can specify a width
 * and height to force the image to be scaled to fit that size.  If
 * you specify 0 for both width and height then the image will be
 * rendered in its natural size. Notice that we need to store the
 * image handle and then free it during the destructor.
 */
method ShowImage.createImage (parent, x, y, width, height, imageFile)
{
 local imageObj = parent.CreateControl(GStatic, x, y, width,
           height, "", SS_BITMAP);
 local handle = LoadImage(0, imageFile, IMAGE_BITMAP,
     width, height, LR_LOADFROMFILE);
 .imageHandles = cons(handle, .imageHandles);
 imageObj.SendMessage(STM_SETIMAGE, IMAGE_BITMAP, handle);
 imageObj;
}

/* Write the 'main line' of the program here. */
method ShowImage.constructor ()
{
 local rect = CreateRect(10, 10, 400, 400);
 local win;

 win = new GWindow();
 win.Create(0, rect, "Test Window", WS_OVERLAPPEDWINDOW, 0);
 win.MessageHandler (WM_DESTROY,
```

```
       `(!destroyed_p(@self) ?
         destroy(@self) : nil));

 .createImage(win, 10, 10, 0, 0, .imageFile);

 .window = win;
 win.ShowWindow(SW_SHOW);
}

/* Any code to be run when the program gets shut down.  We need to
   delete the image handles. */
method ShowImage.destructor ()
{
 with handle in .imageHandles do
  DeleteObject(handle);
 if (instance_p(.window))
  destroy(.window);
}

/* Start the program by instantiating the class. */
ApplicationSingleton (ShowImage);
```

Sample Code: `ListBoxExample.g`

This tutorial demonstrates the list box.

Output



Code

```
/* All user scripts should derive from the base "Application" class */
```

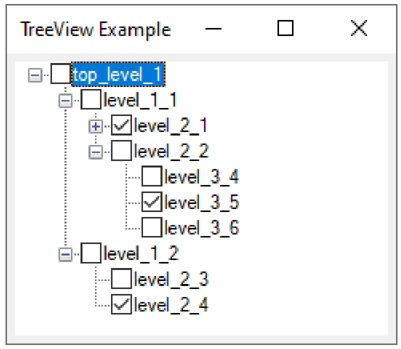
```
require ("Application");
require ("WindowsSupport");

class ListBoxExample Application
{
    window;
}

// Fill the combo box with choices
method ListBoxExample.FillCombo(lb)
{
    local       current = lb.GetWindowText();

    // Clear the combo box if we need to.
    lb.Clear();
    lb.ResetContent();

    // Add some options to the combo box
    lb.AddString("String 1");
    lb.AddString("String 2");

    // If there was an existing choice, reselect it
    lb.SelectString(-1, current);
}

// This is called when the combo box is selected
method ListBoxExample.ComboSelected(lb)
{
    princ ("You selected ", lb.GetWindowText(), "\n");
}

/* Write the 'main line' of the program here. */
method ListBoxExample.constructor ()
{
    local   win = new GWindow();
    local   rect = CreateRect(10, 10, 400, 400);

    win.Create (0, rect, "ListBox Example", WS_OVERLAPPEDWINDOW, 0);
    win.MessageHandler (WM_DESTROY, `(!destroyed_p(@self) ?
          destroy(@self) : nil));
    .window = win;
    .window.SetBackground (0, GetSysColor (COLOR_3DFACE), 0);

    // ------- List box example starts here

    // Create a combo box.  Use CBS_* to set the options.
```

```
    // An editable combo uses CBS_DROPDOWN.
    local   lb = win.CreateControl (GComboBox, 5, 5, 200, 20,
        "ExampleListBox", CBS_DROPDOWNLIST | CBS_SORT);

    // If the window has a different background, make sure the
    // combo box stays white.
    lb.SetChildBackground (0, GetSysColor (COLOR_WINDOW), 0);

    // If we want to fill the combo when the person drops it down,
    // do this
    win.CommandHandler (CBN_DROPDOWN, lb, `(@self).FillCombo(@lb));
    // Otherwise we could just do this to fill it once at the start
    // .FillCombo(lb);

    // Trigger an event when the user selects an option
    win.CommandHandler (CBN_SELCHANGE, lb,
   `(@self).ComboSelected(@lb));

    // ------- List box example ends here

    win.ShowWindow (SW_SHOW);
}

/* Any code to be run when the program gets shut down. */
method ListBoxExample.destructor ()
{
    if (instance_p(.window))
        destroy (.window);
}

/* Start the program by instantiating the class. */
ApplicationSingleton (ListBoxExample);
```

Sample Code: `TreeViewDemo.g`

This tutorial demonstrates how to create a tree to view data.

Output



Code

```
/* All user scripts should derive from the base "Application" class */

require ("Application");
require ("WindowsSupport");

class TreeViewDemo Application
{
    window;
    tree;
    data = [["top_level_1",
                ["level_1_1",
                    ["level_2_1",
                        "level_3_1",
                        ["level_3_2", "level_4_1"],
                        "level_3_3"
                    ],
                    ["level_2_2",
                        "level_3_4", "level_3_5", "level_3_6"
                    ]
                ],
                ["level_1_2",
                    "level_2_3", "level_2_4"
                ]
            ]
           ];
}

/* Use methods to create functions outside the 'main line'. */
method TreeViewDemo.FillTree (data)
{
    local   root = .tree.GetRootItem();
    with descendants in data do
```

```
    {
        .FillTreeRecursive(root, descendants);
    }
}

// Adding an item uses the InsertItem method.
method TreeViewDemo.FillTreeRecursive (parent, data)
{
    local   nodename = array_p(data) ? data[0] : data;
    local   htreeitem = .tree.InsertItem(nodename, 0, 0,
      parent, TVGN_LASTVISIBLE);
    local   i;

    if (array_p(data))
    {
        for (i=1; i<length(data); i++)
        {
            .FillTreeRecursive(htreeitem, data[i]);
        }
    }
}

// Find the full path name of the selected item in the tree
method TreeViewDemo.GetTreeSelection ()
{
    local       hitem = .tree.GetSelectedItem();
    .GetTreeItemFullname (hitem);
}

// Get just the text label of the given item
method TreeViewDemo.GetTreeItemText (hitem)
{
    local       item = new TVITEM();
    local       buf;

    item.hItem = hitem;
    item.mask = TVIF_TEXT;
    item.cchTextMax = 128;
    item.pszText = make_buffer(128);
    .tree.GetItem (item);
    buf = item.pszText;
    buffer_to_string (buf);
}

// Find the full path name of the given item.  The path
// separator can be changed by modifying the / below
```

```
method TreeViewDemo.GetTreeItemFullname (hitem)
{
    local       itemtext, pname, hparent, hgrandparent, sep = "/";
    if (hitem != 0)
    {
        itemtext = .GetTreeItemText (hitem);
        hparent = .tree.GetParentItem(hitem);
        if (hparent != 0)
        {
            hgrandparent = .tree.GetParentItem(hparent);
            // If you want to make the first separator different
     // from the rest, change it here.
            if (hgrandparent == 0)
                sep = "/";
        }

        pname = .GetTreeItemFullname (hparent);
        if (pname)
            string (pname, sep, itemtext);
        else
            itemtext;
    }
    else
        nil;
}

// Callback when an item is selected
method TreeViewDemo.cbItemSelected (itemname)
{
    princ ("You selected item: ", itemname, "\n");
}

// Callback before a branch in the tree is expanded or collapsed
method TreeViewDemo.cbPointExpanding ()
{
    local   item = map_volatile_pointer (pnmh, NMTREEVIEW);
    local   hitem = item.itemNew.hItem;
    local   pointname = .GetTreeItemFullname (hitem);

    if (item.action == TVE_COLLAPSE)
    {
        princ ("Item: ", pointname, " is about to collapse\n");
    }
    else
    {
        princ ("Item: ", pointname, " is about to expand\n");
```

```
    }

    // Allow the tree to expand or collapse
    0;
}

// Callback after a branch is expanded or collapsed
method TreeViewDemo.cbPointExpanded ()
{
    local   item = map_volatile_pointer (pnmh, NMTREEVIEW);
    local   hitem = item.itemNew.hItem;
    local   pointname = .GetTreeItemFullname (hitem);

    if (item.action == TVE_COLLAPSE)
    {
        princ ("Item: ", pointname, " has collapsed\n");
    }
    else
    {
        princ ("Item: ", pointname, " has expanded\n");
    }

    // Allow the tree to expand or collapse
    0;
}

/* Write the 'main line' of the program here. */
method TreeViewDemo.constructor ()
{
    local   win = new GWindow();
    local   rect = CreateRect(100, 100, 220, 220);
    local   clientrect = CreateRect(0,0,0,0);

    win.Create (0, rect, "TreeView Example", WS_OVERLAPPEDWINDOW, 0);
    win.MessageHandler (WM_DESTROY, `(!destroyed_p(@self) ?
          destroy(@self) : nil));
    .window = win;
    .window.SetBackground (0, GetSysColor (COLOR_3DFACE), 0);

    // Find the interior size of the window so we can size
    // the TreeView
    win.GetClientRect(clientrect);

    // ------- TreeView example starts here

    // Create a TreeView.  Use TVS_* to set the options.
```

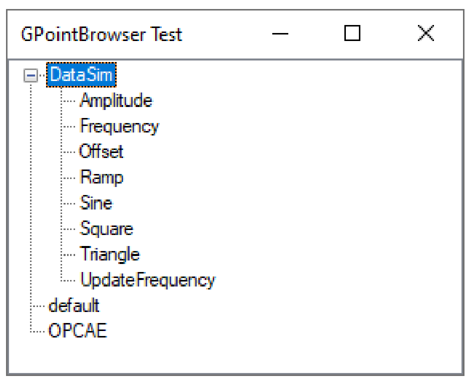
```
    local   tv = win.CreateControl (GTreeViewCtrl, 5, 5,
        clientrect.right - 10,
        clientrect.bottom - 10,
        "ExampleTreeView",
        TVS_CHECKBOXES | TVS_HASLINES |
        TVS_LINESATROOT | TVS_HASBUTTONS |
        TVS_TRACKSELECT | TVS_NOHSCROLL);

    .tree = tv;

    // If the window has a different background, make sure
    // the combo box stays white.
    tv.SetChildBackground (0, GetSysColor (COLOR_WINDOW), 0);

    // Fill the tree once at the start
    .FillTree(.data);

    // Trigger an event when the user selects an item
    win.NotifyHandler (TVN_SELCHANGED, tv,
          `(@self).cbItemSelected((@self).GetTreeSelection()));
    win.NotifyHandler (TVN_ITEMEXPANDING, tv,
         `(@self).cbPointExpanding());
    win.NotifyHandler (TVN_ITEMEXPANDED, tv,
         `(@self).cbPointExpanded());

    // There is no event in Windows for changing a check-box state
    // in a TreeView !? Checkbox events are absurdly difficult to
    // deal with in C++, and impossible in Gamma.

    // You can add events to handle other use cases as well...
    //win.NotifyHandler (NM_DBLCLK, tv,
    //           `(@self).cbDoubleClick((@self).GetTreeSelection()));
    //tv.MessageHandler (WM_RBUTTONDOWN, `((@self).cbRightClick()));

    // Reize the TreeView when the window resizes
    win.AddControlResizeFlags (tv, DLSZ_SIZE_X | DLSZ_SIZE_Y);

    // ------- TreeView example ends here

    win.ShowWindow (SW_SHOW);
}

/* Any code to be run when the program gets shut down. */
method TreeViewDemo.destructor ()
{
    if (instance_p(.window))
```

```
        destroy (.window);
}

/* Start the program by instantiating the class.  If your
 * constructor code does not create a persistent reference to
 * the instance (self), then it will be destroyed by the
 * garbage collector soon after creation.  If you do not want
 * this to happen, assign the instance to a global variable, or
 * create a static data member in your class to which you assign
 * 'self' during the construction process.  ApplicationSingleton()
 * does this for you automatically. */
ApplicationSingleton (TreeViewDemo);
```

Sample Code: Browse DataHub Points using `TreeViewExample.g`

This tutorial demonstrates how to create a tree to browse points in a DataHub instance.

Output



Code

```
/* All user scripts should derive from the base "Application" class */

require ("Application");
require ("WindowsSupport");

/*
 * The real implementation of the point browser is in
 * c:\program files\cogent\opc datahub\require\GPointBrowser.g
 */

require ("GPointBrowser");
```

```
class TreeViewExample Application
{
    window;
    gtree;
}

/*
 * Specialize the GPointBrowser object so that we get our own
 * callbacks when certain events occur in the point tree.  The
 * default event handling will still be processed to fill the
 * tree as the user traverses it.
 */

class MyGPointBrowser GPointBrowser
{
}

method MyGPointBrowser.OnSelect (pointname)
{
    princ ("Selected: ", pointname, "\n");
}

method MyGPointBrowser.OnDoubleClick(pointname)
{
    princ ("Double Click: ", pointname, "\n");
}

method MyGPointBrowser.OnRightClick(pointname)
{
    princ ("Right Click: ", pointname, "\n");
}

method MyGPointBrowser.OnExpanded (pointname)
{
    princ ("Expanded: ", pointname, "\n");
}

method MyGPointBrowser.OnCollapsed (pointname)
{
    princ ("Collapsed: ", pointname, "\n");
}

/* Write the 'main line' of the program here. */
method TreeViewExample.constructor ()
{
    local   rect = CreateRect (0, 0, 300, 300);
```

```
    .window = new GWindow();

    .window.Create (0, rect, "GPointBrowser Test",
      WS_OVERLAPPEDWINDOW, 0);
    .window.CenterWindow();
    .window.GetClientRect (rect);
    .gtree = .window.CreateControl (MyGPointBrowser,
        0, 0, rect.right-rect.left,
                                    rect.bottom-rect.top,
        "Hello world", SS_CENTER);
    .gtree.CenterWindow();
    .gtree.debugging = t;
    .window.MessageHandler (WM_DESTROY, `instance_p(@self) ?
       destroy(@self) : nil);
    .window.AddControlResizeFlags (.gtree, DLSZ_SIZE_X | DLSZ_SIZE_Y);
    .window.ShowWindow (SW_SHOW);
}

/* Any code to be run when the program gets shut down. */
method TreeViewExample.destructor ()
{
    if (instance_p(.window))
        destroy (.window);
}

/* Start the program by instantiating the class. */
ApplicationSingleton (TreeViewExample);
```

Widgets

G3StateButton

G3StateButton — a 3-state button.

Synopsis

```
class G3StateButton GButton
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GButton <-- G3StateButton

Description

This widget is a superclass that provides the BS_3STATE button style of a CButton.

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to C3StateButton::Create.

This class also inherits the functions of GButton and GWindowBase.

GAnimateCtrl

`GAnimateCtrl` — an animation control.

Synopsis

```
class GAnimateCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GAnimateCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Close ()`
: Corresponds to `CAnimateCtrl::Close`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CAnimateCtrl::Create`.

`Play (nFrom, nTo, nRep)`
: Corresponds to `CAnimateCtrl::Play`.

`Seek (nTo)`
: Corresponds to `CAnimateCtrl::Seek`.

`Stop ()`
: Corresponds to `CAnimateCtrl::Stop`.

This class also inherits the functions of `GWindowBase`.

GBitmapButton

`GBitmapButton` — a bitmap button.

Synopsis

```
class GBitmapButton GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GBitmapButton`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CBitmapButton::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CBitmapButton::Create`.

`EndResizeGroup ()`
: Corresponds to `CBitmapButton::EndResizeGroup`.

`StartResizeGroup ()`
: Corresponds to `CBitmapButton::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GButton

GButton — a button.

Synopsis

```
class GButton GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GButton

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CButton::AddControlResizeFlags`.

`Click ()`
: Corresponds to `CButton::Click`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CButton::Create`.

`EndResizeGroup ()`
: Corresponds to `CButton::EndResizeGroup`.

`GetButtonStyle ()`
: Corresponds to `CButton::GetButtonStyle`.

`GetCheck ()`
: Corresponds to `CButton::GetCheck`.

`GetIcon ()`
: Corresponds to `CButton::GetIcon`.

`GetIdealSize (lpSize)`
: Corresponds to `CButton::GetIdealSize`.

`GetState ()`
: Corresponds to `CButton::GetState`.

`GetTextMargin (lpRect)`
: Corresponds to `CButton::GetTextMargin`.

`SetButtonStyle (args?...)`
: Corresponds to `CButton::SetButtonStyle`.

`SetCheck (nCheck)`
: Corresponds to `CButton::SetCheck`.

`SetIcon (hIcon)`
: Corresponds to `CButton::SetIcon`.

`SetState (bHighlight)`
: Corresponds to `CButton::SetState`.

`SetTextMargin (lpRect)`
: Corresponds to `CButton::SetTextMargin`.

`StartResizeGroup ()`
: Corresponds to `CButton::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GCheckBox

GCheckBox — a check box.

Synopsis

```
class GCheckBox GButton
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GButton <-- GCheckBox

Description

This widget is a superclass that provides the BS_CHECKBOX button style of a CButton.

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to CCheckBox::Create.

This class also inherits the functions of GButton and GWindowBase.

GCheckListViewCtrl

`GCheckListViewCtrl` — purpose is not yet documented.

Synopsis

```
class GCheckListViewCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GCheckListViewCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CCheckListViewCtrl::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CCheckListViewCtrl::Create`.

`EndResizeGroup ()`
: Corresponds to `CCheckListViewCtrl::EndResizeGroup`.

`StartResizeGroup ()`
: Corresponds to `CCheckListViewCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GColorDialog

`GColorDialog` — a color-selection dialog box.

Synopsis

```
class GColorDialog
{
    m_hWnd;
}
```

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`DoModal (args?...)`
: Corresponds to `CColorDialog::DoModal`.

`GetColor ()`
: Corresponds to `CColorDialog::GetColor`.

`GetHwnd ()`
: Corresponds to `CColorDialog::GetHwnd`.

`SetCurrentColor (clr)`
: Corresponds to `CColorDialog::SetCurrentColor`.

This class also inherits the functions of

GComboBox

GComboBox — a list box combined with a static or edit control.

Synopsis

```
class GComboBox GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GComboBox

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CComboBox::AddControlResizeFlags`.

`AddString (lpszString)`
: Corresponds to `CComboBox::AddString`.

`Clear ()`
: Corresponds to `CComboBox::Clear`.

`Copy ()`
: Corresponds to `CComboBox::Copy`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CComboBox::Create`.

`Cut ()`
: Corresponds to `CComboBox::Cut`.

`DeleteString (nIndex)`
: Corresponds to `CComboBox::DeleteString`.

`Dir (attr, lpszWildCard)`
: Corresponds to `CComboBox::Dir`.

`EndResizeGroup ()`
: Corresponds to `CComboBox::EndResizeGroup`.

`FindString (nStartAfter, lpszString)`
: Corresponds to `CComboBox::FindString`.

`FindStringExact (nIndexStart, lpszFind)`
: Corresponds to `CComboBox::FindStringExact`.

`GetComboBoxInfo (pComboBoxInfo)`
: Corresponds to `CComboBox::GetComboBoxInfo`.

`GetCount ()`
: Corresponds to `CComboBox::GetCount`.

`GetCurSel ()`
: Corresponds to `CComboBox::GetCurSel`.

`GetDroppedControlRect (lprect)`
: Corresponds to `CComboBox::GetDroppedControlRect`.

`GetDroppedState ()`
: Corresponds to `CComboBox::GetDroppedState`.

`GetDroppedWidth ()`
: Corresponds to `CComboBox::GetDroppedWidth`.

`GetEditSel ()`
: Corresponds to `CComboBox::GetEditSel`.

`GetExtendedUI ()`
: Corresponds to `CComboBox::GetExtendedUI`.

`GetHorizontalExtent ()`
: Corresponds to `CComboBox::GetHorizontalExtent`.

`GetItemData (nIndex)`
: Corresponds to `CComboBox::GetItemData`.

`GetItemHeight (nIndex)`
: Corresponds to `CComboBox::GetItemHeight`.

`GetLBText (nIndex, lpszText)`
: Corresponds to `CComboBox::GetLBText`.

`GetLBTextLen (nIndex)`
: Corresponds to `CComboBox::GetLBTextLen`.

`GetLocale ()`
: Corresponds to `CComboBox::GetLocale`.

`GetMinVisible ()`
: Corresponds to `CComboBox::GetMinVisible`.

`GetTopIndex ()`
: Corresponds to `CComboBox::GetTopIndex`.

`InitStorage (nItems, nBytes)`
: Corresponds to `CComboBox::InitStorage`.

`InsertString (nIndex, lpszString)`
: Corresponds to `CComboBox::InsertString`.

`LimitText (nMaxChars)`
: Corresponds to `CComboBox::LimitText`.

`Paste ()`
: Corresponds to `CComboBox::Paste`.

`ResetContent ()`
: Corresponds to `CComboBox::ResetContent`.

`SelectString (nStartAfter, lpszString)`
: Corresponds to `CComboBox::SelectString`.

`SetCurSel (nSelect)`
: Corresponds to `CComboBox::SetCurSel`.

`SetDroppedWidth (nWidth)`
: Corresponds to `CComboBox::SetDroppedWidth`.

`SetEditSel (nStartChar, nEndChar)`
: Corresponds to `CComboBox::SetEditSel`.

`SetExtendedUI (args?...)`
: Corresponds to `CComboBox::SetExtendedUI`.

`SetHorizontalExtent (nExtent)`
: Corresponds to `CComboBox::SetHorizontalExtent`.

`SetItemData (nIndex, dwItemData)`
: Corresponds to `CComboBox::SetItemData`.

`SetItemHeight (nIndex, cyItemHeight)`
: Corresponds to `CComboBox::SetItemHeight`.

`SetLocale (nNewLocale)`
: Corresponds to `CComboBox::SetLocale`.

`SetMinVisible (nMinVisible)`
: Corresponds to `CComboBox::SetMinVisible`.

`SetTopIndex (nIndex)`
: Corresponds to `CComboBox::SetTopIndex`.

`ShowDropDown (args?...)`
: Corresponds to `CComboBox::ShowDropDown`.

`StartResizeGroup ()`
: Corresponds to `CComboBox::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GComboBoxEx

GComboBoxEx — a combo box with support for image lists.

Synopsis

```
class GComboBoxEx GComboBox
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GComboBox <-- GComboBoxEx

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CComboBoxEx::Create`.

`DeleteItem (nIndex)`
: Corresponds to `CComboBoxEx::DeleteItem`.

`GetExtendedStyle ()`
: Corresponds to `CComboBoxEx::GetExtendedStyle`.

`GetItem (pCBItem)`
: Corresponds to `CComboBoxEx::GetItem`.

`GetUnicodeFormat ()`
: Corresponds to `CComboBoxEx::GetUnicodeFormat`.

`HasEditChanged ()`
: Corresponds to `CComboBoxEx::HasEditChanged`.

`InsertItem (lpcCBItem)`
: Corresponds to `CComboBoxEx::InsertItem`.

`SetExtendedStyle (dwExMask, dwExStyle)`
: Corresponds to `CComboBoxEx::SetExtendedStyle`.

`SetItem (lpcCBItem)`
: Corresponds to `CComboBoxEx::SetItem`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CComboBoxEx::SetUnicodeFormat`.

This class also inherits the functions of `GComboBox` and `GWindowBase`.

GDateTimePickerCtrl

`GDateTimePickerCtrl` — a way to enter a date and time, based on `CDateTimeCtrl`.

Synopsis

```
class GDateTimePickerCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GDateTimePickerCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CDateTimePickerCtrl::Create`.

`GetMonthCalColor (nColorType)`
: Corresponds to `CDateTimePickerCtrl::GetMonthCalColor`.

`GetRange (lpSysTimeArray)`
: Corresponds to `CDateTimePickerCtrl::GetRange`.

`GetSystemTime (lpSysTime)`
: Corresponds to `CDateTimePickerCtrl::GetSystemTime`.

`SetFormat (lpszFormat)`
: Corresponds to `CDateTimePickerCtrl::SetFormat`.

`SetMonthCalColor (nColorType, clr)`
: Corresponds to `CDateTimePickerCtrl::SetMonthCalColor`.

`SetMonthCalFont (args?...)`
: Corresponds to `CDateTimePickerCtrl::SetMonthCalFont`.

`SetRange (dwFlags, lpSysTimeArray)`
: Corresponds to `CDateTimePickerCtrl::SetRange`.

`SetSystemTime (dwFlags, lpSysTime)`
: Corresponds to `CDateTimePickerCtrl::SetSystemTime`.

This class also inherits the functions of `GWindowBase`.

GDialog

GDialog — a dialog box.

Synopsis

```
class GDialog GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GDialog

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (args?...)`
: Corresponds to `CDialog::Create`.

`DoModal (args?...)`
: Corresponds to `CDialog::DoModal`.

`EndDialog (nRetCode)`
: Corresponds to `CDialog::EndDialog`.

`MapDialogRect (lpRect)`
: Corresponds to `CDialog::MapDialogRect`.

This class also inherits the functions of GWindowBase.

GDragListBox

`GDragListBox` — allows listed items in a list box to be moved.

Synopsis

```
class GDragListBox GListBox
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GListBox` <-- `GDragListBox`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CDragListBox::Create`.

`DrawInsert (nItem)`
: Corresponds to `CDragListBox::DrawInsert`.

`LBItemFromPt (args?...)`
: Corresponds to `CDragListBox::LBItemFromPt`.

`MakeDragList ()`
: Corresponds to `CDragListBox::MakeDragList`.

This class also inherits the functions of `GListBox` and `GWindowBase`.

GEdit

GEdit — a text-entry box.

Synopsis

```
class GEdit GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GEdit

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

AddControlResizeFlags (ctrlid, flags)
: Corresponds to CEdit::AddControlResizeFlags.

AppendText (args?...)
: Corresponds to CEdit::AppendText.

CanUndo ()
: Corresponds to CEdit::CanUndo.

CharFromPos (args?...)
: Corresponds to CEdit::CharFromPos.

Clear ()
: Corresponds to CEdit::Clear.

Copy ()
: Corresponds to CEdit::Copy.

Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)
: Corresponds to CEdit::Create.

Cut ()
: Corresponds to CEdit::Cut.

EmptyUndoBuffer ()
: Corresponds to CEdit::EmptyUndoBuffer.

EndResizeGroup ()
: Corresponds to CEdit::EndResizeGroup.

`FmtLines (bAddEOL)`
: Corresponds to `CEdit::FmtLines`.

`GetFirstVisibleLine ()`
: Corresponds to `CEdit::GetFirstVisibleLine`.

`GetHandle ()`
: Corresponds to `CEdit::GetHandle`.

`GetImeStatus (uStatus)`
: Corresponds to `CEdit::GetImeStatus`.

`GetLimitText ()`
: Corresponds to `CEdit::GetLimitText`.

`GetLine (args?...)`
: Corresponds to `CEdit::GetLine`.

`GetLineCount ()`
: Corresponds to `CEdit::GetLineCount`.

`GetMargins ()`
: Corresponds to `CEdit::GetMargins`.

`GetModify ()`
: Corresponds to `CEdit::GetModify`.

`GetPasswordChar ()`
: Corresponds to `CEdit::GetPasswordChar`.

`GetRect (lpRect)`
: Corresponds to `CEdit::GetRect`.

`GetSel (args?...)`
: Corresponds to `CEdit::GetSel`.

`GetThumb ()`
: Corresponds to `CEdit::GetThumb`.

`HideBalloonTip ()`
: Corresponds to `CEdit::HideBalloonTip`.

`InsertText (args?...)`
: Corresponds to `CEdit::InsertText`.

`LimitText (args?...)`
: Corresponds to `CEdit::LimitText`.

`LineFromChar (args?...)`
: Corresponds to `CEdit::LineFromChar`.

`LineIndex (args?...)`
: Corresponds to `CEdit::LineIndex`.

`LineLength (args?...)`
: Corresponds to `CEdit::LineLength`.

`LineScroll (args?...)`
: Corresponds to `CEdit::LineScroll`.

`Paste ()`
: Corresponds to `CEdit::Paste`.

`PosFromChar (nChar)`
: Corresponds to `CEdit::PosFromChar`.

`ReplaceSel (args?...)`
: Corresponds to `CEdit::ReplaceSel`.

`Scroll (nScrollAction)`
: Corresponds to `CEdit::Scroll`.

`ScrollCaret ()`
: Corresponds to `CEdit::ScrollCaret`.

`SetHandle (hBuffer)`
: Corresponds to `CEdit::SetHandle`.

`SetImeStatus (uStatus, uData)`
: Corresponds to `CEdit::SetImeStatus`.

`SetLimitText (nMax)`
: Corresponds to `CEdit::SetLimitText`.

`SetMargins (nLeft, nRight)`
: Corresponds to `CEdit::SetMargins`.

`SetModify (args?...)`
: Corresponds to `CEdit::SetModify`.

`SetPasswordChar (ch)`
: Corresponds to `CEdit::SetPasswordChar`.

`SetReadOnly (args?...)`
: Corresponds to `CEdit::SetReadOnly`.

`SetRect (lpRect)`
: Corresponds to `CEdit::SetRect`.

`SetRectNP (lpRect)`
: Corresponds to `CEdit::SetRectNP`.

`SetSel (args?...)`
: Corresponds to `CEdit::SetSel`.

`SetSelAll (args?...)`
: Corresponds to `CEdit::SetSelAll`.

`SetSelNone (args?...)`
: Corresponds to `CEdit::SetSelNone`.

`SetTabStops (args?...)`
: Corresponds to `CEdit::SetTabStops`.

`ShowBalloonTip (pEditBaloonTip)`

Corresponds to `CEdit::ShowBalloonTip`.

`StartResizeGroup ()`

Corresponds to `CEdit::StartResizeGroup`.

`Undo ()`

Corresponds to `CEdit::Undo`.

This class also inherits the functions of `GWindowBase`.

GFileDialog

`GFileDialog` — a dialog box for opening and saving files.

Synopsis

```
class GFileDialog
{
    m_bOpenFileDialog;
    m_ofn;
    m_szFileName;
    m_szFileTitle;
}
```

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`DoModal (args?...)`
: Corresponds to `CFileDialog::DoModal`.

`EndDialog (args?...)`
: Corresponds to `CFileDialog::EndDialog`.

`GetFilePath (lpstrFilePath, nLength)`
: Corresponds to `CFileDialog::GetFilePath`.

`GetFolderPath (lpstrFolderPath, nLength)`
: Corresponds to `CFileDialog::GetFolderPath`.

`GetHwnd ()`
: Corresponds to `CFileDialog::GetHwnd`.

`GetReadOnlyPref ()`
: Corresponds to `CFileDialog::GetReadOnlyPref`.

`GetSpec (lpstrSpec, nLength)`
: Corresponds to `CFileDialog::GetSpec`.

`HideControl (nCtrlID)`
: Corresponds to `CFileDialog::HideControl`.

`SetControlText (nCtrlID, lpstrText)`
: Corresponds to `CFileDialog::SetControlText`.

`SetDefExt (lpstrExt)`
: Corresponds to `CFileDialog::SetDefExt`.

This class also inherits the functions of

GFlatScrollBar

`GFlatScrollBar` — a scrollbar with an enhanced interface, based on `FlatScrollBar`.

Synopsis

```
class GFlatScrollBar GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GFlatScrollBar`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CFlatScrollBar::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CFlatScrollBar::Create`.

`EndResizeGroup ()`
: Corresponds to `CFlatScrollBar::EndResizeGroup`.

`StartResizeGroup ()`
: Corresponds to `CFlatScrollBar::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GFolderDialog

GFolderDialog — a dialog box to manage folders, based on Folder Dialog.

Synopsis

```
class GFolderDialog GDialog
{
    m_hWnd;
    m_szFolderDisplayName;
    m_szFolderPath;
}
```

Base Classes

GWindowBase <-- GDialog <-- GFolderDialog

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

DoModal (args?...)

Corresponds to CFolderDialog::DoModal.

This class also inherits the functions of GDialog and GWindowBase.

GFontDialog

GFontDialog — a dialog box to manage fonts, based on Font Dialog.

Synopsis

```
class GFontDialog GDialog
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GDialog <-- GFontDialog

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

DoModal (args?...)
: Corresponds to CFontDialog::DoModal.

This class also inherits the functions of GDialog and GWindowBase.

GGroupBox

GGroupBox — a rectangle that groups controls, based on Group Box.

Synopsis

```
class GGroupBox GButton
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GButton <-- GGroupBox

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CGroupBox::Create`.

This class also inherits the functions of GButton and GWindowBase.

GHeaderCtrl

GHeaderCtrl — a header for columns of text or numbers.

Synopsis

```
class GHeaderCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GHeaderCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
    Corresponds to `CHeaderCtrl::AddControlResizeFlags`.

`ClearAllFilters ()`
    Corresponds to `CHeaderCtrl::ClearAllFilters`.

`ClearFilter (nColumn)`
    Corresponds to `CHeaderCtrl::ClearFilter`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
    Corresponds to `CHeaderCtrl::Create`.

`DeleteItem (nIndex)`
    Corresponds to `CHeaderCtrl::DeleteItem`.

`EditFilter (nColumn, bDiscardChanges)`
    Corresponds to `CHeaderCtrl::EditFilter`.

`EndResizeGroup ()`
    Corresponds to `CHeaderCtrl::EndResizeGroup`.

`GetBitmapMargin ()`
    Corresponds to `CHeaderCtrl::GetBitmapMargin`.

`GetItem (nIndex, pHeaderItem)`
    Corresponds to `CHeaderCtrl::GetItem`.

`GetItemCount ()`
    Corresponds to `CHeaderCtrl::GetItemCount`.

`GetItemRect (nIndex, lpItemRect)`
: Corresponds to `CHeaderCtrl::GetItemRect`.

`GetUnicodeFormat ()`
: Corresponds to `CHeaderCtrl::GetUnicodeFormat`.

`HitTest (lpHitTestInfo)`
: Corresponds to `CHeaderCtrl::HitTest`.

`InsertItem (nIndex, phdi)`
: Corresponds to `CHeaderCtrl::InsertItem`.

`Layout (pHeaderLayout)`
: Corresponds to `CHeaderCtrl::Layout`.

`OrderToIndex (nOrder)`
: Corresponds to `CHeaderCtrl::OrderToIndex`.

`SetBitmapMargin (nWidth)`
: Corresponds to `CHeaderCtrl::SetBitmapMargin`.

`SetFilterChangeTimeout (dwTimeOut)`
: Corresponds to `CHeaderCtrl::SetFilterChangeTimeout`.

`SetHotDivider (bPos, dwInputValue)`
: Corresponds to `CHeaderCtrl::SetHotDivider`.

`SetItem (nIndex, pHeaderItem)`
: Corresponds to `CHeaderCtrl::SetItem`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CHeaderCtrl::SetUnicodeFormat`.

`StartResizeGroup ()`
: Corresponds to `CHeaderCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GHotKeyCtrl

GHotKeyCtrl — allows the creation of a hot key.

Synopsis

```
class GHotKeyCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GHotKeyCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CHotKeyCtrl::Create`.

`GetHotKey (args?...)`
: Corresponds to `CHotKeyCtrl::GetHotKey`.

`SetHotKey (wVirtualKeyCode, wModifiers)`
: Corresponds to `CHotKeyCtrl::SetHotKey`.

`SetRules (wInvalidComb, wModifiers)`
: Corresponds to `CHotKeyCtrl::SetRules`.

This class also inherits the functions of `GWindowBase`.

GHyperLink

GHyperLink — displays a link to a web page, based on HyperLink.

Synopsis

```
class GHyperLink GWindowBase
{
    m_clrLink;
    m_clrVisited;
    m_dwExtendedStyle;
    m_hCursor;
    m_hFont;
    m_hFontNormal;
    m_hWnd;
    m_lpstrHyperLink;
    m_lpstrLabel;
    m_rcLink;
}
```

Base Classes

GWindowBase <-- GHyperLink

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CHyperLink::Create`.

`GetHyperLink (lpstrBuffer, nLength)`
: Corresponds to `CHyperLink::GetHyperLink`.

`GetHyperLinkExtendedStyle ()`
: Corresponds to `CHyperLink::GetHyperLinkExtendedStyle`.

`GetIdealHeight ()`
: Corresponds to `CHyperLink::GetIdealHeight`.

`GetIdealSize (args?...)`
: Corresponds to `CHyperLink::GetIdealSize`.

`GetLabel (lpstrBuffer, nLength)`
: Corresponds to `CHyperLink::GetLabel`.

`GetLinkFont ()`
: Corresponds to `CHyperLink::GetLinkFont`.

`GetToolTipText (lpstrBuffer, nLength)`
: Corresponds to `CHyperLink::GetToolTipText`.

`IsCommandButton ()`
: Corresponds to `CHyperLink::IsCommandButton`.

`IsNotUnderlined ()`
: Corresponds to `CHyperLink::IsNotUnderlined`.

`IsNotifyButton ()`
: Corresponds to `CHyperLink::IsNotifyButton`.

`IsUnderlineHover ()`
: Corresponds to `CHyperLink::IsUnderlineHover`.

`IsUnderlined ()`
: Corresponds to `CHyperLink::IsUnderlined`.

`IsUsingTags ()`
: Corresponds to `CHyperLink::IsUsingTags`.

`IsUsingTagsBold ()`
: Corresponds to `CHyperLink::IsUsingTagsBold`.

`IsUsingToolTip ()`
: Corresponds to `CHyperLink::IsUsingToolTip`.

`Navigate ()`
: Corresponds to `CHyperLink::Navigate`.

`SetHyperLink (lpstrLink)`
: Corresponds to `CHyperLink::SetHyperLink`.

`SetHyperLinkExtendedStyle (args?...)`
: Corresponds to `CHyperLink::SetHyperLinkExtendedStyle`.

`SetLabel (lpstrLabel)`
: Corresponds to `CHyperLink::SetLabel`.

`SetLinkFont (hFont)`
: Corresponds to `CHyperLink::SetLinkFont`.

`SetToolTipText (lpstrToolTipText)`
: Corresponds to `CHyperLink::SetToolTipText`.

This class also inherits the functions of `GWindowBase`.

GIPAddressCtrl

GIPAddressCtrl — an entry field for an IP address.

Synopsis

```
class GIPAddressCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GIPAddressCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`ClearAddress ()`
: Corresponds to `CIPAddressCtrl::ClearAddress`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CIPAddressCtrl::Create`.

`IsBlank ()`
: Corresponds to `CIPAddressCtrl::IsBlank`.

`SetAddress (dwAddress)`
: Corresponds to `CIPAddressCtrl::SetAddress`.

`SetFocus (nField)`
: Corresponds to `CIPAddressCtrl::SetFocus`.

`SetRange (args?...)`
: Corresponds to `CIPAddressCtrl::SetRange`.

This class also inherits the functions of GWindowBase.

GLinkCtrl

`GLinkCtrl` — embeds a hypertext link in a window.

Synopsis

```
class GLinkCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GLinkCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CLinkCtrl::Create`.

`GetIdealHeight ()`
: Corresponds to `CLinkCtrl::GetIdealHeight`.

`GetItem (pLItem)`
: Corresponds to `CLinkCtrl::GetItem`.

`HitTest (pLHitTestInfo)`
: Corresponds to `CLinkCtrl::HitTest`.

`SetItem (pLItem)`
: Corresponds to `CLinkCtrl::SetItem`.

This class also inherits the functions of `GWindowBase`.

GListBox

GListBox — a box with a list of items.

Synopsis

```
class GListBox GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GListBox

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CListBox::AddControlResizeFlags`.

`AddFile (lpstrFileName)`
: Corresponds to `CListBox::AddFile`.

`AddString (lpszItem)`
: Corresponds to `CListBox::AddString`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CListBox::Create`.

`DeleteString (nIndex)`
: Corresponds to `CListBox::DeleteString`.

`Dir (attr, lpszWildCard)`
: Corresponds to `CListBox::Dir`.

`EndResizeGroup ()`
: Corresponds to `CListBox::EndResizeGroup`.

`FindString (nStartAfter, lpszItem)`
: Corresponds to `CListBox::FindString`.

`FindStringExact (nIndexStart, lpszFind)`
: Corresponds to `CListBox::FindStringExact`.

`GetAnchorIndex ()`
: Corresponds to `CListBox::GetAnchorIndex`.

`GetCaretIndex ()`
: Corresponds to `CListBox::GetCaretIndex`.

`GetCount ()`
: Corresponds to `CListBox::GetCount`.

`GetCurSel ()`
: Corresponds to `CListBox::GetCurSel`.

`GetHorizontalExtent ()`
: Corresponds to `CListBox::GetHorizontalExtent`.

`GetItemData (nIndex)`
: Corresponds to `CListBox::GetItemData`.

`GetItemHeight (nIndex)`
: Corresponds to `CListBox::GetItemHeight`.

`GetItemRect (nIndex, lpRect)`
: Corresponds to `CListBox::GetItemRect`.

`GetListBoxInfo ()`
: Corresponds to `CListBox::GetListBoxInfo`.

`GetLocale ()`
: Corresponds to `CListBox::GetLocale`.

`GetSel (nIndex)`
: Corresponds to `CListBox::GetSel`.

`GetSelCount ()`
: Corresponds to `CListBox::GetSelCount`.

`GetText (nIndex, lpszBuffer)`
: Corresponds to `CListBox::GetText`.

`GetTextLen (nIndex)`
: Corresponds to `CListBox::GetTextLen`.

`GetTopIndex ()`
: Corresponds to `CListBox::GetTopIndex`.

`InitStorage (nItems, nBytes)`
: Corresponds to `CListBox::InitStorage`.

`InsertString (nIndex, lpszItem)`
: Corresponds to `CListBox::InsertString`.

`ResetContent ()`
: Corresponds to `CListBox::ResetContent`.

`SelItemRange (bSelect, nFirstItem, nLastItem)`
: Corresponds to `CListBox::SelItemRange`.

`SelectString (nStartAfter, lpszItem)`
: Corresponds to `CListBox::SelectString`.

`SetAnchorIndex (nIndex)`
: Corresponds to `CListBox::SetAnchorIndex`.

`SetCaretIndex (args?...)`
: Corresponds to `CListBox::SetCaretIndex`.

`SetColumnWidth (cxWidth)`
: Corresponds to `CListBox::SetColumnWidth`.

`SetCount (cItems)`
: Corresponds to `CListBox::SetCount`.

`SetCurSel (nSelect)`
: Corresponds to `CListBox::SetCurSel`.

`SetHorizontalExtent (cxExtent)`
: Corresponds to `CListBox::SetHorizontalExtent`.

`SetItemData (nIndex, dwItemData)`
: Corresponds to `CListBox::SetItemData`.

`SetItemHeight (nIndex, cyItemHeight)`
: Corresponds to `CListBox::SetItemHeight`.

`SetLocale (nNewLocale)`
: Corresponds to `CListBox::SetLocale`.

`SetSel (args?...)`
: Corresponds to `CListBox::SetSel`.

`SetTabStops (args?...)`
: Corresponds to `CListBox::SetTabStops`.

`SetTopIndex (nIndex)`
: Corresponds to `CListBox::SetTopIndex`.

`StartResizeGroup ()`
: Corresponds to `CListBox::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GListViewCtrl

`GListViewCtrl` — determines how lists are displayed, based on `ListView Control`.

Synopsis

```
class GListViewCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GListViewCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddColumn (args?...)`
: Corresponds to `CListViewCtrl::AddColumn`.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CListViewCtrl::AddControlResizeFlags`.

`AddItem (args?...)`
: Corresponds to `CListViewCtrl::AddItem`.

`ApproximateViewRect (args?...)`
: Corresponds to `CListViewCtrl::ApproximateViewRect`.

`Arrange (nCode)`
: Corresponds to `CListViewCtrl::Arrange`.

`CancelEditLabel ()`
: Corresponds to `CListViewCtrl::CancelEditLabel`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CListViewCtrl::Create`.

`DeleteAllItems ()`
: Corresponds to `CListViewCtrl::DeleteAllItems`.

`DeleteColumn (nCol)`
: Corresponds to `CListViewCtrl::DeleteColumn`.

`DeleteItem (nItem)`
: Corresponds to `CListViewCtrl::DeleteItem`.

`EnableGroupView (bEnable)`
: Corresponds to `CListViewCtrl::EnableGroupView`.

`EndResizeGroup ()`
: Corresponds to `CListViewCtrl::EndResizeGroup`.

`EnsureVisible (nItem, bPartialOK)`
: Corresponds to `CListViewCtrl::EnsureVisible`.

`FindItem (pFindInfo, nStart)`
: Corresponds to `CListViewCtrl::FindItem`.

`GetBkColor ()`
: Corresponds to `CListViewCtrl::GetBkColor`.

`GetBkImage (plvbki)`
: Corresponds to `CListViewCtrl::GetBkImage`.

`GetCallbackMask ()`
: Corresponds to `CListViewCtrl::GetCallbackMask`.

`GetCheckState (nIndex)`
: Corresponds to `CListViewCtrl::GetCheckState`.

`GetColumn (nCol, pColumn)`
: Corresponds to `CListViewCtrl::GetColumn`.

`GetColumnWidth (nCol)`
: Corresponds to `CListViewCtrl::GetColumnWidth`.

`GetCountPerPage ()`
: Corresponds to `CListViewCtrl::GetCountPerPage`.

`GetExtendedListViewStyle ()`
: Corresponds to `CListViewCtrl::GetExtendedListViewStyle`.

`GetGroupInfo (nGroupID, pGroup)`
: Corresponds to `CListViewCtrl::GetGroupInfo`.

`GetGroupMetrics (pGroupMetrics)`
: Corresponds to `CListViewCtrl::GetGroupMetrics`.

`GetHotCursor ()`
: Corresponds to `CListViewCtrl::GetHotCursor`.

`GetHotItem ()`
: Corresponds to `CListViewCtrl::GetHotItem`.

`GetHoverTime ()`
: Corresponds to `CListViewCtrl::GetHoverTime`.

`GetISearchString (lpstr)`
: Corresponds to `CListViewCtrl::GetISearchString`.

`GetInsertMarkColor ()`
: Corresponds to `CListViewCtrl::GetInsertMarkColor`.

`GetInsertMarkRect (lpRect)`
: Corresponds to `CListViewCtrl::GetInsertMarkRect`.

`GetItem (pItem)`
: Corresponds to `CListViewCtrl::GetItem`.

`GetItemCount ()`
: Corresponds to `CListViewCtrl::GetItemCount`.

`GetItemData (nItem)`
: Corresponds to `CListViewCtrl::GetItemData`.

`GetItemPosition (nItem, lpPoint)`
: Corresponds to `CListViewCtrl::GetItemPosition`.

`GetItemRect (nItem, lpRect, nCode)`
: Corresponds to `CListViewCtrl::GetItemRect`.

`GetItemSpacing (args?...)`
: Corresponds to `CListViewCtrl::GetItemSpacing`.

`GetItemState (nItem, nMask)`
: Corresponds to `CListViewCtrl::GetItemState`.

`GetItemText (args?...)`
: Corresponds to `CListViewCtrl::GetItemText`.

`GetNextItem (nItem, nFlags)`
: Corresponds to `CListViewCtrl::GetNextItem`.

`GetOrigin (lpPoint)`
: Corresponds to `CListViewCtrl::GetOrigin`.

`GetOutlineColor ()`
: Corresponds to `CListViewCtrl::GetOutlineColor`.

`GetSelectedColumn ()`
: Corresponds to `CListViewCtrl::GetSelectedColumn`.

`GetSelectedCount ()`
: Corresponds to `CListViewCtrl::GetSelectedCount`.

`GetSelectedIndex ()`
: Corresponds to `CListViewCtrl::GetSelectedIndex`.

`GetSelectedItem (pItem)`
: Corresponds to `CListViewCtrl::GetSelectedItem`.

`GetSelectionMark ()`
: Corresponds to `CListViewCtrl::GetSelectionMark`.

`GetStringWidth (lpsz)`
: Corresponds to `CListViewCtrl::GetStringWidth`.

`GetSubItemRect (nItem, nSubItem, nFlag, lpRect)`
: Corresponds to `CListViewCtrl::GetSubItemRect`.

`GetTextBkColor ()`
Corresponds to `CListViewCtrl::GetTextBkColor`.

`GetTextColor ()`
Corresponds to `CListViewCtrl::GetTextColor`.

`GetTileInfo (pTileInfo)`
Corresponds to `CListViewCtrl::GetTileInfo`.

`GetTileViewInfo (pTileViewInfo)`
Corresponds to `CListViewCtrl::GetTileViewInfo`.

`GetTopIndex ()`
Corresponds to `CListViewCtrl::GetTopIndex`.

`GetUnicodeFormat ()`
Corresponds to `CListViewCtrl::GetUnicodeFormat`.

`GetView ()`
Corresponds to `CListViewCtrl::GetView`.

`GetViewRect (lpRect)`
Corresponds to `CListViewCtrl::GetViewRect`.

`GetViewType ()`
Corresponds to `CListViewCtrl::GetViewType`.

`GetWorkAreas (nWorkAreas, lpRect)`
Corresponds to `CListViewCtrl::GetWorkAreas`.

`HasGroup (nGroupID)`
Corresponds to `CListViewCtrl::HasGroup`.

`HitTest (args?...)`
Corresponds to `CListViewCtrl::HitTest`.

`InsertColumn (args?...)`
Corresponds to `CListViewCtrl::InsertColumn`.

`InsertGroup (nItem, pGroup)`
Corresponds to `CListViewCtrl::InsertGroup`.

`InsertGroupSorted (pInsertGroupSorted)`
Corresponds to `CListViewCtrl::InsertGroupSorted`.

`InsertItem (args?...)`
Corresponds to `CListViewCtrl::InsertItem`.

`IsGroupViewEnabled ()`
Corresponds to `CListViewCtrl::IsGroupViewEnabled`.

`MapIDToIndex (uID)`
Corresponds to `CListViewCtrl::MapIDToIndex`.

`MapIndexToID (nIndex)`
Corresponds to `CListViewCtrl::MapIndexToID`.

`MoveGroup (nGroupID, nItem)`
: Corresponds to `CListViewCtrl::MoveGroup`.

`MoveItemToGroup (nItem, nGroupID)`
: Corresponds to `CListViewCtrl::MoveItemToGroup`.

`RedrawItems (nFirst, nLast)`
: Corresponds to `CListViewCtrl::RedrawItems`.

`RemoveAllGroups ()`
: Corresponds to `CListViewCtrl::RemoveAllGroups`.

`RemoveGroup (nGroupID)`
: Corresponds to `CListViewCtrl::RemoveGroup`.

`Scroll (size)`
: Corresponds to `CListViewCtrl::Scroll`.

`SelectItem (nIndex)`
: Corresponds to `CListViewCtrl::SelectItem`.

`SetBkColor (cr)`
: Corresponds to `CListViewCtrl::SetBkColor`.

`SetBkImage (plvbki)`
: Corresponds to `CListViewCtrl::SetBkImage`.

`SetCallbackMask (nMask)`
: Corresponds to `CListViewCtrl::SetCallbackMask`.

`SetCheckState (nItem, bCheck)`
: Corresponds to `CListViewCtrl::SetCheckState`.

`SetColumn (nCol, pColumn)`
: Corresponds to `CListViewCtrl::SetColumn`.

`SetColumnWidth (nCol, cx)`
: Corresponds to `CListViewCtrl::SetColumnWidth`.

`SetExtendedListViewStyle (args?...)`
: Corresponds to `CListViewCtrl::SetExtendedListViewStyle`.

`SetGroupInfo (nGroupID, pGroup)`
: Corresponds to `CListViewCtrl::SetGroupInfo`.

`SetGroupMetrics (pGroupMetrics)`
: Corresponds to `CListViewCtrl::SetGroupMetrics`.

`SetHotCursor (hHotCursor)`
: Corresponds to `CListViewCtrl::SetHotCursor`.

`SetHotItem (nIndex)`
: Corresponds to `CListViewCtrl::SetHotItem`.

`SetHoverTime (dwHoverTime)`
: Corresponds to `CListViewCtrl::SetHoverTime`.

`SetIconSpacing (cx, cy)`
: Corresponds to `CListViewCtrl::SetIconSpacing`.

`SetInfoTip (pSetInfoTip)`
: Corresponds to `CListViewCtrl::SetInfoTip`.

`SetInsertMarkColor (clr)`
: Corresponds to `CListViewCtrl::SetInsertMarkColor`.

`SetItem (args?...)`
: Corresponds to `CListViewCtrl::SetItem`.

`SetItemCount (nItems)`
: Corresponds to `CListViewCtrl::SetItemCount`.

`SetItemCountEx (nItems, dwFlags)`
: Corresponds to `CListViewCtrl::SetItemCountEx`.

`SetItemData (nItem, dwData)`
: Corresponds to `CListViewCtrl::SetItemData`.

`SetItemPosition (args?...)`
: Corresponds to `CListViewCtrl::SetItemPosition`.

`SetItemState (args?...)`
: Corresponds to `CListViewCtrl::SetItemState`.

`SetItemText (nItem, nSubItem, lpszText)`
: Corresponds to `CListViewCtrl::SetItemText`.

`SetOutlineColor (clr)`
: Corresponds to `CListViewCtrl::SetOutlineColor`.

`SetSelectedColumn (nColumn)`
: Corresponds to `CListViewCtrl::SetSelectedColumn`.

`SetSelectionMark (nIndex)`
: Corresponds to `CListViewCtrl::SetSelectionMark`.

`SetTextBkColor (cr)`
: Corresponds to `CListViewCtrl::SetTextBkColor`.

`SetTextColor (cr)`
: Corresponds to `CListViewCtrl::SetTextColor`.

`SetTileInfo (pTileInfo)`
: Corresponds to `CListViewCtrl::SetTileInfo`.

`SetTileViewInfo (pTileViewInfo)`
: Corresponds to `CListViewCtrl::SetTileViewInfo`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CListViewCtrl::SetUnicodeFormat`.

`SetView (dwView)`
: Corresponds to `CListViewCtrl::SetView`.

`SetViewType (dwType)`
: Corresponds to `CListViewCtrl::SetViewType`.

`SetWorkAreas (nWorkAreas, lpRect)`
: Corresponds to `CListViewCtrl::SetWorkAreas`.

`SortGroups (args?...)`
: Corresponds to `CListViewCtrl::SortGroups`.

`StartResizeGroup ()`
: Corresponds to `CListViewCtrl::StartResizeGroup`.

`SubItemHitTest (lpInfo)`
: Corresponds to `CListViewCtrl::SubItemHitTest`.

`Update (nItem)`
: Corresponds to `CListViewCtrl::Update`.

This class also inherits the functions of `GWindowBase`.

GMonthCalendarCtrl

GMonthCalendarCtrl — a control for setting dates and times, based on MonthCalendar Control.

Synopsis

```
class GMonthCalendarCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GMonthCalendarCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CMonthCalendarCtrl::Create`.

`GetColor (nColorType)`
: Corresponds to `CMonthCalendarCtrl::GetColor`.

`GetCurSel (lpSysTime)`
: Corresponds to `CMonthCalendarCtrl::GetCurSel`.

`GetFirstDayOfWeek (args?...)`
: Corresponds to `CMonthCalendarCtrl::GetFirstDayOfWeek`.

`GetMaxSelCount ()`
: Corresponds to `CMonthCalendarCtrl::GetMaxSelCount`.

`GetMinReqRect (lpRectInfo)`
: Corresponds to `CMonthCalendarCtrl::GetMinReqRect`.

`GetMonthDelta ()`
: Corresponds to `CMonthCalendarCtrl::GetMonthDelta`.

`GetMonthRange (args?...)`
: Corresponds to `CMonthCalendarCtrl::GetMonthRange`.

`GetRange (lprgSysTimeArray)`
: Corresponds to `CMonthCalendarCtrl::GetRange`.

`GetSelRange (lprgSysTimeArray)`
: Corresponds to `CMonthCalendarCtrl::GetSelRange`.

`GetToday (lpSysTime)`
: Corresponds to `CMonthCalendarCtrl::GetToday`.

`GetUnicodeFormat ()`
: Corresponds to `CMonthCalendarCtrl::GetUnicodeFormat`.

`SetColor (nColorType, clr)`
: Corresponds to `CMonthCalendarCtrl::SetColor`.

`SetCurSel (lpSysTime)`
: Corresponds to `CMonthCalendarCtrl::SetCurSel`.

`SetFirstDayOfWeek (args?...)`
: Corresponds to `CMonthCalendarCtrl::SetFirstDayOfWeek`.

`SetMaxSelCount (nMax)`
: Corresponds to `CMonthCalendarCtrl::SetMaxSelCount`.

`SetMonthDelta (nDelta)`
: Corresponds to `CMonthCalendarCtrl::SetMonthDelta`.

`SetRange (dwFlags, lprgSysTimeArray)`
: Corresponds to `CMonthCalendarCtrl::SetRange`.

`SetSelRange (lprgSysTimeArray)`
: Corresponds to `CMonthCalendarCtrl::SetSelRange`.

`SetToday (lpSysTime)`
: Corresponds to `CMonthCalendarCtrl::SetToday`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CMonthCalendarCtrl::SetUnicodeFormat`.

This class also inherits the functions of `GWindowBase`.

GPageSetupDialog

GPageSetupDialog — a control for print page setup options.

Synopsis

```
class GPageSetupDialog GDialog
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GDialog <-- GPageSetupDialog

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

DoModal (args?...)
: Corresponds to CPageSetupDialog::DoModal.

This class also inherits the functions of GDialog and GWindowBase.

GPagerCtrl

`GPagerCtrl` — a container for a window without enough area to display its content.

Synopsis

```
class GPagerCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GPagerCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CPagerCtrl::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CPagerCtrl::Create`.

`EndResizeGroup ()`
: Corresponds to `CPagerCtrl::EndResizeGroup`.

`ForwardMouse (args?...)`
: Corresponds to `CPagerCtrl::ForwardMouse`.

`GetBkColor ()`
: Corresponds to `CPagerCtrl::GetBkColor`.

`GetBorder ()`
: Corresponds to `CPagerCtrl::GetBorder`.

`GetButtonSize ()`
: Corresponds to `CPagerCtrl::GetButtonSize`.

`GetButtonState (nButton)`
: Corresponds to `CPagerCtrl::GetButtonState`.

`GetPos ()`
: Corresponds to `CPagerCtrl::GetPos`.

`RecalcSize ()`
: Corresponds to `CPagerCtrl::RecalcSize`.

`SetBkColor (clrBk)`
: Corresponds to `CPagerCtrl::SetBkColor`.

`SetBorder (nBorderSize)`
: Corresponds to `CPagerCtrl::SetBorder`.

`SetButtonSize (nButtonSize)`
: Corresponds to `CPagerCtrl::SetButtonSize`.

`SetChild (hWndChild)`
: Corresponds to `CPagerCtrl::SetChild`.

`SetPos (nPos)`
: Corresponds to `CPagerCtrl::SetPos`.

`StartResizeGroup ()`
: Corresponds to `CPagerCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GPrintDialog

`GPrintDialog` — a print dialog window.

Synopsis

```
class GPrintDialog GDialog
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GDialog` <-- `GPrintDialog`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`DoModal (args?...)`
Corresponds to `CPrintDialog::DoModal`.

This class also inherits the functions of `GDialog` and `GWindowBase`.

GProgressBarCtrl

`GProgressBarCtrl` — a rectangle that fills over time, based on `ProgressBar Control`.

Synopsis

```
class GProgressBarCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GProgressBarCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CProgressBarCtrl::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CProgressBarCtrl::Create`.

`EndResizeGroup ()`
: Corresponds to `CProgressBarCtrl::EndResizeGroup`.

`GetPos ()`
: Corresponds to `CProgressBarCtrl::GetPos`.

`GetRangeLimit (bLimit)`
: Corresponds to `CProgressBarCtrl::GetRangeLimit`.

`OffsetPos (nPos)`
: Corresponds to `CProgressBarCtrl::OffsetPos`.

`SetBarColor (clr)`
: Corresponds to `CProgressBarCtrl::SetBarColor`.

`SetBkColor (clr)`
: Corresponds to `CProgressBarCtrl::SetBkColor`.

`SetMarquee (args?...)`
: Corresponds to `CProgressBarCtrl::SetMarquee`.

`SetPos (nPos)`
: Corresponds to `CProgressBarCtrl::SetPos`.

`SetRange (nLower, nUpper)`
: Corresponds to `CProgressBarCtrl::SetRange`.

`SetRange32 (nMin, nMax)`
: Corresponds to `CProgressBarCtrl::SetRange32`.

`SetStep (nStep)`
: Corresponds to `CProgressBarCtrl::SetStep`.

`StartResizeGroup ()`
: Corresponds to `CProgressBarCtrl::StartResizeGroup`.

`StepIt ()`
: Corresponds to `CProgressBarCtrl::StepIt`.

This class also inherits the functions of `GWindowBase`.

GRadioButton

GRadioButton — a radio button, based on CButton.

Synopsis

```
class GRadioButton GButton
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GButton <-- GRadioButton

Description

This widget is a superclass that provides the BS_RADIOBUTTON button style of a CButton.

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
Corresponds to CRadioButton::Create.

This class also inherits the functions of GButton and GWindowBase.

GReBarCtrl

GReBarCtrl — a container for a child window.

Synopsis

```
class GReBarCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GReBarCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CReBarCtrl::AddControlResizeFlags`.

`BeginDrag (args?...)`
: Corresponds to `CReBarCtrl::BeginDrag`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CReBarCtrl::Create`.

`DeleteBand (nBand)`
: Corresponds to `CReBarCtrl::DeleteBand`.

`DragMove (args?...)`
: Corresponds to `CReBarCtrl::DragMove`.

`EndDrag ()`
: Corresponds to `CReBarCtrl::EndDrag`.

`EndResizeGroup ()`
: Corresponds to `CReBarCtrl::EndResizeGroup`.

`GetBandBorders (nBand, lpRect)`
: Corresponds to `CReBarCtrl::GetBandBorders`.

`GetBandCount ()`
: Corresponds to `CReBarCtrl::GetBandCount`.

`GetBandInfo (nBand, lprbbi)`
: Corresponds to `CReBarCtrl::GetBandInfo`.

`GetBarHeight ()`
: Corresponds to `CReBarCtrl::GetBarHeight`.

`GetBarInfo (lprbi)`
: Corresponds to `CReBarCtrl::GetBarInfo`.

`GetBkColor ()`
: Corresponds to `CReBarCtrl::GetBkColor`.

`GetColorScheme (lpColorScheme)`
: Corresponds to `CReBarCtrl::GetColorScheme`.

`GetPalette ()`
: Corresponds to `CReBarCtrl::GetPalette`.

`GetRect (nBand, lpRect)`
: Corresponds to `CReBarCtrl::GetRect`.

`GetRowCount ()`
: Corresponds to `CReBarCtrl::GetRowCount`.

`GetRowHeight (nBand)`
: Corresponds to `CReBarCtrl::GetRowHeight`.

`GetTextColor ()`
: Corresponds to `CReBarCtrl::GetTextColor`.

`GetUnicodeFormat ()`
: Corresponds to `CReBarCtrl::GetUnicodeFormat`.

`HitTest (lprbht)`
: Corresponds to `CReBarCtrl::HitTest`.

`IdToIndex (uBandID)`
: Corresponds to `CReBarCtrl::IdToIndex`.

`InsertBand (nBand, lprbbi)`
: Corresponds to `CReBarCtrl::InsertBand`.

`LockBands (bLock)`
: Corresponds to `CReBarCtrl::LockBands`.

`MaximizeBand (nBand)`
: Corresponds to `CReBarCtrl::MaximizeBand`.

`MinimizeBand (nBand)`
: Corresponds to `CReBarCtrl::MinimizeBand`.

`MoveBand (nBand, nNewPos)`
: Corresponds to `CReBarCtrl::MoveBand`.

`PushChevron (nBand, lAppValue)`
: Corresponds to `CReBarCtrl::PushChevron`.

`SetBandInfo (nBand, lprbbi)`
: Corresponds to `CReBarCtrl::SetBandInfo`.

`SetBarInfo (lprbi)`
: Corresponds to `CReBarCtrl::SetBarInfo`.

`SetBkColor (clr)`
: Corresponds to `CReBarCtrl::SetBkColor`.

`SetColorScheme (lpColorScheme)`
: Corresponds to `CReBarCtrl::SetColorScheme`.

`SetPalette (hPalette)`
: Corresponds to `CReBarCtrl::SetPalette`.

`SetTextColor (clr)`
: Corresponds to `CReBarCtrl::SetTextColor`.

`SetToolTips (hwndToolTip)`
: Corresponds to `CReBarCtrl::SetToolTips`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CReBarCtrl::SetUnicodeFormat`.

`ShowBand (nBand, bShow)`
: Corresponds to `CReBarCtrl::ShowBand`.

`SizeToRect (lpRect)`
: Corresponds to `CReBarCtrl::SizeToRect`.

`StartResizeGroup ()`
: Corresponds to `CReBarCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GRichEditCtrl

`GRichEditCtrl` — a text entry and editing window.

Synopsis

```
class GRichEditCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GRichEditCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CRichEditCtrl::AddControlResizeFlags`.

`AppendText (args?...)`
: Corresponds to `CRichEditCtrl::AppendText`.

`CanPaste (args?...)`
: Corresponds to `CRichEditCtrl::CanPaste`.

`CanRedo ()`
: Corresponds to `CRichEditCtrl::CanRedo`.

`CanUndo ()`
: Corresponds to `CRichEditCtrl::CanUndo`.

`CharFromPos (pt)`
: Corresponds to `CRichEditCtrl::CharFromPos`.

`Clear ()`
: Corresponds to `CRichEditCtrl::Clear`.

`Copy ()`
: Corresponds to `CRichEditCtrl::Copy`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CRichEditCtrl::Create`.

`Cut ()`
: Corresponds to `CRichEditCtrl::Cut`.

`DisplayBand (pDisplayRect)`
: Corresponds to `CRichEditCtrl::DisplayBand`.

`EmptyUndoBuffer ()`
: Corresponds to `CRichEditCtrl::EmptyUndoBuffer`.

`EndResizeGroup ()`
: Corresponds to `CRichEditCtrl::EndResizeGroup`.

`FindTextA (args?...)`
: Corresponds to `CRichEditCtrl::FindTextA`.

`FindWordBreak (nCode, nStartChar)`
: Corresponds to `CRichEditCtrl::FindWordBreak`.

`FormatRange (args?...)`
: Corresponds to `CRichEditCtrl::FormatRange`.

`GetAutoURLDetect ()`
: Corresponds to `CRichEditCtrl::GetAutoURLDetect`.

`GetDefaultCharFormat (args?...)`
: Corresponds to `CRichEditCtrl::GetDefaultCharFormat`.

`GetEventMask ()`
: Corresponds to `CRichEditCtrl::GetEventMask`.

`GetFirstVisibleLine ()`
: Corresponds to `CRichEditCtrl::GetFirstVisibleLine`.

`GetLimitText ()`
: Corresponds to `CRichEditCtrl::GetLimitText`.

`GetLine (args?...)`
: Corresponds to `CRichEditCtrl::GetLine`.

`GetLineCount ()`
: Corresponds to `CRichEditCtrl::GetLineCount`.

`GetModify ()`
: Corresponds to `CRichEditCtrl::GetModify`.

`GetOptions ()`
: Corresponds to `CRichEditCtrl::GetOptions`.

`GetParaFormat (args?...)`
: Corresponds to `CRichEditCtrl::GetParaFormat`.

`GetRect (lpRect)`
: Corresponds to `CRichEditCtrl::GetRect`.

`GetRedoName ()`
: Corresponds to `CRichEditCtrl::GetRedoName`.

`GetSel (args?...)`
: Corresponds to `CRichEditCtrl::GetSel`.

`GetSelText (lpBuf)`
: Corresponds to `CRichEditCtrl::GetSelText`.

`GetSelectionCharFormat (args?...)`
: Corresponds to `CRichEditCtrl::GetSelectionCharFormat`.

`GetSelectionType ()`
: Corresponds to `CRichEditCtrl::GetSelectionType`.

`GetTextEx (args?...)`
: Corresponds to `CRichEditCtrl::GetTextEx`.

`GetTextLength ()`
: Corresponds to `CRichEditCtrl::GetTextLength`.

`GetTextLengthEx (args?...)`
: Corresponds to `CRichEditCtrl::GetTextLengthEx`.

`GetTextMode ()`
: Corresponds to `CRichEditCtrl::GetTextMode`.

`GetTextRange (args?...)`
: Corresponds to `CRichEditCtrl::GetTextRange`.

`GetUndoName ()`
: Corresponds to `CRichEditCtrl::GetUndoName`.

`HideSelection (args?...)`
: Corresponds to `CRichEditCtrl::HideSelection`.

`InsertText (args?...)`
: Corresponds to `CRichEditCtrl::InsertText`.

`LimitText (args?...)`
: Corresponds to `CRichEditCtrl::LimitText`.

`LineFromChar (nIndex)`
: Corresponds to `CRichEditCtrl::LineFromChar`.

`LineIndex (args?...)`
: Corresponds to `CRichEditCtrl::LineIndex`.

`LineLength (args?...)`
: Corresponds to `CRichEditCtrl::LineLength`.

`LineScroll (args?...)`
: Corresponds to `CRichEditCtrl::LineScroll`.

`Paste ()`
: Corresponds to `CRichEditCtrl::Paste`.

`PasteSpecial (args?...)`
: Corresponds to `CRichEditCtrl::PasteSpecial`.

`PosFromChar (nChar)`
: Corresponds to `CRichEditCtrl::PosFromChar`.

`Redo ()`
: Corresponds to `CRichEditCtrl::Redo`.

`ReplaceSel (args?...)`
: Corresponds to `CRichEditCtrl::ReplaceSel`.

`RequestResize ()`
: Corresponds to `CRichEditCtrl::RequestResize`.

`ScrollCaret ()`
: Corresponds to `CRichEditCtrl::ScrollCaret`.

`SetAutoURLDetect (args?...)`
: Corresponds to `CRichEditCtrl::SetAutoURLDetect`.

`SetBackgroundColor (args?...)`
: Corresponds to `CRichEditCtrl::SetBackgroundColor`.

`SetCharFormat (args?...)`
: Corresponds to `CRichEditCtrl::SetCharFormat`.

`SetDefaultCharFormat (args?...)`
: Corresponds to `CRichEditCtrl::SetDefaultCharFormat`.

`SetEventMask (dwEventMask)`
: Corresponds to `CRichEditCtrl::SetEventMask`.

`SetModify (args?...)`
: Corresponds to `CRichEditCtrl::SetModify`.

`SetOptions (wOperation, dwOptions)`
: Corresponds to `CRichEditCtrl::SetOptions`.

`SetPalette (hPalette)`
: Corresponds to `CRichEditCtrl::SetPalette`.

`SetParaFormat (args?...)`
: Corresponds to `CRichEditCtrl::SetParaFormat`.

`SetReadOnly (args?...)`
: Corresponds to `CRichEditCtrl::SetReadOnly`.

`SetRect (lpRect)`
: Corresponds to `CRichEditCtrl::SetRect`.

`SetSel (args?...)`
: Corresponds to `CRichEditCtrl::SetSel`.

`SetSelAll ()`
: Corresponds to `CRichEditCtrl::SetSelAll`.

`SetSelNone ()`
: Corresponds to `CRichEditCtrl::SetSelNone`.

`SetSelectionCharFormat (args?...)`
: Corresponds to `CRichEditCtrl::SetSelectionCharFormat`.

`SetTargetDevice (hDC, cxLineWidth)`
Corresponds to `CRichEditCtrl::SetTargetDevice`.

`SetTextMode (enumTextMode)`
Corresponds to `CRichEditCtrl::SetTextMode`.

`SetUndoLimit (uUndoLimit)`
Corresponds to `CRichEditCtrl::SetUndoLimit`.

`SetWordCharFormat (args?...)`
Corresponds to `CRichEditCtrl::SetWordCharFormat`.

`ShowScrollBar (args?...)`
Corresponds to `CRichEditCtrl::ShowScrollBar`.

`StartResizeGroup ()`
Corresponds to `CRichEditCtrl::StartResizeGroup`.

`StopGroupTyping ()`
Corresponds to `CRichEditCtrl::StopGroupTyping`.

`StreamIn (uFormat, es)`
Corresponds to `CRichEditCtrl::StreamIn`.

`StreamOut (uFormat, es)`
Corresponds to `CRichEditCtrl::StreamOut`.

`Undo ()`
Corresponds to `CRichEditCtrl::Undo`.

This class also inherits the functions of `GWindowBase`.

GScrollBar

GScrollBar — a scroll-bar control.

Synopsis

```
class GScrollBar GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GScrollBar

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CScrollBar::Create`.

`EnableScrollBar (args?...)`
: Corresponds to `CScrollBar::EnableScrollBar`.

`GetScrollBarInfo (pScrollBarInfo)`
: Corresponds to `CScrollBar::GetScrollBarInfo`.

`GetScrollInfo (lpScrollInfo)`
: Corresponds to `CScrollBar::GetScrollInfo`.

`GetScrollLimit ()`
: Corresponds to `CScrollBar::GetScrollLimit`.

`GetScrollPos ()`
: Corresponds to `CScrollBar::GetScrollPos`.

`SetScrollInfo (args?...)`
: Corresponds to `CScrollBar::SetScrollInfo`.

`SetScrollPos (args?...)`
: Corresponds to `CScrollBar::SetScrollPos`.

`SetScrollRange (args?...)`
: Corresponds to `CScrollBar::SetScrollRange`.

`ShowScrollBar (args?...)`
: Corresponds to `CScrollBar::ShowScrollBar`.

This class also inherits the functions of `GWindowBase`.

GStatic

`GStatic` — a static control for text strings, rectangles, bitmaps, etc.

Synopsis

```
class GStatic GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GStatic`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CStatic::Create`.

`GetCursor ()`
: Corresponds to `CStatic::GetCursor`.

`GetEnhMetaFile ()`
: Corresponds to `CStatic::GetEnhMetaFile`.

`GetIcon ()`
: Corresponds to `CStatic::GetIcon`.

`SetCursor (hCursor)`
: Corresponds to `CStatic::SetCursor`.

`SetEnhMetaFile (hMetaFile)`
: Corresponds to `CStatic::SetEnhMetaFile`.

`SetIcon (hIcon)`
: Corresponds to `CStatic::SetIcon`.

This class also inherits the functions of `GWindowBase`.

GStatusBarCtrl

GStatusBarCtrl — an area at the bottom of a window that displays information.

Synopsis

```
class GStatusBarCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GStatusBarCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CStatusBarCtrl::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CStatusBarCtrl::Create`.

`EndResizeGroup ()`
: Corresponds to `CStatusBarCtrl::EndResizeGroup`.

`GetBorders (args?...)`
: Corresponds to `CStatusBarCtrl::GetBorders`.

`GetIcon (nPane)`
: Corresponds to `CStatusBarCtrl::GetIcon`.

`GetRect (nPane, lpRect)`
: Corresponds to `CStatusBarCtrl::GetRect`.

`GetText (args?...)`
: Corresponds to `CStatusBarCtrl::GetText`.

`GetTextBSTR (args?...)`
: Corresponds to `CStatusBarCtrl::GetTextBSTR`.

`GetTextLength (args?...)`
: Corresponds to `CStatusBarCtrl::GetTextLength`.

`GetTipText (nPane, lpstrText, nSize)`
: Corresponds to `CStatusBarCtrl::GetTipText`.

`GetUnicodeFormat ()`
: Corresponds to `CStatusBarCtrl::GetUnicodeFormat`.

`IsSimple ()`
: Corresponds to `CStatusBarCtrl::IsSimple`.

`SetBkColor (clrBk)`
: Corresponds to `CStatusBarCtrl::SetBkColor`.

`SetIcon (nPane, hIcon)`
: Corresponds to `CStatusBarCtrl::SetIcon`.

`SetMinHeight (nMin)`
: Corresponds to `CStatusBarCtrl::SetMinHeight`.

`SetSimple (args?...)`
: Corresponds to `CStatusBarCtrl::SetSimple`.

`SetText (args?...)`
: Corresponds to `CStatusBarCtrl::SetText`.

`SetTipText (nPane, lpstrText)`
: Corresponds to `CStatusBarCtrl::SetTipText`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CStatusBarCtrl::SetUnicodeFormat`.

`StartResizeGroup ()`
: Corresponds to `CStatusBarCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GTabCtrl

`GTabCtrl` — a tabbed label for marking multiple pages.

Synopsis

```
class GTabCtrl GWindowBase
{
    ChangeFunctions;
    _SequentialCtrlID;
    _children;
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GTabCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CTabCtrl::AddControlResizeFlags`.

`AddWindow (tabno, label, win)`
: Corresponds to `CTabCtrl::AddWindow`.

`AdjustRect (bLarger, lpRect)`
: Corresponds to `CTabCtrl::AdjustRect`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CTabCtrl::Create`.

`DeleteAllItems ()`
: Corresponds to `CTabCtrl::DeleteAllItems`.

`DeleteItem (nItem)`
: Corresponds to `CTabCtrl::DeleteItem`.

`DeselectAll (args?...)`
: Corresponds to `CTabCtrl::DeselectAll`.

`EndResizeGroup ()`
: Corresponds to `CTabCtrl::EndResizeGroup`.

`GetCurFocus ()`
    Corresponds to `CTabCtrl::GetCurFocus`.

`GetCurSel ()`
    Corresponds to `CTabCtrl::GetCurSel`.

`GetExtendedStyle ()`
    Corresponds to `CTabCtrl::GetExtendedStyle`.

`GetItem (nItem, pTabCtrlItem)`
    Corresponds to `CTabCtrl::GetItem`.

`GetItemCount ()`
    Corresponds to `CTabCtrl::GetItemCount`.

`GetItemRect (nItem, lpRect)`
    Corresponds to `CTabCtrl::GetItemRect`.

`GetRowCount ()`
    Corresponds to `CTabCtrl::GetRowCount`.

`GetUnicodeFormat ()`
    Corresponds to `CTabCtrl::GetUnicodeFormat`.

`HighlightItem (args?...)`
    Corresponds to `CTabCtrl::HighlightItem`.

`HitTest (pHitTestInfo)`
    Corresponds to `CTabCtrl::HitTest`.

`InsertItem (nItem, pTabCtrlItem)`
    Corresponds to `CTabCtrl::InsertItem`.

`RemoveImage (nImage)`
    Corresponds to `CTabCtrl::RemoveImage`.

`SelChange ()`
    Corresponds to `CTabCtrl::SelChange`.

`SetCurFocus (nItem)`
    Corresponds to `CTabCtrl::SetCurFocus`.

`SetCurSel (nItem)`
    Corresponds to `CTabCtrl::SetCurSel`.

`SetExtendedStyle (dwExMask, dwExStyle)`
    Corresponds to `CTabCtrl::SetExtendedStyle`.

`SetItem (nItem, pTabCtrlItem)`
    Corresponds to `CTabCtrl::SetItem`.

`SetItemExtra (cbExtra)`
    Corresponds to `CTabCtrl::SetItemExtra`.

`SetItemSize (size)`
    Corresponds to `CTabCtrl::SetItemSize`.

`SetMinTabWidth (args?...)`
: Corresponds to `CTabCtrl::SetMinTabWidth`.

`SetPadding (size)`
: Corresponds to `CTabCtrl::SetPadding`.

`SetTooltips (hWndToolTip)`
: Corresponds to `CTabCtrl::SetTooltips`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CTabCtrl::SetUnicodeFormat`.

`StartResizeGroup ()`
: Corresponds to `CTabCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GToolBarCtrl

GToolBarCtrl — a toolbar with one or more buttons.

Synopsis

```
class GToolBarCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GToolBarCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

AddBitmap (args?...)
: Corresponds to CToolBarCtrl::AddBitmap.

AddButtons (nNumButtons, lpButtons)
: Corresponds to CToolBarCtrl::AddButtons.

AddControlResizeFlags (ctrlid, flags)
: Corresponds to CToolBarCtrl::AddControlResizeFlags.

AddString (nStringID)
: Corresponds to CToolBarCtrl::AddString.

AddStrings (lpszStrings)
: Corresponds to CToolBarCtrl::AddStrings.

AutoSize ()
: Corresponds to CToolBarCtrl::AutoSize.

ChangeBitmap (nID, nBitmap)
: Corresponds to CToolBarCtrl::ChangeBitmap.

CheckButton (args?...)
: Corresponds to CToolBarCtrl::CheckButton.

CommandToIndex (nID)
: Corresponds to CToolBarCtrl::CommandToIndex.

Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)
: Corresponds to CToolBarCtrl::Create.

`Customize ()`
: Corresponds to `CToolBarCtrl::Customize`.

`DeleteButton (nIndex)`
: Corresponds to `CToolBarCtrl::DeleteButton`.

`EnableButton (args?...)`
: Corresponds to `CToolBarCtrl::EnableButton`.

`EndResizeGroup ()`
: Corresponds to `CToolBarCtrl::EndResizeGroup`.

`GetAnchorHighlight ()`
: Corresponds to `CToolBarCtrl::GetAnchorHighlight`.

`GetBitmap (nID)`
: Corresponds to `CToolBarCtrl::GetBitmap`.

`GetBitmapFlags ()`
: Corresponds to `CToolBarCtrl::GetBitmapFlags`.

`GetButton (nIndex, lpButton)`
: Corresponds to `CToolBarCtrl::GetButton`.

`GetButtonCount ()`
: Corresponds to `CToolBarCtrl::GetButtonCount`.

`GetButtonInfo (nID, lptbbi)`
: Corresponds to `CToolBarCtrl::GetButtonInfo`.

`GetButtonSize (args?...)`
: Corresponds to `CToolBarCtrl::GetButtonSize`.

`GetButtonText (nID, lpstrText)`
: Corresponds to `CToolBarCtrl::GetButtonText`.

`GetColorScheme (lpcs)`
: Corresponds to `CToolBarCtrl::GetColorScheme`.

`GetExtendedStyle ()`
: Corresponds to `CToolBarCtrl::GetExtendedStyle`.

`GetHotItem ()`
: Corresponds to `CToolBarCtrl::GetHotItem`.

`GetInsertMarkColor ()`
: Corresponds to `CToolBarCtrl::GetInsertMarkColor`.

`GetItemRect (nIndex, lpRect)`
: Corresponds to `CToolBarCtrl::GetItemRect`.

`GetMaxSize (lpSize)`
: Corresponds to `CToolBarCtrl::GetMaxSize`.

`GetPadding (lpSizePadding)`
: Corresponds to `CToolBarCtrl::GetPadding`.

`GetRect (nID, lpRect)`
: Corresponds to `CToolBarCtrl::GetRect`.

`GetRows ()`
: Corresponds to `CToolBarCtrl::GetRows`.

`GetState (nID)`
: Corresponds to `CToolBarCtrl::GetState`.

`GetString (nString, lpstrString, cchMaxLen)`
: Corresponds to `CToolBarCtrl::GetString`.

`GetStyle ()`
: Corresponds to `CToolBarCtrl::GetStyle`.

`GetTextRows ()`
: Corresponds to `CToolBarCtrl::GetTextRows`.

`GetUnicodeFormat ()`
: Corresponds to `CToolBarCtrl::GetUnicodeFormat`.

`HideButton (args?...)`
: Corresponds to `CToolBarCtrl::HideButton`.

`HitTest (lpPoint)`
: Corresponds to `CToolBarCtrl::HitTest`.

`Indeterminate (args?...)`
: Corresponds to `CToolBarCtrl::Indeterminate`.

`InsertButton (nIndex, lpButton)`
: Corresponds to `CToolBarCtrl::InsertButton`.

`InsertMarkHitTest (args?...)`
: Corresponds to `CToolBarCtrl::InsertMarkHitTest`.

`IsButtonChecked (nID)`
: Corresponds to `CToolBarCtrl::IsButtonChecked`.

`IsButtonEnabled (nID)`
: Corresponds to `CToolBarCtrl::IsButtonEnabled`.

`IsButtonHidden (nID)`
: Corresponds to `CToolBarCtrl::IsButtonHidden`.

`IsButtonHighlighted (nButtonID)`
: Corresponds to `CToolBarCtrl::IsButtonHighlighted`.

`IsButtonIndeterminate (nID)`
: Corresponds to `CToolBarCtrl::IsButtonIndeterminate`.

`IsButtonPressed (nID)`
: Corresponds to `CToolBarCtrl::IsButtonPressed`.

`LoadImages (nBitmapID)`
: Corresponds to `CToolBarCtrl::LoadImages`.

`LoadStdImages (nBitmapID)`
: Corresponds to `CToolBarCtrl::LoadStdImages`.

`MarkButton (args?...)`
: Corresponds to `CToolBarCtrl::MarkButton`.

`MoveButton (nOldPos, nNewPos)`
: Corresponds to `CToolBarCtrl::MoveButton`.

`PressButton (args?...)`
: Corresponds to `CToolBarCtrl::PressButton`.

`RestoreState (hKeyRoot, lpszSubKey, lpszValueName)`
: Corresponds to `CToolBarCtrl::RestoreState`.

`SaveState (hKeyRoot, lpszSubKey, lpszValueName)`
: Corresponds to `CToolBarCtrl::SaveState`.

`SetAnchorHighlight (args?...)`
: Corresponds to `CToolBarCtrl::SetAnchorHighlight`.

`SetBitmapSize (args?...)`
: Corresponds to `CToolBarCtrl::SetBitmapSize`.

`SetButtonInfo (nID, lptbbi)`
: Corresponds to `CToolBarCtrl::SetButtonInfo`.

`SetButtonSize (args?...)`
: Corresponds to `CToolBarCtrl::SetButtonSize`.

`SetButtonStructSize (args?...)`
: Corresponds to `CToolBarCtrl::SetButtonStructSize`.

`SetButtonWidth (cxMin, cxMax)`
: Corresponds to `CToolBarCtrl::SetButtonWidth`.

`SetCmdID (nIndex, nID)`
: Corresponds to `CToolBarCtrl::SetCmdID`.

`SetColorScheme (lpcs)`
: Corresponds to `CToolBarCtrl::SetColorScheme`.

`SetDrawTextFlags (dwMask, dwFlags)`
: Corresponds to `CToolBarCtrl::SetDrawTextFlags`.

`SetExtendedStyle (dwStyle)`
: Corresponds to `CToolBarCtrl::SetExtendedStyle`.

`SetHotItem (nItem)`
: Corresponds to `CToolBarCtrl::SetHotItem`.

`SetIndent (nIndent)`
: Corresponds to `CToolBarCtrl::SetIndent`.

`SetInsertMarkColor (clr)`
: Corresponds to `CToolBarCtrl::SetInsertMarkColor`.

`SetMaxTextRows (nMaxTextRows)`
: Corresponds to `CToolBarCtrl::SetMaxTextRows`.

`SetNotifyWnd (hWnd)`
: Corresponds to `CToolBarCtrl::SetNotifyWnd`.

`SetPadding (args?...)`
: Corresponds to `CToolBarCtrl::SetPadding`.

`SetRows (nRows, bLarger, lpRect)`
: Corresponds to `CToolBarCtrl::SetRows`.

`SetState (nID, nState)`
: Corresponds to `CToolBarCtrl::SetState`.

`SetStyle (dwStyle)`
: Corresponds to `CToolBarCtrl::SetStyle`.

`SetToolTips (hWndToolTip)`
: Corresponds to `CToolBarCtrl::SetToolTips`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CToolBarCtrl::SetUnicodeFormat`.

`StartResizeGroup ()`
: Corresponds to `CToolBarCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GToolTipCtrl

GToolTipCtrl — a pop-up window with a line of text.

Synopsis

```
class GToolTipCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GToolTipCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Activate (bActivate)`
: Corresponds to `CToolTipCtrl::Activate`.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CToolTipCtrl::AddControlResizeFlags`.

`AdjustRect (lpRect, bLarger)`
: Corresponds to `CToolTipCtrl::AdjustRect`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CToolTipCtrl::Create`.

`DelTool (args?...)`
: Corresponds to `CToolTipCtrl::DelTool`.

`EndResizeGroup ()`
: Corresponds to `CToolTipCtrl::EndResizeGroup`.

`EnumTools (nTool, lpToolInfo)`
: Corresponds to `CToolTipCtrl::EnumTools`.

`GetBubbleSize (lpToolInfo)`
: Corresponds to `CToolTipCtrl::GetBubbleSize`.

`GetCurrentTool (lpToolInfo)`
: Corresponds to `CToolTipCtrl::GetCurrentTool`.

`GetDelayTime (dwType)`
: Corresponds to `CToolTipCtrl::GetDelayTime`.

`GetMargin (lpRect)`
: Corresponds to `CToolTipCtrl::GetMargin`.

`GetMaxTipWidth ()`
: Corresponds to `CToolTipCtrl::GetMaxTipWidth`.

`GetText (args?...)`
: Corresponds to `CToolTipCtrl::GetText`.

`GetTipBkColor ()`
: Corresponds to `CToolTipCtrl::GetTipBkColor`.

`GetTipTextColor ()`
: Corresponds to `CToolTipCtrl::GetTipTextColor`.

`GetTitle (pTTGetTitle)`
: Corresponds to `CToolTipCtrl::GetTitle`.

`GetToolCount ()`
: Corresponds to `CToolTipCtrl::GetToolCount`.

`GetToolInfo (args?...)`
: Corresponds to `CToolTipCtrl::GetToolInfo`.

`HitTest (args?...)`
: Corresponds to `CToolTipCtrl::HitTest`.

`Pop ()`
: Corresponds to `CToolTipCtrl::Pop`.

`Popup ()`
: Corresponds to `CToolTipCtrl::Popup`.

`RelayEvent (lpMsg)`
: Corresponds to `CToolTipCtrl::RelayEvent`.

`SetDelayTime (dwType, nTime)`
: Corresponds to `CToolTipCtrl::SetDelayTime`.

`SetMargin (lpRect)`
: Corresponds to `CToolTipCtrl::SetMargin`.

`SetMaxTipWidth (nWidth)`
: Corresponds to `CToolTipCtrl::SetMaxTipWidth`.

`SetTipBkColor (clr)`
: Corresponds to `CToolTipCtrl::SetTipBkColor`.

`SetTipTextColor (clr)`
: Corresponds to `CToolTipCtrl::SetTipTextColor`.

`SetTitle (uIcon, lpstrTitle)`
: Corresponds to `CToolTipCtrl::SetTitle`.

`SetToolInfo (lpToolInfo)`
: Corresponds to `CToolTipCtrl::SetToolInfo`.

`SetToolRect (args?...)`
    Corresponds to `CToolTipCtrl::SetToolRect`.

`StartResizeGroup ()`
    Corresponds to `CToolTipCtrl::StartResizeGroup`.

`TrackActivate (lpToolInfo, bActivate)`
    Corresponds to `CToolTipCtrl::TrackActivate`.

`TrackPosition (xPos, yPos)`
    Corresponds to `CToolTipCtrl::TrackPosition`.

`Update ()`
    Corresponds to `CToolTipCtrl::Update`.

This class also inherits the functions of `GWindowBase`.

GTrackBarCtrl

`GTrackBarCtrl` — a slider with optional tick marks, based on `TrackBar Control`.

Synopsis

```
class GTrackBarCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GTrackBarCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CTrackBarCtrl::AddControlResizeFlags`.

`ClearSel (args?...)`
: Corresponds to `CTrackBarCtrl::ClearSel`.

`ClearTics (args?...)`
: Corresponds to `CTrackBarCtrl::ClearTics`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CTrackBarCtrl::Create`.

`EndResizeGroup ()`
: Corresponds to `CTrackBarCtrl::EndResizeGroup`.

`GetBuddy (args?...)`
: Corresponds to `CTrackBarCtrl::GetBuddy`.

`GetChannelRect (lprc)`
: Corresponds to `CTrackBarCtrl::GetChannelRect`.

`GetLineSize ()`
: Corresponds to `CTrackBarCtrl::GetLineSize`.

`GetNumTics ()`
: Corresponds to `CTrackBarCtrl::GetNumTics`.

`GetPageSize ()`
: Corresponds to `CTrackBarCtrl::GetPageSize`.

`GetPos ()`
: Corresponds to `CTrackBarCtrl::GetPos`.

`GetRangeMax ()`
: Corresponds to `CTrackBarCtrl::GetRangeMax`.

`GetRangeMin ()`
: Corresponds to `CTrackBarCtrl::GetRangeMin`.

`GetSelEnd ()`
: Corresponds to `CTrackBarCtrl::GetSelEnd`.

`GetSelStart ()`
: Corresponds to `CTrackBarCtrl::GetSelStart`.

`GetThumbLength ()`
: Corresponds to `CTrackBarCtrl::GetThumbLength`.

`GetThumbRect (lprc)`
: Corresponds to `CTrackBarCtrl::GetThumbRect`.

`GetTic (nTic)`
: Corresponds to `CTrackBarCtrl::GetTic`.

`GetTicPos (nTic)`
: Corresponds to `CTrackBarCtrl::GetTicPos`.

`GetUnicodeFormat ()`
: Corresponds to `CTrackBarCtrl::GetUnicodeFormat`.

`SetBuddy (args?...)`
: Corresponds to `CTrackBarCtrl::SetBuddy`.

`SetLineSize (nSize)`
: Corresponds to `CTrackBarCtrl::SetLineSize`.

`SetPageSize (nSize)`
: Corresponds to `CTrackBarCtrl::SetPageSize`.

`SetPos (nPos)`
: Corresponds to `CTrackBarCtrl::SetPos`.

`SetRange (args?...)`
: Corresponds to `CTrackBarCtrl::SetRange`.

`SetRangeMax (args?...)`
: Corresponds to `CTrackBarCtrl::SetRangeMax`.

`SetRangeMin (args?...)`
: Corresponds to `CTrackBarCtrl::SetRangeMin`.

`SetSel (args?...)`
: Corresponds to `CTrackBarCtrl::SetSel`.

`SetSelEnd (nMax)`
: Corresponds to `CTrackBarCtrl::SetSelEnd`.

`SetSelStart (nMin)`
: Corresponds to `CTrackBarCtrl::SetSelStart`.

`SetSelection (nMin, nMax)`
: Corresponds to `CTrackBarCtrl::SetSelection`.

`SetThumbLength (nLength)`
: Corresponds to `CTrackBarCtrl::SetThumbLength`.

`SetTic (nTic)`
: Corresponds to `CTrackBarCtrl::SetTic`.

`SetTicFreq (nFreq)`
: Corresponds to `CTrackBarCtrl::SetTicFreq`.

`SetTipSide (nSide)`
: Corresponds to `CTrackBarCtrl::SetTipSide`.

`SetToolTips (hWndTT)`
: Corresponds to `CTrackBarCtrl::SetToolTips`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CTrackBarCtrl::SetUnicodeFormat`.

`StartResizeGroup ()`
: Corresponds to `CTrackBarCtrl::StartResizeGroup`.

`VerifyPos ()`
: Corresponds to `CTrackBarCtrl::VerifyPos`.

This class also inherits the functions of `GWindowBase`.

GTreeViewCtrl

GTreeViewCtrl — displays a hierarchy of nodes as a tree, based on TreeView Control.

Synopsis

```
class GTreeViewCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GTreeViewCtrl

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CTreeViewCtrl::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CTreeViewCtrl::Create`.

`DeleteAllItems ()`
: Corresponds to `CTreeViewCtrl::DeleteAllItems`.

`DeleteItem (hItem)`
: Corresponds to `CTreeViewCtrl::DeleteItem`.

`EndEditLabelNow (bCancel)`
: Corresponds to `CTreeViewCtrl::EndEditLabelNow`.

`EndResizeGroup ()`
: Corresponds to `CTreeViewCtrl::EndResizeGroup`.

`EnsureVisible (hItem)`
: Corresponds to `CTreeViewCtrl::EnsureVisible`.

`Expand (args?...)`
: Corresponds to `CTreeViewCtrl::Expand`.

`GetBkColor ()`
: Corresponds to `CTreeViewCtrl::GetBkColor`.

`GetCheckState (hItem)`
: Corresponds to `CTreeViewCtrl::GetCheckState`.

`GetChildItem (hItem)`
: Corresponds to `CTreeViewCtrl::GetChildItem`.

`GetCount ()`
: Corresponds to `CTreeViewCtrl::GetCount`.

`GetDropHilightItem ()`
: Corresponds to `CTreeViewCtrl::GetDropHilightItem`.

`GetFirstVisibleItem ()`
: Corresponds to `CTreeViewCtrl::GetFirstVisibleItem`.

`GetISearchString (lpstr)`
: Corresponds to `CTreeViewCtrl::GetISearchString`.

`GetIndent ()`
: Corresponds to `CTreeViewCtrl::GetIndent`.

`GetInsertMarkColor ()`
: Corresponds to `CTreeViewCtrl::GetInsertMarkColor`.

`GetItem (args?...)`
: Corresponds to `CTreeViewCtrl::GetItem`.

`GetItemData (hItem)`
: Corresponds to `CTreeViewCtrl::GetItemData`.

`GetItemHeight ()`
: Corresponds to `CTreeViewCtrl::GetItemHeight`.

`GetItemRect (hItem, lpRect, bTextOnly)`
: Corresponds to `CTreeViewCtrl::GetItemRect`.

`GetItemState (hItem, nStateMask)`
: Corresponds to `CTreeViewCtrl::GetItemState`.

`GetItemText (args?...)`
: Corresponds to `CTreeViewCtrl::GetItemText`.

`GetLineColor ()`
: Corresponds to `CTreeViewCtrl::GetLineColor`.

`GetNextItem (hItem, nCode)`
: Corresponds to `CTreeViewCtrl::GetNextItem`.

`GetNextSiblingItem (hItem)`
: Corresponds to `CTreeViewCtrl::GetNextSiblingItem`.

`GetNextVisibleItem (hItem)`
: Corresponds to `CTreeViewCtrl::GetNextVisibleItem`.

`GetParentItem (hItem)`
: Corresponds to `CTreeViewCtrl::GetParentItem`.

`GetPrevSiblingItem (hItem)`
: Corresponds to `CTreeViewCtrl::GetPrevSiblingItem`.

`GetPrevVisibleItem (hItem)`
: Corresponds to `CTreeViewCtrl::GetPrevVisibleItem`.

`GetRootItem ()`
: Corresponds to `CTreeViewCtrl::GetRootItem`.

`GetScrollTime ()`
: Corresponds to `CTreeViewCtrl::GetScrollTime`.

`GetSelectedItem ()`
: Corresponds to `CTreeViewCtrl::GetSelectedItem`.

`GetTextColor ()`
: Corresponds to `CTreeViewCtrl::GetTextColor`.

`GetUnicodeFormat ()`
: Corresponds to `CTreeViewCtrl::GetUnicodeFormat`.

`GetVisibleCount ()`
: Corresponds to `CTreeViewCtrl::GetVisibleCount`.

`HitTest (args?...)`
: Corresponds to `CTreeViewCtrl::HitTest`.

`InsertItem (args?...)`
: Corresponds to `CTreeViewCtrl::InsertItem`.

`ItemHasChildren (hItem)`
: Corresponds to `CTreeViewCtrl::ItemHasChildren`.

`MapAccIDToHTREEITEM (uID)`
: Corresponds to `CTreeViewCtrl::MapAccIDToHTREEITEM`.

`MapHTREEITEMToAccID (hTreeItem)`
: Corresponds to `CTreeViewCtrl::MapHTREEITEMToAccID`.

`RemoveInsertMark ()`
: Corresponds to `CTreeViewCtrl::RemoveInsertMark`.

`Select (hItem, nCode)`
: Corresponds to `CTreeViewCtrl::Select`.

`SelectDropTarget (hItem)`
: Corresponds to `CTreeViewCtrl::SelectDropTarget`.

`SelectItem (hItem)`
: Corresponds to `CTreeViewCtrl::SelectItem`.

`SelectSetFirstVisible (hItem)`
: Corresponds to `CTreeViewCtrl::SelectSetFirstVisible`.

`SetBkColor (clr)`
: Corresponds to `CTreeViewCtrl::SetBkColor`.

`SetCheckState (hItem, bCheck)`
: Corresponds to `CTreeViewCtrl::SetCheckState`.

`SetIndent (nIndent)`
: Corresponds to `CTreeViewCtrl::SetIndent`.

`SetInsertMark (hTreeItem, bAfter)`
: Corresponds to `CTreeViewCtrl::SetInsertMark`.

`SetInsertMarkColor (clr)`
: Corresponds to `CTreeViewCtrl::SetInsertMarkColor`.

`SetItem (args?...)`
: Corresponds to `CTreeViewCtrl::SetItem`.

`SetItemData (hItem, dwData)`
: Corresponds to `CTreeViewCtrl::SetItemData`.

`SetItemHeight (cyHeight)`
: Corresponds to `CTreeViewCtrl::SetItemHeight`.

`SetItemImage (hItem, nImage, nSelectedImage)`
: Corresponds to `CTreeViewCtrl::SetItemImage`.

`SetItemState (hItem, nState, nStateMask)`
: Corresponds to `CTreeViewCtrl::SetItemState`.

`SetItemText (hItem, lpszItem)`
: Corresponds to `CTreeViewCtrl::SetItemText`.

`SetLineColor (clrNew)`
: Corresponds to `CTreeViewCtrl::SetLineColor`.

`SetScrollTime (nScrollTime)`
: Corresponds to `CTreeViewCtrl::SetScrollTime`.

`SetTextColor (clr)`
: Corresponds to `CTreeViewCtrl::SetTextColor`.

`SetUnicodeFormat (args?...)`
: Corresponds to `CTreeViewCtrl::SetUnicodeFormat`.

`SortChildren (args?...)`
: Corresponds to `CTreeViewCtrl::SortChildren`.

`SortChildrenCB (args?...)`
: Corresponds to `CTreeViewCtrl::SortChildrenCB`.

`StartResizeGroup ()`
: Corresponds to `CTreeViewCtrl::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GTreeViewCtrlEx

GTreeViewCtrlEx — an extended TreeViewCtrl.

Synopsis

```
class GTreeViewCtrlEx GWindowBase
{
    m_hWnd;
}
```

Base Classes

GWindowBase <-- GTreeViewCtrlEx

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

AddControlResizeFlags (ctrlid, flags)
: Corresponds to CTreeViewCtrlEx::AddControlResizeFlags.

Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)
: Corresponds to CTreeViewCtrlEx::Create.

EndResizeGroup ()
: Corresponds to CTreeViewCtrlEx::EndResizeGroup.

StartResizeGroup ()
: Corresponds to CTreeViewCtrlEx::StartResizeGroup.

This class also inherits the functions of GWindowBase.

GUpDownCtrl

`GUpDownCtrl` — a pair of arrows for incrementing and decrementing values, based on `UpDown Control`.

Synopsis

```
class GUpDownCtrl GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GUpDownCtrl`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CUpDownCtrl::Create`.

`GetAccel (nAccel, pAccel)`
: Corresponds to `CUpDownCtrl::GetAccel`.

`GetBase ()`
: Corresponds to `CUpDownCtrl::GetBase`.

`GetPos (args?...)`
: Corresponds to `CUpDownCtrl::GetPos`.

`GetPos32 (args?...)`
: Corresponds to `CUpDownCtrl::GetPos32`.

`GetRange (args?...)`
: Corresponds to `CUpDownCtrl::GetRange`.

`GetUnicodeFormat ()`
: Corresponds to `CUpDownCtrl::GetUnicodeFormat`.

`SetAccel (nAccel, pAccel)`
: Corresponds to `CUpDownCtrl::SetAccel`.

`SetBase (nBase)`
: Corresponds to `CUpDownCtrl::SetBase`.

`SetPos (nPos)`
  Corresponds to `CUpDownCtrl::SetPos`.

`SetPos32 (nPos)`
  Corresponds to `CUpDownCtrl::SetPos32`.

`SetRange (nLower, nUpper)`
  Corresponds to `CUpDownCtrl::SetRange`.

`SetRange32 (nLower, nUpper)`
  Corresponds to `CUpDownCtrl::SetRange32`.

`SetUnicodeFormat (args?...)`
  Corresponds to `CUpDownCtrl::SetUnicodeFormat`.

This class also inherits the functions of `GWindowBase`.

GWindow

`GWindow` — methods for manipulating a window.

Synopsis

```
class GWindow GWindowBase
{
    m_hWnd;
}
```

Base Classes

`GWindowBase` <-- `GWindow`

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`AddControlResizeFlags (ctrlid, flags)`
: Corresponds to `CWindow::AddControlResizeFlags`.

`Create (hWndParent, rect, szWindowName, dwStyle, dwExStyle)`
: Corresponds to `CWindow::Create`.

`EndResizeGroup ()`
: Corresponds to `CWindow::EndResizeGroup`.

`StartResizeGroup ()`
: Corresponds to `CWindow::StartResizeGroup`.

This class also inherits the functions of `GWindowBase`.

GWindowBase

GWindowBase — the base for most of these widgets, based on CWindow.

Synopsis

```
class GWindowBase
{
    ChangeFunctions;
    _SequentialCtrlID;
    m_hWnd;
}
```

Class Members

These functions correspond to Windows functions, but may not have exactly the same name. The links attempt a search on the name, but you might have to refine the search manually.

`ArrangeIconicWindows ()`
: Corresponds to `CWindowBase::ArrangeIconicWindows`.

`Attach (hWndNew)`
: Corresponds to `CWindowBase::Attach`.

`BeginPaint (lpPaint)`
: Corresponds to `CWindowBase::BeginPaint`.

`BringWindowToTop ()`
: Corresponds to `CWindowBase::BringWindowToTop`.

`CenterWindow (args?...)`
: Corresponds to `CWindowBase::CenterWindow`.

`ChangeClipboardChain (hWndNewNext)`
: Corresponds to `CWindowBase::ChangeClipboardChain`.

`CheckDlgButton (nIDButton, nCheck)`
: Corresponds to `CWindowBase::CheckDlgButton`.

`CheckRadioButton (nIDFirstButton, nIDLastButton, nIDCheckButton)`
: Corresponds to `CWindowBase::CheckRadioButton`.

`ClientToScreen (args?...)`
: Corresponds to `CWindowBase::ClientToScreen`.

`CommandHandler (wNotifyCode, wID, code)`
: Corresponds to `CWindowBase::CommandHandler`.

`CreateCaret (hBitmap)`

Corresponds to `CWindowBase::CreateCaret`.

`CreateControl (klass, x, y, w, h, label, style_add?=0, exstyle_add=0, style_del=0, exstyle_del=0)`

Corresponds to `CWindowBase::CreateControl`.

`CreateGrayCaret (nWidth, nHeight)`

Corresponds to `CWindowBase::CreateGrayCaret`.

`CreateSolidCaret (nWidth, nHeight)`

Corresponds to `CWindowBase::CreateSolidCaret`.

`DeferWindowPos (hWinPosInfo, hWndInsertAfter, x, y, cx, cy, uFlags)`

Corresponds to `CWindowBase::DeferWindowPos`.

`DestroyWindow ()`

Corresponds to `CWindowBase::DestroyWindow`.

`Detach ()`

Corresponds to `CWindowBase::Detach`.

`DlgDirList (lpPathSpec, nIDListBox, nIDStaticPath, nFileType)`

Corresponds to `CWindowBase::DlgDirList`.

`DlgDirListComboBox (lpPathSpec, nIDComboBox, nIDStaticPath, nFileType)`

Corresponds to `CWindowBase::DlgDirListComboBox`.

`DlgDirSelect (lpString, nCount, nIDListBox)`

Corresponds to `CWindowBase::DlgDirSelect`.

`DlgDirSelectComboBox (lpString, nCount, nIDComboBox)`

Corresponds to `CWindowBase::DlgDirSelectComboBox`.

`DragAcceptFiles (args?...)`

Corresponds to `CWindowBase::DragAcceptFiles`.

`DrawMenuBar ()`

Corresponds to `CWindowBase::DrawMenuBar`.

`EnableScrollBar (args?...)`

Corresponds to `CWindowBase::EnableScrollBar`.

`EnableWindow (args?...)`

Corresponds to `CWindowBase::EnableWindow`.

`EndPaint (lpPaint)`

Corresponds to `CWindowBase::EndPaint`.

`FlashWindow (bInvert)`

Corresponds to `CWindowBase::FlashWindow`.

`GetClientRect (lpRect)`

Corresponds to `CWindowBase::GetClientRect`.

`GetDC ()`
: Corresponds to `CWindowBase::GetDC`.

`GetDCEx (hRgnClip, flags)`
: Corresponds to `CWindowBase::GetDCEx`.

`GetDlgCtrlID ()`
: Corresponds to `CWindowBase::GetDlgCtrlID`.

`GetDlgItemInt (args?...)`
: Corresponds to `CWindowBase::GetDlgItemInt`.

`GetDlgItemText (args?...)`
: Corresponds to `CWindowBase::GetDlgItemText`.

`GetExStyle ()`
: Corresponds to `CWindowBase::GetExStyle`.

`GetFont ()`
: Corresponds to `CWindowBase::GetFont`.

`GetHotKey ()`
: Corresponds to `CWindowBase::GetHotKey`.

`GetHwnd ()`
: Corresponds to `CWindowBase::GetHwnd`.

`GetIcon (args?...)`
: Corresponds to `CWindowBase::GetIcon`.

`GetMenu ()`
: Corresponds to `CWindowBase::GetMenu`.

`GetNextDlgGroupItem (args?...)`
: Corresponds to `CWindowBase::GetNextDlgGroupItem`.

`GetNextDlgTabItem (args?...)`
: Corresponds to `CWindowBase::GetNextDlgTabItem`.

`GetScrollInfo (nBar, lpScrollInfo)`
: Corresponds to `CWindowBase::GetScrollInfo`.

`GetScrollPos (nBar)`
: Corresponds to `CWindowBase::GetScrollPos`.

`GetStyle ()`
: Corresponds to `CWindowBase::GetStyle`.

`GetSystemMenu (bRevert)`
: Corresponds to `CWindowBase::GetSystemMenu`.

`GetUpdateRect (args?...)`
: Corresponds to `CWindowBase::GetUpdateRect`.

`GetUpdateRgn (args?...)`
: Corresponds to `CWindowBase::GetUpdateRgn`.

`GetWindowContextHelpId ()`
: Corresponds to `CWindowBase::GetWindowContextHelpId`.

`GetWindowDC ()`
: Corresponds to `CWindowBase::GetWindowDC`.

`GetWindowLong (nIndex)`
: Corresponds to `CWindowBase::GetWindowLong`.

`GetWindowPlacement (lpwndpl)`
: Corresponds to `CWindowBase::GetWindowPlacement`.

`GetWindowProcessID ()`
: Corresponds to `CWindowBase::GetWindowProcessID`.

`GetWindowRect (lpRect)`
: Corresponds to `CWindowBase::GetWindowRect`.

`GetWindowRgn (hRgn)`
: Corresponds to `CWindowBase::GetWindowRgn`.

`GetWindowText ()`
: Corresponds to `CWindowBase::GetWindowText`.

`GetWindowTextLength ()`
: Corresponds to `CWindowBase::GetWindowTextLength`.

`GetWindowThreadID ()`
: Corresponds to `CWindowBase::GetWindowThreadID`.

`GetWindowWord (nIndex)`
: Corresponds to `CWindowBase::GetWindowWord`.

`GotoDlgCtrl (hWndCtrl)`
: Corresponds to `CWindowBase::GotoDlgCtrl`.

`HideCaret ()`
: Corresponds to `CWindowBase::HideCaret`.

`HiliteMenuItem (hMenu, uItemHilite, uHilite)`
: Corresponds to `CWindowBase::HiliteMenuItem`.

`ImplementedControl (klass, x, y, w, h, label)`
: Corresponds to `CWindowBase::ImplementedControl`.

`Invalidate (args?...)`
: Corresponds to `CWindowBase::Invalidate`.

`InvalidateRect (args?...)`
: Corresponds to `CWindowBase::InvalidateRect`.

`InvalidateRgn (args?...)`
: Corresponds to `CWindowBase::InvalidateRgn`.

`IsChild (hWnd)`
: Corresponds to `CWindowBase::IsChild`.

`IsDialogMessage (lpMsg)`
: Corresponds to `CWindowBase::IsDialogMessage`.

`IsDlgButtonChecked (nIDButton)`
: Corresponds to `CWindowBase::IsDlgButtonChecked`.

`IsIconic ()`
: Corresponds to `CWindowBase::IsIconic`.

`IsParentDialog ()`
: Corresponds to `CWindowBase::IsParentDialog`.

`IsWindow ()`
: Corresponds to `CWindowBase::IsWindow`.

`IsWindowEnabled ()`
: Corresponds to `CWindowBase::IsWindowEnabled`.

`IsWindowUnicode ()`
: Corresponds to `CWindowBase::IsWindowUnicode`.

`IsWindowVisible ()`
: Corresponds to `CWindowBase::IsWindowVisible`.

`IsZoomed ()`
: Corresponds to `CWindowBase::IsZoomed`.

`KillTimer (nIDEvent)`
: Corresponds to `CWindowBase::KillTimer`.

`LockWindowUpdate (args?...)`
: Corresponds to `CWindowBase::LockWindowUpdate`.

`MapWindowPoints (args?...)`
: Corresponds to `CWindowBase::MapWindowPoints`.

`MessageBox (args?...)`
: Corresponds to `CWindowBase::MessageBox`.

`MessageHandler (uMsg, code)`
: Corresponds to `CWindowBase::MessageHandler`.

`ModifyStyle (args?...)`
: Corresponds to `CWindowBase::ModifyStyle`.

`ModifyStyleEx (args?...)`
: Corresponds to `CWindowBase::ModifyStyleEx`.

`MoveWindow (args?...)`
: Corresponds to `CWindowBase::MoveWindow`.

`NextCtrlID ()`
: Corresponds to `CWindowBase::NextCtrlID`.

`NextDlgCtrl ()`
: Corresponds to `CWindowBase::NextDlgCtrl`.

`NotifyHandler (idCtrl, iNotifyCode, code)`
: Corresponds to `CWindowBase::NotifyHandler`.

`OpenClipboard ()`
: Corresponds to `CWindowBase::OpenClipboard`.

`PostMessage (args?...)`
: Corresponds to `CWindowBase::PostMessage`.

`PrevDlgCtrl ()`
: Corresponds to `CWindowBase::PrevDlgCtrl`.

`Print (hDC, dwFlags)`
: Corresponds to `CWindowBase::Print`.

`PrintClient (hDC, dwFlags)`
: Corresponds to `CWindowBase::PrintClient`.

`RedrawWindow (args?...)`
: Corresponds to `CWindowBase::RedrawWindow`.

`ReleaseDC (hDC)`
: Corresponds to `CWindowBase::ReleaseDC`.

`ResizeClient (args?...)`
: Corresponds to `CWindowBase::ResizeClient`.

`ScreenToClient (args?...)`
: Corresponds to `CWindowBase::ScreenToClient`.

`ScrollWindow (args?...)`
: Corresponds to `CWindowBase::ScrollWindow`.

`ScrollWindowEx (args?...)`
: Corresponds to `CWindowBase::ScrollWindowEx`.

`SendDlgItemMessage (args?...)`
: Corresponds to `CWindowBase::SendDlgItemMessage`.

`SendMessage (args?...)`
: Corresponds to `CWindowBase::SendMessage`.

`SendMessageToDescendants (args?...)`
: Corresponds to `CWindowBase::SendMessageToDescendants`.

`SendNotifyMessage (args?...)`
: Corresponds to `CWindowBase::SendNotifyMessage`.

`SetActiveWindow ()`
: Corresponds to `CWindowBase::SetActiveWindow`.

`SetBackground (style, color, hatch)`
: Corresponds to `CWindowBase::SetBackground`.

`SetCapture ()`
: Corresponds to `CWindowBase::SetCapture`.

`SetChildBackground (style, color, hatch)`

Corresponds to `CWindowBase::SetChildBackground`.

`SetChildFontEx (nHeight, nWidth, nEscapement, nOrientation, nWeight, bItalic, bUnderline, cStrikeOut, nCharSet, nOutPrecision, nClipPrecision, nQuality, nPitchAndFamily, lpszFacename)`

Corresponds to `CWindowBase::SetChildFontEx`.

`SetChildForeground (penstyles, width, color)`

Corresponds to `CWindowBase::SetChildForeground`.

`SetClipboardViewer ()`

Corresponds to `CWindowBase::SetClipboardViewer`.

`SetDlgCtrlID (nID)`

Corresponds to `CWindowBase::SetDlgCtrlID`.

`SetDlgItemInt (args?...)`

Corresponds to `CWindowBase::SetDlgItemInt`.

`SetDlgItemText (nID, lpszString)`

Corresponds to `CWindowBase::SetDlgItemText`.

`SetFocus ()`

Corresponds to `CWindowBase::SetFocus`.

`SetFont (args?...)`

Corresponds to `CWindowBase::SetFont`.

`SetFontEx (nHeight, nWidth, nEscapement, nOrientation, nWeight, bItalic, bUnderline, cStrikeOut, nCharSet, nOutPrecision, nClipPrecision, nQuality, nPitchAndFamily, lpszFacename)`

Corresponds to `CWindowBase::SetFontEx`.

`SetForeground (penstyles, width, color)`

Corresponds to `CWindowBase::SetForeground`.

`SetHotKey (wVirtualKeyCode, wModifiers)`

Corresponds to `CWindowBase::SetHotKey`.

`SetIcon (args?...)`

Corresponds to `CWindowBase::SetIcon`.

`SetMenu (hMenu)`

Corresponds to `CWindowBase::SetMenu`.

`SetRedraw (args?...)`

Corresponds to `CWindowBase::SetRedraw`.

`SetScrollInfo (args?...)`

Corresponds to `CWindowBase::SetScrollInfo`.

`SetScrollPos (args?...)`

Corresponds to `CWindowBase::SetScrollPos`.

`SetScrollRange (args?...)`
: Corresponds to `CWindowBase::SetScrollRange`.

`SetTimer (args?...)`
: Corresponds to `CWindowBase::SetTimer`.

`SetWindowContextHelpId (dwContextHelpId)`
: Corresponds to `CWindowBase::SetWindowContextHelpId`.

`SetWindowLong (args?...)`
: Corresponds to `CWindowBase::SetWindowLong`.

`SetWindowPlacement (lpwndpl)`
: Corresponds to `CWindowBase::SetWindowPlacement`.

`SetWindowPos (args?...)`
: Corresponds to `CWindowBase::SetWindowPos`.

`SetWindowRgn (args?...)`
: Corresponds to `CWindowBase::SetWindowRgn`.

`SetWindowText (lpszString)`
: Corresponds to `CWindowBase::SetWindowText`.

`SetWindowWord (nIndex, wNewWord)`
: Corresponds to `CWindowBase::SetWindowWord`.

`ShowCaret ()`
: Corresponds to `CWindowBase::ShowCaret`.

`ShowOwnedPopups (args?...)`
: Corresponds to `CWindowBase::ShowOwnedPopups`.

`ShowScrollBar (args?...)`
: Corresponds to `CWindowBase::ShowScrollBar`.

`ShowWindow (nCmdShow)`
: Corresponds to `CWindowBase::ShowWindow`.

`ShowWindowAsync (nCmdShow)`
: Corresponds to `CWindowBase::ShowWindowAsync`.

`UpdateWindow ()`
: Corresponds to `CWindowBase::UpdateWindow`.

`ValidateRect (lpRect)`
: Corresponds to `CWindowBase::ValidateRect`.

`ValidateRgn (hRgn)`
: Corresponds to `CWindowBase::ValidateRgn`.

`WinHelp (args?...)`
: Corresponds to `CWindowBase::WinHelp`.

`constructor (!args?=nil)`
: Corresponds to `CWindowBase::constructor`.

`destructor ()`

Corresponds to `CWindowBase::destructor`.

`onChange (sym, fn)`

Corresponds to `CWindowBase::onChange`.

This class also inherits the functions of

Global Functions

A

AbortDoc
AbortPath
ActivateKeyboardLayout
AddFontResource
AdjustWindowRect
AdjustWindowRectEx
AllowSetForegroundWindow
AlphaBlend
AngleArc
AnimatePalette
AnimateWindow
AnyPopup
AppendMenu
Arc
ArcTo
ArrangeIconicWindows
AttachThreadInput

B

BeginDeferWindowPos
BeginPaint
BeginPath
BitBlt
BringWindowToTop

C

CallMsgFilter
CallNextHookEx
CancelDC
ChangeClipboardChain
ChangeMenu
CharLower
CharLowerBuff
CharNext
CharNextEx
CharPrev
CharPrevEx
CharToOem
CharToOemBuff
CharUpper
CharUpperBuff
CheckDlgButton
CheckMenuItem
CheckMenuRadioItem
CheckRadioButton
ChildWindowFromPoint
ChildWindowFromPointEx
ChoosePixelFormat
Chord
ClientToScreen
ClipCursor
CloseClipboard
CloseDesktop
CloseEnhMetaFile
CloseFigure
CloseMetaFile
CloseWindow
CloseWindowStation
ColorCorrectPalette
ColorMatchToTarget
CombineRgn
CombineTransform
CopyAcceleratorTable
CopyEnhMetaFile
CopyIcon
CopyImage
CopyMetaFile
CopyRect
CountClipboardFormats
CreateAcceleratorTable
CreateBitmapIndirect
CreateBrushIndirect
CreateCaret
CreateColorSpace
CreateCompatibleBitmap
CreateCompatibleDC
CreateDC
CreateDIBPatternBrush
CreateDiscardableBitmap
CreateEllipticRgn
CreateEllipticRgnIndirect
CreateEnhMetaFile
CreateFont
CreateFontIndirect
CreateFontIndirectEx
CreateHalftonePalette
CreateHatchBrush
CreateIC
CreateIconIndirect
CreateMappedBitmap
CreateMDIWindow
CreateMenu
CreateMetaFile
CreatePalette
CreatePatternBrush
CreatePen
CreatePenIndirect
CreatePolygonRgn
CreatePopupMenu
CreateRect
CreateRectRgn
CreateRectRgnIndirect
CreateRoundRectRgn
CreateScalableFontResource
CreateSolidBrush
CreateStatusWindow
CreateToolbarEx
CreateUpDownControl

D

DefDlgProc
DeferWindowPos
DefFrameProc
DefMDIChildProc
DefSubclassProc
DefWindowProc
DeleteColorSpace
DeleteDC
DeleteEnhMetaFile
DeleteMenu
DeleteMetaFile
DeleteObject
DeregisterShellHookWindow
DescribePixelFormat
DestroyAcceleratorTable
DestroyCaret
DestroyCursor
DestroyIcon
DestroyMenu
DestroyWindow
DeviceCapabilities
DispatchMessage
DlgDirList
DlgDirListComboBox
DlgDirSelectComboBoxEx
DlgDirSelectEx
DragDetect
DragObject
DrawAnimatedRects
DrawCaption
DrawEdge
DrawEscape
DrawFocusRect
DrawFrameControl
DrawIcon
DrawIconEx
DrawInsert
DrawMenuBar
DrawStatusText
DrawText
DrawTextEx

E

Ellipse
EmptyClipboard
EnableMenuItem
EnableScrollBar
EnableWindow
EndDeferWindowPos
EndDialog
EndDoc
EndMenu
EndPage
EndPaint
EndPath
EnumClipboardFormats
EnumWindows
EqualRect
EqualRgn
ExcludeClipRect
ExcludeUpdateRgn
ExitWindowsEx
ExtCreateRegion
ExtEscape
ExtFloodFill
ExtSelectClipRgn

F

FillPath
FillRect
FillRgn
FindPixelInArea
FindWindow
FindWindowEx
FixBrushOrgEx
FlashWindow
FlatSB_EnableScrollBar
FlatSB_GetScrollInfo
FlatSB_GetScrollPos
FlatSB_SetScrollInfo
FlatSB_SetScrollPos
FlatSB_SetScrollProp
FlatSB_SetScrollRange
FlatSB_ShowScrollBar
FlattenPath
FloodFill
FrameRect
FrameRgn

G

GdiFlush
GdiGetBatchLimit
GdiSetBatchLimit
GetActiveWindow
GetAltTabInfo
GetAncestor
GetArcDirection
GetEnhMetaFileHeader
GetEnhMetaFilePaletteEntries
GetEnhMetaFilePixelFormat
GetFileTitleA
GetFocus
GetFontLanguageInfo
GetFontUnicodeRanges
GetPixel
GetPixelFormat
GetPolyFillMode
GetProcessWindowStation
GetProp
GetQueueStatus
GetRandomRgn

GetAspectRatioFilterEx
GetAsyncKeyState
GetBitmapDimensionEx
GetBkColor
GetBkMode
GetBoundsRect
GetBrushOrgEx
GetCapture
GetCaretBlinkTime
GetCaretPos
GetCharABCWidths
GetCharABCWidthsFloat
GetCharacterPlacement
GetClassInfo
GetClassInfoEx
GetClassLong
GetClassName
GetClassWord
GetClientRect
GetClipboardData
GetClipboardFormatName
GetClipboardOwner
GetClipboardSequenceNumber
GetClipboardViewer
GetClipBox
GetClipCursor
GetClipRgn
GetColorAdjustment
GetColorSpace
GetComboBoxInfo
GetCurrentObject
GetCurrentPositionEx
GetCursor
GetCursorInfo
GetCursorPos
GetDC
GetDCBrushColor
GetDCEx
GetDCOrgEx
GetDCPenColor
GetDesktopWindow
GetDeviceCaps
GetDialogBaseUnits
GetDIBColorTable
GetDlgCtrlID
GetDlgItem
GetForegroundWindow
GetGraphicsMode
GetGuiResources
GetGUIThreadInfo
GetIconInfo
GetInputState
GetKBCodePage
GetKerningPairs
GetKeyboardLayout
GetKeyboardLayoutName
GetKeyboardType
GetKeyNameText
GetKeyState
GetLastActivePopup
GetLastInputInfo
GetLayout
GetListBoxInfo
GetLogColorSpace
GetMapMode
GetMenu
GetMenuBarInfo
GetMenuCheckMarkDimensions
GetMenuContextHelpId
GetMenuDefaultItem
GetMenuInfo
GetMenuItemCount
GetMenuItemID
GetMenuItemInfo
GetMenuItemRect
GetMenuState
GetMenuString
GetMessage
GetMessageExtraInfo
GetMessagePos
GetMessageTime
GetMetaFile
GetMetaRgn
GetMonitorInfo
GetMouseMovePointsEx
GetMUILanguage
GetNearestColor
GetNearestPaletteIndex
GetNextDlgGroupItem
GetNextDlgTabItem
GetObjectType
GetOpenClipboardWindow
GetRasterizerCaps
GetRegionData
GetRgnBox
GetROP2
GetScrollBarInfo
GetScrollInfo
GetScrollPos
GetShellWindow
GetStockObject
GetStretchBltMode
GetSubMenu
GetSysColor
GetSysColorBrush
GetSystemMenu
GetSystemMetrics
GetSystemPaletteEntries
GetSystemPaletteUse
GetTextAlign
GetTextCharacterExtra
GetTextCharset
GetTextCharsetInfo
GetTextColor
GetTextExtentPoint
GetTextExtentPoint32
GetTextFace
GetTextMetrics
GetThreadDesktop
GetTitleBarInfo
GetTopWindow
GetUpdateRect
GetUpdateRgn
GetViewportExtEx
GetViewportOrgEx
GetWindow
GetWindowContextHelpId
GetWindowDC
GetWindowExtEx
GetWindowInfo
GetWindowLong
GetWindowModuleFileName
GetWindowOrgEx
GetWindowPlacement
GetWindowRect
GetWindowRgn
GetWindowRgnBox
GetWindowText

GetDlgItemText	GetOpenFileNameW	GetWindowTextLength
GetDoubleClickTime	GetOutlineTextMetrics	GetWindowWord
GetEnhMetaFile	GetPaletteEntries	GetWorldTransform
GetEnhMetaFileDescription	GetParent	

H

HideCaret	HiliteMenuItem

I

ImageList_Add	ImageList_Merge	InvertRect
ImageList_AddMasked	ImageList_Remove	InvertRgn
ImageList_BeginDrag	ImageList_Replace	IsCharAlpha
ImageList_Copy	ImageList_ReplaceIcon	IsCharAlphaNumeric
ImageList_Create	ImageList_SetBkColor	IsCharLower
ImageList_Destroy	ImageList_SetDragCursorImage	IsCharUpper
ImageList_DragEnter	ImageList_SetIconSize	IsChild
ImageList_DragLeave	ImageList_SetImageCount	IsClipboardFormatAvailable
ImageList_DragMove	ImageList_SetOverlayImage	IsDialogMessage
ImageList_DragShowNolock	InflateRect	IsDlgButtonChecked
ImageList_Draw	InitCommonControls	IsGUIThread
ImageList_DrawEx	InitCommonControlsEx	IsIconic
ImageList_DrawIndirect	InitializeFlatSB	IsMenu
ImageList_Duplicate	InitMUILanguage	IsRectEmpty
ImageList_EndDrag	InSendMessage	IsWindow
ImageList_GetBkColor	InsertMenu	IsWindowEnabled
ImageList_GetDragImage	InsertMenuItem	IsWindowUnicode
ImageList_GetIcon	IntersectClipRect	IsWindowVisible
ImageList_GetImageCount	IntersectRect	IsWinEventHookInstalled
ImageList_GetImageInfo	InvalidateRect	IsZoomed
ImageList_LoadImage	InvalidateRgn	

K

keybd_event	KillTimer

L

LineTo	LoadIcon	LoadString
LoadAccelerators	LoadImage	LockSetForegroundWindow
LoadBitmap	LoadImageID	LockWindowUpdate
LoadCursor	LoadKeyboardLayout	LockWorkStation
LoadCursorFromFile	LoadMenu	

M

MakeDragList
MapDialogRect
MapVirtualKey
MapVirtualKeyEx
MapWindowPoints
MaskBlt
MenuItemFromPoint
MessageBeep
MessageBox
MessageBoxEx
MessageBoxIndirect
ModifyMenu
ModifyWorldTransform
MonitorFromPoint
MonitorFromRect
MonitorFromWindow
mouse_event
MoveToEx
MoveWindow

N

new__U_MENUorID
new__U_RECT
new__U_STRINGorID
new_CMenu
new_GColorDialog
new_GFileDialog
NotifyWinEvent

O

OemKeyScan
OemToChar
OemToCharBuff
OffsetClipRgn
OffsetRect
OffsetRgn
OffsetViewportOrgEx
OffsetWindowOrgEx
OpenClipboard
OpenIcon

P

PaintDesktop
PaintRgn
PatBlt
PathToRegion
PeekMessage
Pie
PlayEnhMetaFile
PlayEnhMetaFileRecord
PlayMetaFile
PlayMetaFileRecord
PlgBlt
PolyBezier
PolyBezierTo
Polygon
Polyline
PolylineTo
PolyTextOut
PostMessage
PostQuitMessage
PostThreadMessage
PrintWindow
PtInRect
PtInRegion
PtVisible

R

RealChildWindowFromPoint
RealGetWindowClass
RealizePalette
Rectangle
RectInRegion
RectVisible
RedrawWindow
RegisterClass
RegisterClassEx
RegisterClipboardFormat
RegisterHotKey
RegisterRawInputDevices
RegisterShellHookWindow
RegisterWindowMessage
ReleaseCapture
ReleaseDC
RemoveFontMemResourceEx
RemoveFontResource
RemoveMenu
RemoveProp
ReplyMessage
ResetDC
ResizePalette
RestoreDC
RoundRect

S

SaveDC
ScaleViewportExtEx
ScaleWindowExtEx
ScreenToClient
ScrollDC
ScrollWindow
ScrollWindowEx
SelectClipPath
SelectClipRgn
SelectObject
SelectPalette
SendDlgItemMessage
SendInput
SendMessage
SendNotifyMessage
SetActiveWindow
SetArcDirection
SetBitmapDimensionEx
SetBkColor
SetBkMode
SetBoundsRect
SetBrushOrgEx
SetCapture
SetCaretBlinkTime
SetCaretPos
SetClassLong
SetClassWord
SetClipboardData
SetClipboardViewer
SetColorAdjustment
SetColorSpace
SetCursor
SetCursorPos
SetDCBrushColor
SetDCPenColor
SetDebugErrorLevel
SetDIBColorTable
SetDlgItemInt
SetDlgItemText
SetDoubleClickTime
SetFocus
SetForegroundWindow
SetGraphicsMode
SetICMMode
SetICMProfile
SetLastErrorEx
SetLayeredWindowAttributes
SetLayout
SetMapMode
SetMapperFlags
SetMenu
SetMenuContextHelpId
SetMenuDefaultItem
SetMenuInfo
SetMenuItemBitmaps
SetMenuItemInfo
SetMessageExtraInfo
SetMessageQueue
SetMetaRgn
SetPaletteEntries
SetParent
SetPixel
SetPixelFormat
SetPixelV
SetPolyFillMode
SetProcessDefaultLayout
SetProcessWindowStation
SetProp
SetRect
SetRectEmpty
SetRectRgn
SetROP2
SetScrollInfo
SetScrollPos
SetScrollRange
SetStretchBltMode
SetSystemCursor
SetSystemPaletteUse
SetTextAlign
SetTextCharacterExtra
SetTextColor
SetTextJustification
SetThreadDesktop
SetViewportExtEx
SetViewportOrgEx
SetWindowContextHelpId
SetWindowExtEx
SetWindowLong
SetWindowOrgEx
SetWindowPlacement
SetWindowPos
SetWindowRgn
SetWindowText
SetWindowWord
SetWorldTransform
ShowCaret
ShowCursor
ShowOwnedPopups
ShowScrollBar
ShowWindow
ShowWindowAsync
StartDoc
StartPage
StretchBlt
StrokeAndFillPath
StrokePath
SubtractRect
SwapBuffers
SwapMouseButton
SwitchDesktop
SwitchToThisWindow

T

TextOut
TrackMouseEvent
TrackPopupMenu
TrackPopupMenuEx
TranslateAccelerator
TranslateMDISysAccel
TranslateMessage
TransparentBlt

U

UnhookWindowsHookEx
UnhookWinEvent
UninitializeFlatSB
UnionRect
UnloadKeyboardLayout
UnrealizeObject
UnregisterClass
UnregisterDeviceNotification
UnregisterHotKey
UpdateColors
UpdateICMRegKey
UpdateWindow
UserHandleGrantAccess

V

ValidateRect
ValidateRgn
VkKeyScan
VkKeyScanEx

Non-Widget Classes

_

_DialogSplitHelper
_U_MENUorID
_U_RECT
_U_STRINGorID

A

ABC
ABCFLOAT
ACCEL
ACCESSTIMEOUT
ALTTABINFO
ANIMATIONINFO
AXESLIST
AXISINFO

B

BITMAP
BITMAPCOREHEADER
BITMAPCOREINFO
BITMAPFILEHEADER
BITMAPINFO
BITMAPINFOHEADER
BITMAPV4HEADER
BITMAPV5HEADER
BLENDFUNCTION
BSMINFO
BUTTON_IMAGELIST

C

CBT_CREATEWND
CBTACTIVATESTRUCT
CHARFORMAT
CHARFORMAT2
CHARRANGE
CHARSETINFO
CHOOSECOLORA
CHOOSECOLORW
CHOOSEFONTA
CHOOSEFONTW
CIEXYZ
CIEXYZTRIPLE
CLIENTCREATESTRUCT
CMenu
CMenuItemInfo
COLORADJUSTMENT
COLORMAP
COLORSCHEME
COMBOBOXEXITEM
COMBOBOXINFO
COMPAREITEMSTRUCT
COPYDATASTRUCT
CREATESTRUCT
CURSORINFO
CURSORSHAPE
CWPRETSTRUCT
CWPSTRUCT

D

DEBUGHOOKINFO
DELETEITEMSTRUCT
DESIGNVECTOR
DEVMODE
DEVMODEW
DEVNAMES
DIBSECTION
DISPLAY_DEVICE
DISPLAY_DEVICEW
DLGITEMTEMPLATE
DLGTEMPLATE
DOCINFO
DOCINFOW
DRAGLISTINFO
DRAWITEMSTRUCT
DRAWPATRECT
DRAWTEXTPARAMS
DROPSTRUCT

E

EDITBALLOONTIP
EMRFRAMERGN
EMRSETBKCOLOR

EDITSTREAM
EMR
EMRABORTPATH
EMRALPHABLEND
EMRANGLEARC
EMRARC
EMRBITBLT
EMRCOLORCORRECTPALETTE
EMRCOLORMATCHTOTARGET
EMRCREATEBRUSHINDIRECT
EMRCREATECOLORSPACE
EMRCREATEDIBPATTERNBRUSHPT
EMRCREATEMONOBRUSH
EMRCREATEPALETTE
EMRCREATEPEN
EMRELLIPSE
EMREOF
EMREXCLUDECLIPRECT
EMREXTCREATEPEN
EMREXTESCAPE
EMREXTFLOODFILL
EMREXTSELECTCLIPRGN
EMREXTTEXTOUTA
EMRFILLPATH
EMRFILLRGN
EMRFORMAT
EMRGDICOMMENT
EMRGLSBOUNDEDRECORD
EMRGLSRECORD
EMRGRADIENTFILL
EMRINVERTRGN
EMRLINETO
EMRMASKBLT
EMRMODIFYWORLDTRANSFORM
EMRNAMEDESCAPE
EMROFFSETCLIPRGN
EMRPIXELFORMAT
EMRPLGBLT
EMRPOLYDRAW16
EMRPOLYLINE
EMRPOLYLINE16
EMRPOLYPOLYLINE
EMRPOLYPOLYLINE16
EMRPOLYTEXTOUTA
EMRRESIZEPALETTE
EMRRESTOREDC
EMRROUNDRECT
EMRSCALEVIEWPORTEXTEX
EMRSELECTCLIPPATH
EMRSELECTOBJECT
EMRSELECTPALETTE
EMRSETARCDIRECTION
EMRSETCOLORADJUSTMENT
EMRSETCOLORSPACE
EMRSETDIBITSTODEVICE
EMRSETICMPROFILE
EMRSETMAPPERFLAGS
EMRSETMITERLIMIT
EMRSETPALETTEENTRIES
EMRSETPIXELV
EMRSETVIEWPORTEXTEX
EMRSETVIEWPORTORGEX
EMRSETWORLDTRANSFORM
EMRSTRETCHBLT
EMRSTRETCHDIBITS
EMRTEXT
EMRTRANSPARENTBLT
ENHMETAHEADER
ENHMETARECORD
ENUMLOGFONT
ENUMLOGFONTEX
ENUMLOGFONTEXDV
ENUMTEXTMETRIC
EVENTMSG
EXTLOGFONT
EXTLOGPEN

F

FILETIME
FILTERKEYS
FINDREPLACEA
FINDREPLACEW
FINDTEXT
FINDTEXTEX
FIXED
FLASHWINFO
FONTSIGNATURE
FORMATRANGE

G

GCP_RESULTS
GETTEXTEX
GETTEXTLENGTHEX
GLYPHMETRICS
GLYPHMETRICSFLOAT
GLYPHSET
GRADIENT_RECT
GRADIENT_TRIANGLE
GUITHREADINFO

H

HANDLETABLE
HARDWAREHOOKSTRUCT
HARDWAREINPUT
HD_TEXTFILTERA
HD_TEXTFILTERW
HDHITTESTINFO
HDITEM
HDITEMW
HDLAYOUT
HELPINFO
HELPWININFO
HIGHCONTRAST

I

ICONINFO
IMAGEINFO
IMAGELISTDRAWPARAMS
INITCOMMONCONTROLSEX
INPUT

K

KBDLLHOOKSTRUCT
KERNINGPAIR
KEYBDINPUT

L

LASTINPUTINFO
LAYERPLANEDESCRIPTOR
LHITTESTINFO
LITEM
LOCALESIGNATURE
LOGBRUSH
LOGBRUSH32
LOGCOLORSPACE
LOGFONT
LOGPALETTE
LOGPEN
LVBKIMAGE
LVCOLUMN
LVFINDINFO
LVGROUP
LVGROUPMETRICS
LVHITTESTINFO
LVINSERTGROUPSORTED
LVINSERTMARK
LVITEM
LVSETINFOTIP
LVTILEINFO
LVTILEVIEWINFO

M

MAT2
MCHITTESTINFO
MDICREATESTRUCT
MDINEXTMENU
MEASUREITEMSTRUCT
MENUBARINFO
MENUGETOBJECTINFO
MENUINFO
MENUITEMINFO
MENUITEMTEMPLATE
MENUITEMTEMPLATEHEADER
METAFILEPICT
METAHEADER
METARECORD
MINIMIZEDMETRICS
MINMAXINFO
MONITORINFO
MONITORINFOEX
MOUSEHOOKSTRUCT
MOUSEHOOKSTRUCTEX
MOUSEINPUT
MOUSEKEYS
MOUSEMOVEPOINT
MSG
MSGBOXPARAMS
MSLLHOOKSTRUCT
MULTIKEYHELP

N

NCCALCSIZE_PARAMS
NEWTEXTMETRIC
NEWTEXTMETRICEX
NMBCHOTITEM
NMCBEDRAGBEGIN
NMCBEENDEDIT
NMCHAR
NMCOMBOBOXEX
NMCUSTOMDRAW
NMDATETIMECHANGE
NMDATETIMEFORMAT
NMDATETIMEFORMATQUERY
NMITEMACTIVATE
NMKEY
NMLINK
NMLVCACHEHINT
NMLVDISPINFO
NMLVDISPINFOW
NMLVFINDITEM
NMLVGETINFOTIP
NMLVKEYDOWN
NMLVODSTATECHANGE
NMLVSCROLL
NMMOUSE
NMREBARCHILDSIZE
NMSELCHANGE
NMTBCUSTOMDRAW
NMTBDISPINFO
NMTBGETINFOTIP
NMTBHOTITEM
NMTBRESTORE
NMTBSAVE
NMTCKEYDOWN
NMTOOLBAR
NMTOOLTIPSCREATED
NMTREEVIEW

NMDATETIMESTRING
NMDATETIMEWMKEYDOWN
NMDAYSTATE
NMHDDISPINFO
NMHDFILTERBTNCLICK
NMHDR
NMHEADER
NMIPADDRESS
NMOBJECTNOTIFY
NMPGCALCSIZE
NMPGHOTITEM
NMPGSCROLL
NMRBAUTOSIZE
NMREBAR
NMREBARAUTOBREAK
NMREBARCHEVRON
NMTTDISPINFO
NMTVDISPINFO
NMTVDISPINFOW
NMTVGETINFOTIP
NMTVKEYDOWN
NMUPDOWN

O

OFNOTIFYA
OFNOTIFYEXA
OFNOTIFYEXW
OFNOTIFYW
OPENFILENAME
OPENFILENAME_NT4A
OPENFILENAME_NT4W
OPENFILENAMEA
OPENFILENAMEW
OUTLINETEXTMETRIC
OUTLINETEXTMETRICW

P

PAGESETUPDLGA
PAGESETUPDLGW
PAINTSTRUCT
PALETTEENTRY
PANOSE
PARAFORMAT
PARAFORMAT2
PBRANGE
PELARRAY
PIXELFORMATDESCRIPTOR
POINT
POINTFLOAT
POINTFX
POINTL
POINTS
POLYTEXT
PRINTDLGA
PRINTDLGW
PSFEATURE_CUSTPAPER
PSFEATURE_OUTPUT
PSINJECTDATA

R

RASTERIZER_STATUS
RAWHID
RAWINPUT
RAWINPUT_data
RAWINPUTDEVICE
RAWINPUTDEVICELIST
RAWINPUTHEADER
RAWKEYBOARD
RAWMOUSE
RBHITTESTINFO
REBARBANDINFO
REBARINFO
RECT
RECTL
RGBQUAD
RGBTRIPLE
RGNDATA
RGNDATAHEADER
RID_DEVICE_INFO
RID_DEVICE_INFO_HID
RID_DEVICE_INFO_KEYBOARD
RID_DEVICE_INFO_MOUSE

S

SCROLLBARINFO
SCROLLINFO
SERIALKEYS
SHELLHOOKINFO
SIZE
SOUNDSENTRY
STICKYKEYS
STYLESTRUCT
SYSTEMTIME

T

TBADDBITMAP
TEXTMETRIC
TTPOLYCURVE

TBBUTTON
TBBUTTONINFO
TBINSERTMARK
TBMETRICS
TBREPLACEBITMAP
TBSAVEPARAMS
TCHITTESTINFO
TCITEM
TCITEMHEADER
TEXTRANGE
TITLEBARINFO
TOGGLEKEYS
TPMPARAMS
TRACKMOUSEEVENT
TRIVERTEX
TTGETTITLE
TTHITTESTINFO
TTHITTESTINFOW
TTPOLYGONHEADER
TTTOOLINFO
TTTOOLINFOW
TVHITTESTINFO
TVINSERTSTRUCT
TVITEM
TVITEMEX
TVSORTCB

U

UDACCEL
USEROBJECTFLAGS

W

WCRANGE
WGLSWAP
WINDOWINFO
WINDOWPLACEMENT
WINDOWPOS
WNDCLASS
WNDCLASSEX
WTSSESSION_NOTIFICATION

Constants

_

_DialogSplitHelper::ATL_DISPID_DATAFIELD
_DialogSplitHelper::ATL_DISPID_DATASOURCE
_DialogSplitHelper::ATL_WM_OCC_INITNEW
_DialogSplitHelper::ATL_WM_OCC_LOADFROMSTORAGE
_DialogSplitHelper::ATL_WM_OCC_LOADFROMSTORAGE_EX
_DialogSplitHelper::ATL_WM_OCC_LOADFROMSTRE
_DialogSplitHelper::ATL_WM_OCC_LOADFROMSTRE
_RICHEDIT_VER
_WIN32_IE
_WIN32_WINNT

A

ABORTDOC
ABSOLUTE
AC_SRC_ALPHA
AC_SRC_OVER
ACCESS_FILTERKEYS
ACCESS_MOUSEKEYS
ACCESS_STICKYKEYS
ACM_OPEN
ACM_OPENA
ACM_OPENW
ACM_PLAY
ACM_STOP
ACN_START
ACN_STOP
ACS_AUTOPLAY
ACS_CENTER
ACS_TIMER
ACS_TRANSPARENT
AD_CLOCKWISE
AD_COUNTERCLOCKWISE
ALERT_SYSTEM_CRITICAL
ALERT_SYSTEM_ERROR
ALERT_SYSTEM_INFORMATIONAL
ALERT_SYSTEM_QUERY
ALERT_SYSTEM_WARNING
ALTERNATE
ANSI_CHARSET
ANSI_FIXED_FONT
ANSI_VAR_FONT
ANTIALIASED_QUALITY
APPCOMMAND_BASS_BOOST
APPCOMMAND_BASS_DOWN
APPCOMMAND_BASS_UP
APPCOMMAND_BROWSER_BACKWARD
APPCOMMAND_MEDIA_NEXTTRACK
APPCOMMAND_MEDIA_PAUSE
APPCOMMAND_MEDIA_PLAY
APPCOMMAND_MEDIA_PLAY_PAUSE
APPCOMMAND_MEDIA_PREVIOUSTRACK
APPCOMMAND_MEDIA_RECORD
APPCOMMAND_MEDIA_REWIND
APPCOMMAND_MEDIA_STOP
APPCOMMAND_MIC_ON_OFF_TOGGLE
APPCOMMAND_MICROPHONE_VOLUME_DOWN
APPCOMMAND_MICROPHONE_VOLUME_MUTE
APPCOMMAND_MICROPHONE_VOLUME_UP
APPCOMMAND_NEW
APPCOMMAND_OPEN
APPCOMMAND_PASTE
APPCOMMAND_PRINT
APPCOMMAND_REDO
APPCOMMAND_REPLY_TO_MAIL
APPCOMMAND_SAVE
APPCOMMAND_SEND_MAIL
APPCOMMAND_SPELL_CHECK
APPCOMMAND_TREBLE_DOWN
APPCOMMAND_TREBLE_UP
APPCOMMAND_UNDO
APPCOMMAND_VOLUME_DOWN
APPCOMMAND_VOLUME_MUTE
APPCOMMAND_VOLUME_UP
ARABIC_CHARSET
ARW_BOTTOMLEFT
ARW_BOTTOMRIGHT
ARW_DOWN
ARW_HIDE
ARW_LEFT
ARW_RIGHT

APPCOMMAND_BROWSER_FAVORITES
APPCOMMAND_BROWSER_FORWARD
APPCOMMAND_BROWSER_HOME
APPCOMMAND_BROWSER_REFRESH
APPCOMMAND_BROWSER_SEARCH
APPCOMMAND_BROWSER_STOP
APPCOMMAND_CLOSE
APPCOMMAND_COPY
APPCOMMAND_CORRECTION_LIST
APPCOMMAND_CUT
APPCOMMAND_DICTATE_OR_COMMAND_CONTROL_TOGGLE
APPCOMMAND_FIND
APPCOMMAND_FORWARD_MAIL
APPCOMMAND_HELP
APPCOMMAND_LAUNCH_APP1
APPCOMMAND_LAUNCH_APP2
APPCOMMAND_LAUNCH_MAIL
APPCOMMAND_LAUNCH_MEDIA_SELECT
APPCOMMAND_MEDIA_CHANNEL_DOWN
APPCOMMAND_MEDIA_CHANNEL_UP
APPCOMMAND_MEDIA_FAST_FORWARD
ARW_STARTMASK
ARW_STARTRIGHT
ARW_STARTTOP
ARW_TOPLEFT
ARW_TOPRIGHT
ARW_UP
ASPECT_FILTERING
ASPECTX
ASPECTXY
ASPECTY
ATF_ONOFFFEEDBACK
ATF_TIMEOUTON
AW_ACTIVATE
AW_BLEND
AW_CENTER
AW_HIDE
AW_HOR_NEGATIVE
AW_HOR_POSITIVE
AW_SLIDE
AW_VER_NEGATIVE
AW_VER_POSITIVE

B

BALTIC_CHARSET
BANDINFO
BCM_FIRST
BCM_GETIDEALSIZE
BCM_GETIMAGELIST
BCM_GETTEXTMARGIN
BCM_SETIMAGELIST
BCM_SETTEXTMARGIN
BCN_HOTITEMCHANGE
BDR_INNER
BDR_OUTER
BDR_RAISED
BDR_RAISEDINNER
BDR_RAISEDOUTER
BDR_SUNKEN
BDR_SUNKENINNER
BDR_SUNKENOUTER
BEGIN_PATH
BF_ADJUST
BF_BOTTOM
BF_BOTTOMLEFT
BF_BOTTOMRIGHT
BS_CHECKBOX
BS_DEFPUSHBUTTON
BS_DIBPATTERN
BS_DIBPATTERN8X8
BS_DIBPATTERNPT
BS_FLAT
BS_GROUPBOX
BS_HATCHED
BS_HOLLOW
BS_ICON
BS_INDEXED
BS_LEFT
BS_LEFTTEXT
BS_MONOPATTERN
BS_MULTILINE
BS_NOTIFY
BS_NULL
BS_OWNERDRAW
BS_PATTERN
BS_PATTERN8X8
BS_PUSHBOX
BS_PUSHBUTTON

BF_DIAGONAL
BF_DIAGONAL_ENDBOTTOMLEFT
BF_DIAGONAL_ENDBOTTOMRIGHT
BF_DIAGONAL_ENDTOPLEFT
BF_DIAGONAL_ENDTOPRIGHT
BF_FLAT
BF_LEFT
BF_MIDDLE
BF_MONO
BF_RECT
BF_RIGHT
BF_SOFT
BF_TOP
BF_TOPLEFT
BF_TOPRIGHT
BITSPIXEL
BKMODE_LAST
BLACK_BRUSH
BLACK_PEN
BLACKONWHITE
BLTALIGNMENT
BM_CLICK
BM_GETCHECK
BM_GETIMAGE
BM_GETSTATE
BM_SETCHECK
BM_SETIMAGE
BM_SETSTATE
BM_SETSTYLE
BN_CLICKED
BN_DBLCLK
BN_DISABLE
BN_DOUBLECLICKED
BN_HILITE
BN_KILLFOCUS
BN_PAINT
BN_PUSHED
BN_SETFOCUS
BN_UNHILITE
BN_UNPUSHED
BOLD_FONTTYPE
BROADCAST_QUERY_DENY
BS_3STATE
BS_AUTO3STATE
BS_AUTOCHECKBOX
BS_AUTORADIOBUTTON
BS_PUSHLIKE
BS_RADIOBUTTON
BS_RIGHT
BS_RIGHTBUTTON
BS_SOLID
BS_TEXT
BS_TOP
BS_TYPEMASK
BS_USERBUTTON
BS_VCENTER
BSF_ALLOWSFW
BSF_FLUSHDISK
BSF_FORCEIFHUNG
BSF_IGNORECURRENTTASK
BSF_LUID
BSF_NOHANG
BSF_NOTIMEOUTIFNOTHUNG
BSF_POSTMESSAGE
BSF_QUERY
BSF_RETURNHDESK
BSF_SENDNOTIFYMESSAGE
BSM_ALLCOMPONENTS
BSM_ALLDESKTOPS
BSM_APPLICATIONS
BSM_INSTALLABLEDRIVERS
BSM_NETDRIVER
BSM_VXDS
BST_CHECKED
BST_FOCUS
BST_HOT
BST_INDETERMINATE
BST_PUSHED
BST_UNCHECKED
BTNS_AUTOSIZE
BTNS_BUTTON
BTNS_CHECK
BTNS_CHECKGROUP
BTNS_DROPDOWN
BTNS_GROUP
BTNS_NOPREFIX
BTNS_SEP
BTNS_SHOWTEXT
BTNS_WHOLEDROPDOWN
BUTTON_IMAGELIST_ALIGN_BOTTOM
BUTTON_IMAGELIST_ALIGN_CENTER
BUTTON_IMAGELIST_ALIGN_LEFT

BS_BITMAP
BS_BOTTOM
BS_CENTER
BUTTON_IMAGELIST_ALIGN_RIGHT
BUTTON_IMAGELIST_ALIGN_TOP

C

CA_LOG_FILTER
CA_NEGATIVE
CALERT_SYSTEM
CB_ADDSTRING
CB_DELETESTRING
CB_DIR
CB_ERR
CB_ERRSPACE
CB_FINDSTRING
CB_FINDSTRINGEXACT
CB_GETCOMBOBOXINFO
CB_GETCOUNT
CB_GETCURSEL
CB_GETDROPPEDCONTROLRECT
CB_GETDROPPEDSTATE
CB_GETDROPPEDWIDTH
CB_GETEDITSEL
CB_GETEXTENDEDUI
CB_GETHORIZONTALEXTENT
CB_GETITEMDATA
CB_GETITEMHEIGHT
CB_GETLBTEXT
CB_GETLBTEXTLEN
CB_GETLOCALE
CB_GETMINVISIBLE
CB_GETTOPINDEX
CB_INITSTORAGE
CB_INSERTSTRING
CB_LIMITTEXT
CB_MSGMAX
CB_MULTIPLEADDSTRING
CB_OKAY
CB_RESETCONTENT
CB_SELECTSTRING
CB_SETCURSEL
CB_SETDROPPEDWIDTH
CB_SETEDITSEL
CB_SETEXTENDEDUI
CB_SETHORIZONTALEXTENT
CB_SETITEMDATA
CDIS_FOCUS
CDIS_GRAYED
CDIS_HOT
CDIS_INDETERMINATE
CDIS_MARKED
CDIS_SELECTED
CDIS_SHOWKEYBOARDCUES
CDM_FIRST
CDM_GETFILEPATH
CDM_GETFOLDERIDLIST
CDM_GETFOLDERPATH
CDM_GETSPEC
CDM_HIDECONTROL
CDM_LAST
CDM_SETCONTROLTEXT
CDM_SETDEFEXT
CDN_FILEOK
CDN_FOLDERCHANGE
CDN_HELP
CDN_INCLUDEITEM
CDN_INITDONE
CDN_SELCHANGE
CDN_SHAREVIOLATION
CDN_TYPECHANGE
CDRF_DODEFAULT
CDRF_NEWFONT
CDRF_NOTIFYITEMDRAW
CDRF_NOTIFYPOSTERASE
CDRF_NOTIFYPOSTPAINT
CDRF_NOTIFYSUBITEMDRAW
CDRF_SKIPDEFAULT
CDS_FULLSCREEN
CDS_GLOBAL
CDS_NORESET
CDS_RESET
CDS_SET_PRIMARY
CDS_TEST
CDS_UPDATEREGISTRY
CDS_VIDEOPARAMETERS
CF_BITMAP

CB_SETITEMHEIGHT
CB_SETLOCALE
CB_SETMINVISIBLE
CB_SETTOPINDEX
CB_SHOWDROPDOWN
CBEIF_DI_SETITEM
CBEIF_IMAGE
CBEIF_INDENT
CBEIF_LPARAM
CBEIF_OVERLAY
CBEIF_SELECTEDIMAGE
CBEIF_TEXT
CBEM_DELETEITEM
CBEM_GETCOMBOCONTROL
CBEM_GETEDITCONTROL
CBEM_GETEXSTYLE
CBEM_GETEXTENDEDSTYLE
CBEM_GETIMAGELIST
CBEM_GETITEM
CBEM_GETITEMA
CBEM_GETITEMW
CBEM_GETUNICODEFORMAT
CBEM_HASEDITCHANGED
CBEM_INSERTITEM
CBEM_INSERTITEMA
CBEM_INSERTITEMW
CBEM_SETEXSTYLE
CBEM_SETEXTENDEDSTYLE
CBEM_SETIMAGELIST
CBEM_SETITEM
CBEM_SETITEMA
CBEM_SETITEMW
CBEM_SETUNICODEFORMAT
CBEM_SETWINDOWTHEME
CBEMAXSTRLEN
CBEN_BEGINEDIT
CBEN_DELETEITEM
CBEN_DRAGBEGIN
CBEN_DRAGBEGINA
CBEN_DRAGBEGINW
CBEN_ENDEDIT
CBEN_ENDEDITA
CBEN_ENDEDITW
CBEN_GETDISPINFOA
CBEN_GETDISPINFOW
CBEN_INSERTITEM
CF_BOTH
CF_DIB
CF_DIBV5
CF_DIF
CF_DSPBITMAP
CF_DSPENHMETAFILE
CF_DSPMETAFILEPICT
CF_DSPTEXT
CF_ENHMETAFILE
CF_GDIOBJFIRST
CF_GDIOBJLAST
CF_HDROP
CF_LOCALE
CF_MAX
CF_METAFILEPICT
CF_OEMTEXT
CF_OWNERDISPLAY
CF_PALETTE
CF_PENDATA
CF_PRINTERFONTS
CF_PRIVATEFIRST
CF_PRIVATELAST
CF_RIFF
CF_SCREENFONTS
CF_SYLK
CF_TEXT
CF_TIFF
CF_UNICODETEXT
CF_WAVE
CHECKJPEGFORMAT
CHECKPNGFORMAT
CHILDID_SELF
CHINESEBIG5_CHARSET
CLEARTYPE_NATURAL_QUALITY
CLEARTYPE_QUALITY
CLIP_CHARACTER_PRECIS
CLIP_DEFAULT_PRECIS
CLIP_EMBEDDED
CLIP_LH_ANGLES
CLIP_MASK
CLIP_STROKE_PRECIS
CLIP_TO_PATH
CLIP_TT_ALWAYS
CLIPCAPS
CLOSECHANNEL
CLR_DEFAULT

CBENF_DROPDOWN
CBENF_ESCAPE
CBENF_KILLFOCUS
CBENF_RETURN
CBES_EX_CASESENSITIVE
CBES_EX_NOEDITIMAGE
CBES_EX_NOEDITIMAGEINDENT
CBES_EX_NOSIZELIMIT
CBES_EX_PATHWORDBREAKPROC
CBM_FIRST
CBN_CLOSEUP
CBN_DBLCLK
CBN_DROPDOWN
CBN_EDITCHANGE
CBN_EDITUPDATE
CBN_ERRSPACE
CBN_KILLFOCUS
CBN_SELCHANGE
CBN_SELENDCANCEL
CBN_SELENDOK
CBN_SETFOCUS
CBS_AUTOHSCROLL
CBS_DISABLENOSCROLL
CBS_DROPDOWN
CBS_DROPDOWNLIST
CBS_HASSTRINGS
CBS_LOWERCASE
CBS_NOINTEGRALHEIGHT
CBS_OEMCONVERT
CBS_OWNERDRAWFIXED
CBS_OWNERDRAWVARIABLE
CBS_SIMPLE
CBS_SORT
CBS_UPPERCASE
CC_ANYCOLOR
CC_CHORD
CC_CIRCLES
CC_ELLIPSES
CC_ENABLEHOOK
CC_ENABLETEMPLATE
CC_ENABLETEMPLATEHANDLE
CC_FULLOPEN
CC_INTERIORS
CC_NONE
CC_PIE
CC_PREVENTFULLOPEN
CLR_HILIGHT
CLR_INVALID
CLR_NONE
CM_CMYK_COLOR
CM_DEVICE_ICM
CM_GAMMA_RAMP
CM_IN_GAMUT
CM_NONE
CM_OUT_OF_GAMUT
CMB_MASKED
COLOR_3DDKSHADOW
COLOR_3DFACE
COLOR_3DHIGHLIGHT
COLOR_3DHILIGHT
COLOR_3DLIGHT
COLOR_3DSHADOW
COLOR_ACTIVEBORDER
COLOR_ACTIVECAPTION
COLOR_APPWORKSPACE
COLOR_BACKGROUND
COLOR_BTNFACE
COLOR_BTNHIGHLIGHT
COLOR_BTNHILIGHT
COLOR_BTNSHADOW
COLOR_BTNTEXT
COLOR_CAPTIONTEXT
COLOR_DESKTOP
COLOR_GRADIENTACTIVECAPTION
COLOR_GRADIENTINACTIVECAPTION
COLOR_GRAYTEXT
COLOR_HIGHLIGHT
COLOR_HIGHLIGHTTEXT
COLOR_HOTLIGHT
COLOR_INACTIVEBORDER
COLOR_INACTIVECAPTION
COLOR_INACTIVECAPTIONTEXT
COLOR_INFOBK
COLOR_INFOTEXT
COLOR_MENU
COLOR_MENUBAR
COLOR_MENUHILIGHT
COLOR_MENUTEXT
COLOR_SCROLLBAR
COLOR_WINDOW
COLOR_WINDOWFRAME
COLOR_WINDOWTEXT

CC_RGBINIT
CC_ROUNDRECT
CC_SHOWHELP
CC_SOLIDCOLOR
CC_STYLED
CC_WIDE
CC_WIDESTYLED
CCHDEVICENAME
CCHFORMNAME
CCHILDREN_SCROLLBAR
CCHILDREN_TITLEBAR
CCM_DPISCALE
CCM_FIRST
CCM_GETCOLORSCHEME
CCM_GETDROPTARGET
CCM_GETUNICODEFORMAT
CCM_GETVERSION
CCM_LAST
CCM_SETBKCOLOR
CCM_SETCOLORSCHEME
CCM_SETNOTIFYWINDOW
CCM_SETUNICODEFORMAT
CCM_SETVERSION
CCM_SETWINDOWTHEME
CD_LBSELADD
CD_LBSELCHANGE
CD_LBSELNOITEMS
CD_LBSELSUB
CDDS_ITEM
CDDS_ITEMPOSTERASE
CDDS_ITEMPOSTPAINT
CDDS_ITEMPREERASE
CDDS_ITEMPREPAINT
CDDS_POSTERASE
CDDS_POSTPAINT
CDDS_PREERASE
CDDS_PREPAINT
CDDS_SUBITEM
CDIS_CHECKED
CDIS_DEFAULT
CDIS_DISABLED
COLORMATCHTOTARGET_EMBEDED
COLORMGMTCAPS
COLORONCOLOR
COLORRES
COMCTL32_VERSION
COMPLEXREGION
CONSOLE_APPLICATION_16BIT
CONSOLE_CARET_SELECTION
CONSOLE_CARET_VISIBLE
CP_NONE
CP_RECTANGLE
CP_REGION
CREATECOLORSPACE_EMBEDED
CS_BYTEALIGNCLIENT
CS_BYTEALIGNWINDOW
CS_CLASSDC
CS_DBLCLKS
CS_DROPSHADOW
CS_GLOBALCLASS
CS_HREDRAW
CS_IME
CS_NOCLOSE
CS_OWNDC
CS_PARENTDC
CS_SAVEBITS
CS_VREDRAW
CSOUND_SYSTEM
CTLCOLOR_BTN
CTLCOLOR_DLG
CTLCOLOR_EDIT
CTLCOLOR_LISTBOX
CTLCOLOR_MAX
CTLCOLOR_MSGBOX
CTLCOLOR_SCROLLBAR
CTLCOLOR_STATIC
CURSOR_SHOWING
CURVECAPS
CWP_ALL
CWP_SKIPDISABLED
CWP_SKIPINVISIBLE
CWP_SKIPTRANSPARENT

D

DA_LAST
DC_ACTIVE
DMMEDIA_GLOSSY
DMMEDIA_STANDARD

DC_BINADJUST
DC_BINNAMES
DC_BINS
DC_BRUSH
DC_BUTTONS
DC_COLLATE
DC_COLORDEVICE
DC_COPIES
DC_DATATYPE_PRODUCED
DC_DRIVER
DC_DUPLEX
DC_EMF_COMPLIANT
DC_ENUMRESOLUTIONS
DC_EXTRA
DC_FIELDS
DC_FILEDEPENDENCIES
DC_GRADIENT
DC_HASDEFID
DC_ICON
DC_INBUTTON
DC_MANUFACTURER
DC_MAXEXTENT
DC_MEDIAREADY
DC_MEDIATYPENAMES
DC_MEDIATYPES
DC_MINEXTENT
DC_MODEL
DC_NUP
DC_ORIENTATION
DC_PAPERNAMES
DC_PAPERS
DC_PAPERSIZE
DC_PEN
DC_PERSONALITY
DC_PRINTERMEM
DC_PRINTRATE
DC_PRINTRATEPPM
DC_PRINTRATEUNIT
DC_SIZE
DC_SMALLCAP
DC_STAPLE
DC_TEXT
DC_TRUETYPE
DC_VERSION
DCB_ACCUMULATE
DCB_DIRTY
DMMEDIA_TRANSPARENCY
DMMEDIA_USER
DMNUP_ONEUP
DMNUP_SYSTEM
DMORIENT_LANDSCAPE
DMORIENT_PORTRAIT
DMPAPER_10X11
DMPAPER_10X14
DMPAPER_11X17
DMPAPER_12X11
DMPAPER_15X11
DMPAPER_9X11
DMPAPER_A2
DMPAPER_A3
DMPAPER_A3_EXTRA
DMPAPER_A3_EXTRA_TRANSVERSE
DMPAPER_A3_ROTATED
DMPAPER_A3_TRANSVERSE
DMPAPER_A4
DMPAPER_A4_EXTRA
DMPAPER_A4_PLUS
DMPAPER_A4_ROTATED
DMPAPER_A4_TRANSVERSE
DMPAPER_A4SMALL
DMPAPER_A5
DMPAPER_A5_EXTRA
DMPAPER_A5_ROTATED
DMPAPER_A5_TRANSVERSE
DMPAPER_A6
DMPAPER_A6_ROTATED
DMPAPER_A_PLUS
DMPAPER_B4
DMPAPER_B4_JIS_ROTATED
DMPAPER_B5
DMPAPER_B5_EXTRA
DMPAPER_B5_JIS_ROTATED
DMPAPER_B5_TRANSVERSE
DMPAPER_B6_JIS
DMPAPER_B6_JIS_ROTATED
DMPAPER_B_PLUS
DMPAPER_CSHEET
DMPAPER_DBL_JAPANESE_POSTCARD
DMPAPER_DBL_JAPANESE_POSTCARD_ROTATED
DMPAPER_DSHEET
DMPAPER_ENV_10
DMPAPER_ENV_11

DCB_DISABLE
DCB_ENABLE
DCB_RESET
DCB_SET
DCBA_FACEDOWNCENTER
DCBA_FACEDOWNLEFT
DCBA_FACEDOWNNONE
DCBA_FACEDOWNRIGHT
DCBA_FACEUPCENTER
DCBA_FACEUPLEFT
DCBA_FACEUPNONE
DCBA_FACEUPRIGHT
DCX_CACHE
DCX_CLIPCHILDREN
DCX_CLIPSIBLINGS
DCX_EXCLUDERGN
DCX_EXCLUDEUPDATE
DCX_INTERSECTRGN
DCX_INTERSECTUPDATE
DCX_LOCKWINDOWUPDATE
DCX_NORESETATTRS
DCX_PARENTCLIP
DCX_VALIDATE
DCX_WINDOW
DDL_ARCHIVE
DDL_DIRECTORY
DDL_DRIVES
DDL_EXCLUSIVE
DDL_HIDDEN
DDL_POSTMSGS
DDL_READONLY
DDL_READWRITE
DDL_SYSTEM
DEFAULT_CHARSET
DEFAULT_GUI_FONT
DEFAULT_PALETTE
DEFAULT_PITCH
DEFAULT_QUALITY
DESKTOP_CREATEMENU
DESKTOP_CREATEWINDOW
DESKTOP_ENUMERATE
DESKTOP_HOOKCONTROL
DESKTOP_JOURNALPLAYBACK
DESKTOP_JOURNALRECORD
DESKTOP_READOBJECTS
DESKTOP_SWITCHDESKTOP
DMPAPER_ENV_12
DMPAPER_ENV_14
DMPAPER_ENV_9
DMPAPER_ENV_B4
DMPAPER_ENV_B5
DMPAPER_ENV_B6
DMPAPER_ENV_C3
DMPAPER_ENV_C4
DMPAPER_ENV_C5
DMPAPER_ENV_C6
DMPAPER_ENV_C65
DMPAPER_ENV_DL
DMPAPER_ENV_INVITE
DMPAPER_ENV_ITALY
DMPAPER_ENV_MONARCH
DMPAPER_ENV_PERSONAL
DMPAPER_ESHEET
DMPAPER_EXECUTIVE
DMPAPER_FANFOLD_LGL_GERMAN
DMPAPER_FANFOLD_STD_GERMAN
DMPAPER_FANFOLD_US
DMPAPER_FOLIO
DMPAPER_ISO_B4
DMPAPER_JAPANESE_POSTCARD
DMPAPER_JAPANESE_POSTCARD_ROTATED
DMPAPER_JENV_CHOU3
DMPAPER_JENV_CHOU3_ROTATED
DMPAPER_JENV_CHOU4
DMPAPER_JENV_CHOU4_ROTATED
DMPAPER_JENV_KAKU2
DMPAPER_JENV_KAKU2_ROTATED
DMPAPER_JENV_KAKU3
DMPAPER_JENV_KAKU3_ROTATED
DMPAPER_JENV_YOU4
DMPAPER_JENV_YOU4_ROTATED
DMPAPER_LAST
DMPAPER_LEDGER
DMPAPER_LEGAL
DMPAPER_LEGAL_EXTRA
DMPAPER_LETTER
DMPAPER_LETTER_EXTRA
DMPAPER_LETTER_EXTRA_TRANSVERSE
DMPAPER_LETTER_PLUS
DMPAPER_LETTER_ROTATED
DMPAPER_LETTER_TRANSVERSE
DMPAPER_LETTERSMALL

DESKTOP_WRITEOBJECTS
DESKTOPHORZRES
DESKTOPVERTRES
DEVICE_DEFAULT_FONT
DEVICE_FONTTYPE
DEVICE_NOTIFY_ALL_INTERFACE_CLASSES
DEVICE_NOTIFY_SERVICE_HANDLE
DEVICE_NOTIFY_WINDOW_HANDLE
DEVICEDATA
DFC_BUTTON
DFC_CAPTION
DFC_MENU
DFC_POPUPMENU
DFC_SCROLL
DFCS_ADJUSTRECT
DFCS_BUTTON3STATE
DFCS_BUTTONCHECK
DFCS_BUTTONPUSH
DFCS_BUTTONRADIO
DFCS_BUTTONRADIOIMAGE
DFCS_BUTTONRADIOMASK
DFCS_CAPTIONCLOSE
DFCS_CAPTIONHELP
DFCS_CAPTIONMAX
DFCS_CAPTIONMIN
DFCS_CAPTIONRESTORE
DFCS_CHECKED
DFCS_FLAT
DFCS_HOT
DFCS_INACTIVE
DFCS_MENUARROW
DFCS_MENUARROWRIGHT
DFCS_MENUBULLET
DFCS_MENUCHECK
DFCS_MONO
DFCS_PUSHED
DFCS_SCROLLCOMBOBOX
DFCS_SCROLLDOWN
DFCS_SCROLLLEFT
DFCS_SCROLLRIGHT
DFCS_SCROLLSIZEGRIP
DFCS_SCROLLSIZEGRIPRIGHT
DFCS_SCROLLUP
DFCS_TRANSPARENT
DI_APPBANDING
DI_COMPAT
DMPAPER_NOTE
DMPAPER_P16K
DMPAPER_P16K_ROTATED
DMPAPER_P32K
DMPAPER_P32K_ROTATED
DMPAPER_P32KBIG
DMPAPER_P32KBIG_ROTATED
DMPAPER_PENV_1
DMPAPER_PENV_10
DMPAPER_PENV_10_ROTATED
DMPAPER_PENV_1_ROTATED
DMPAPER_PENV_2
DMPAPER_PENV_2_ROTATED
DMPAPER_PENV_3
DMPAPER_PENV_3_ROTATED
DMPAPER_PENV_4
DMPAPER_PENV_4_ROTATED
DMPAPER_PENV_5
DMPAPER_PENV_5_ROTATED
DMPAPER_PENV_6
DMPAPER_PENV_6_ROTATED
DMPAPER_PENV_7
DMPAPER_PENV_7_ROTATED
DMPAPER_PENV_8
DMPAPER_PENV_8_ROTATED
DMPAPER_PENV_9
DMPAPER_PENV_9_ROTATED
DMPAPER_QUARTO
DMPAPER_RESERVED_48
DMPAPER_RESERVED_49
DMPAPER_STATEMENT
DMPAPER_TABLOID
DMPAPER_TABLOID_EXTRA
DMPAPER_USER
DMRES_DRAFT
DMRES_HIGH
DMRES_LOW
DMRES_MEDIUM
DMTT_BITMAP
DMTT_DOWNLOAD
DMTT_DOWNLOAD_OUTLINE
DMTT_SUBDEV
DN_DEFAULTPRN
DO_DROPFILE
DO_PRINTFILE
DOF_DIRECTORY

DI_DEFAULTSIZE
DI_IMAGE
DI_MASK
DI_NOMIRROR
DI_NORMAL
DI_ROPS_READ_DESTINATION
DIB_PAL_COLORS
DIB_RGB_COLORS
DIFFERENCE
DISP_CHANGE_BADDUALVIEW
DISP_CHANGE_BADFLAGS
DISP_CHANGE_BADMODE
DISP_CHANGE_BADPARAM
DISP_CHANGE_FAILED
DISP_CHANGE_NOTUPDATED
DISP_CHANGE_RESTART
DISP_CHANGE_SUCCESSFUL
DISPLAY_DEVICE_ACTIVE
DISPLAY_DEVICE_ATTACHED
DISPLAY_DEVICE_ATTACHED_TO_DESKTOP
DISPLAY_DEVICE_DISCONNECT
DISPLAY_DEVICE_MIRRORING_DRIVER
DISPLAY_DEVICE_MODESPRUNED
DISPLAY_DEVICE_MULTI_DRIVER
DISPLAY_DEVICE_PRIMARY_DEVICE
DISPLAY_DEVICE_REMOTE
DISPLAY_DEVICE_REMOVABLE
DISPLAY_DEVICE_VGA_COMPATIBLE
DKGRAY_BRUSH
DL_BEGINDRAG
DL_CANCELDRAG
DL_COPYCURSOR
DL_CURSORSET
DL_DRAGGING
DL_DROPPED
DL_MOVECURSOR
DL_STOPCURSOR
DLGC_BUTTON
DLGC_DEFPUSHBUTTON
DLGC_HASSETSEL
DLGC_RADIOBUTTON
DLGC_STATIC
DLGC_UNDEFPUSHBUTTON
DLGC_WANTALLKEYS
DLGC_WANTARROWS
DLGC_WANTCHARS
DOF_DOCUMENT
DOF_EXECUTABLE
DOF_MULTIPLE
DOF_PROGMAN
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DPA_APPEND
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DPAS_INSERTAFTER
DPAS_INSERTBEFORE
DPAS_SORTED
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DS_ABSALIGN
DS_CENTER
DS_CENTERMOUSE
DS_CONTEXTHELP
DS_CONTROL
DS_FIXEDSYS
DS_LOCALEDIT
DS_MODALFRAME
DS_NOFAILCREATE
DS_NOIDLEMSG
DS_SETFONT
DS_SETFOREGROUND
DS_SHELLFONT
DS_SYSMODAL
DS_USEPIXELS
DSA_APPEND
DSA_ERR
DSS_DISABLED
DSS_HIDEPREFIX
DSS_MONO
DSS_NORMAL
DSS_PREFIXONLY
DSS_RIGHT
DSS_UNION
DST_BITMAP
DST_COMPLEX
DST_ICON
DST_PREFIXTEXT
DST_TEXT

DLGC_WANTMESSAGE
DLGC_WANTTAB
DLGWINDOWEXTRA
DLSZ_MOVE_X
DLSZ_MOVE_Y
DLSZ_REPAINT
DLSZ_SIZE_X
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DM_GETDEFID
DM_IN_BUFFER
DM_IN_PROMPT
DM_MODIFY
DM_OUT_BUFFER
DM_OUT_DEFAULT
DM_PROMPT
DM_REPOSITION
DM_SETDEFID
DM_SPECVERSION
DM_UPDATE
DMBIN_AUTO
DMBIN_CASSETTE
DMBIN_ENVELOPE
DMBIN_ENVMANUAL
DMBIN_FORMSOURCE
DMBIN_LARGECAPACITY
DMBIN_LARGEFMT
DMBIN_LAST
DMBIN_LOWER
DMBIN_MANUAL
DMBIN_MIDDLE
DMBIN_ONLYONE
DMBIN_SMALLFMT
DMBIN_TRACTOR
DMBIN_UPPER
DMBIN_USER
DMCOLLATE_FALSE
DMCOLLATE_TRUE
DMCOLOR_COLOR
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DMDFO_CENTER
DMDFO_DEFAULT
DMDFO_STRETCH
DMDISPLAYFLAGS_TEXTMODE
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DT_CALCRECT
DT_CENTER
DT_CHARSTREAM
DT_DISPFILE
DT_EDITCONTROL
DT_END_ELLIPSIS
DT_EXPANDTABS
DT_EXTERNALLEADING
DT_HIDEPREFIX
DT_INTERNAL
DT_LEFT
DT_METAFILE
DT_MODIFYSTRING
DT_NOCLIP
DT_NOFULLWIDTHCHARBREAK
DT_NOPREFIX
DT_PATH_ELLIPSIS
DT_PLOTTER
DT_PREFIXONLY
DT_RASCAMERA
DT_RASDISPLAY
DT_RASPRINTER
DT_RIGHT
DT_RTLREADING
DT_SINGLELINE
DT_TABSTOP
DT_TOP
DT_VCENTER
DT_WORD_ELLIPSIS
DT_WORDBREAK
DTM_FIRST
DTM_GETMCCOLOR
DTM_GETMCFONT
DTM_GETMONTHCAL
DTM_GETRANGE
DTM_GETSYSTEMTIME
DTM_SETFORMAT
DTM_SETFORMATA
DTM_SETFORMATW
DTM_SETMCCOLOR
DTM_SETMCFONT
DTM_SETRANGE
DTM_SETSYSTEMTIME
DTN_CLOSEUP
DTN_DATETIMECHANGE

DMDITHER_FINE
DMDITHER_GRAYSCALE
DMDITHER_LINEART
DMDITHER_NONE
DMDITHER_RESERVED6
DMDITHER_RESERVED7
DMDITHER_RESERVED8
DMDITHER_RESERVED9
DMDITHER_USER
DMDO_180
DMDO_270
DMDO_90
DMDO_DEFAULT
DMDUP_HORIZONTAL
DMDUP_SIMPLEX
DMDUP_VERTICAL
DMICM_ABS_COLORIMETRIC
DMICM_COLORIMETRIC
DMICM_CONTRAST
DMICM_SATURATE
DMICM_USER
DMICMMETHOD_DEVICE
DMICMMETHOD_DRIVER
DMICMMETHOD_NONE
DMICMMETHOD_SYSTEM
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DTN_FORMAT
DTN_FORMATA
DTN_FORMATQUERY
DTN_FORMATQUERYA
DTN_FORMATQUERYW
DTN_FORMATW
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DTN_WMKEYDOWN
DTN_WMKEYDOWNA
DTN_WMKEYDOWNW
DTS_APPCANPARSE
DTS_LONGDATEFORMAT
DTS_RIGHTALIGN
DTS_SHORTDATECENTURYFORMAT
DTS_SHORTDATEFORMAT
DTS_SHOWNONE
DTS_TIMEFORMAT
DTS_UPDOWN
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DWL_MSGRESULT
DWL_USER
DWLP_MSGRESULT

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EC_RIGHTMARGIN
EC_USEFONTINFO
ECM_FIRST
EDGE_BUMP
EDGE_ETCHED
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EIMES_CANCELCOMPSTRINFOCUS
EIMES_COMPLETECOMPSTRKILLFOCUS
EIMES_GETCOMPSTRATONCE
ELF_CULTURE_LATIN
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EM_CHARFROMPOS
EMR_SETARCDIRECTION
EMR_SETBKCOLOR
EMR_SETBKMODE
EMR_SETBRUSHORGEX
EMR_SETCOLORADJUSTMENT
EMR_SETCOLORSPACE
EMR_SETDIBITSTODEVICE
EMR_SETICMMODE
EMR_SETICMPROFILEA
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EMR_SETLAYOUT
EMR_SETMAPMODE
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EMR_SETPIXELV

EM_EMPTYUNDOBUFFER
EM_FMTLINES
EM_GETCUEBANNER
EM_GETFIRSTVISIBLELINE
EM_GETHANDLE
EM_GETIMESTATUS
EM_GETLIMITTEXT
EM_GETLINE
EM_GETLINECOUNT
EM_GETMARGINS
EM_GETMODIFY
EM_GETPASSWORDCHAR
EM_GETRECT
EM_GETSEL
EM_GETTHUMB
EM_GETWORDBREAKPROC
EM_HIDEBALLOONTIP
EM_LIMITTEXT
EM_LINEFROMCHAR
EM_LINEINDEX
EM_LINELENGTH
EM_LINESCROLL
EM_POSFROMCHAR
EM_REPLACESEL
EM_SCROLL
EM_SCROLLCARET
EM_SETCUEBANNER
EM_SETHANDLE
EM_SETIMESTATUS
EM_SETLIMITTEXT
EM_SETMARGINS
EM_SETMODIFY
EM_SETPASSWORDCHAR
EM_SETREADONLY
EM_SETRECT
EM_SETRECTNP
EM_SETSEL
EM_SETTABSTOPS
EM_SETWORDBREAKPROC
EM_SHOWBALLOONTIP
EM_UNDO
EMR_ABORTPATH
EMR_ALPHABLEND
EMR_ANGLEARC
EMR_ARC
EMR_ARCTO
EMR_SETPOLYFILLMODE
EMR_SETROP2
EMR_SETSTRETCHBLTMODE
EMR_SETTEXTALIGN
EMR_SETTEXTCOLOR
EMR_SETVIEWPORTEXTEX
EMR_SETVIEWPORTORGEX
EMR_SETWINDOWEXTEX
EMR_SETWINDOWORGEX
EMR_SETWORLDTRANSFORM
EMR_STRETCHBLT
EMR_STRETCHDIBITS
EMR_STROKEANDFILLPATH
EMR_STROKEPATH
EMR_TRANSPARENTBLT
EMR_WIDENPATH
EMSIS_COMPOSITIONSTRING
EN_ALIGN_LTR_EC
EN_ALIGN_RTL_EC
EN_CHANGE
EN_ERRSPACE
EN_HSCROLL
EN_KILLFOCUS
EN_MAXTEXT
EN_SETFOCUS
EN_UPDATE
EN_VSCROLL
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ENABLERELATIVEWIDTHS
ENCAPSULATED_POSTSCRIPT
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ENDSESSION_LOGOFF
ENHMETA_SIGNATURE
ENHMETA_STOCK_OBJECT
ENUMPAPERBINS
ENUMPAPERMETRICS
EPS_SIGNATURE
EPSPRINTING
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ES_AUTOHSCROLL
ES_AUTOVSCROLL
ES_CENTER
ES_LEFT
ES_LOWERCASE

EMR_BEGINPATH
EMR_BITBLT
EMR_CHORD
EMR_CLOSEFIGURE
EMR_COLORCORRECTPALETTE
EMR_COLORMATCHTOTARGETW
EMR_CREATEBRUSHINDIRECT
EMR_CREATECOLORSPACE
EMR_CREATECOLORSPACEW
EMR_CREATEDIBPATTERNBRUSHPT
EMR_CREATEMONOBRUSH
EMR_CREATEPALETTE
EMR_CREATEPEN
EMR_DELETECOLORSPACE
EMR_DELETEOBJECT
EMR_ELLIPSE
EMR_ENDPATH
EMR_EOF
EMR_EXCLUDECLIPRECT
EMR_EXTCREATEFONTINDIRECTW
EMR_EXTCREATEPEN
EMR_EXTFLOODFILL
EMR_EXTSELECTCLIPRGN
EMR_EXTTEXTOUTA
EMR_EXTTEXTOUTW
EMR_FILLPATH
EMR_FILLRGN
EMR_FLATTENPATH
EMR_FRAMERGN
EMR_GDICOMMENT
EMR_GLSBOUNDEDRECORD
EMR_GLSRECORD
EMR_GRADIENTFILL
EMR_HEADER
EMR_INTERSECTCLIPRECT
EMR_INVERTRGN
EMR_LINETO
EMR_MASKBLT
EMR_MAX
EMR_MIN
EMR_MODIFYWORLDTRANSFORM
EMR_MOVETOEX
EMR_OFFSETCLIPRGN
EMR_PAINTRGN
EMR_PIE
EMR_PIXELFORMAT
ES_MULTILINE
ES_NOHIDESEL
ES_NUMBER
ES_OEMCONVERT
ES_PASSWORD
ES_READONLY
ES_RIGHT
ES_UPPERCASE
ES_WANTRETURN
ESB_DISABLE_BOTH
ESB_DISABLE_DOWN
ESB_DISABLE_LEFT
ESB_DISABLE_LTUP
ESB_DISABLE_RIGHT
ESB_DISABLE_RTDN
ESB_DISABLE_UP
ESB_ENABLE_BOTH
ETO_CLIPPED
ETO_GLYPH_INDEX
ETO_IGNORELANGUAGE
ETO_NUMERICSLATIN
ETO_NUMERICSLOCAL
ETO_OPAQUE
ETO_PDY
ETO_RTLREADING
EVENT_CONSOLE_CARET
EVENT_CONSOLE_END_APPLICATION
EVENT_CONSOLE_LAYOUT
EVENT_CONSOLE_START_APPLICATION
EVENT_CONSOLE_UPDATE_REGION
EVENT_CONSOLE_UPDATE_SCROLL
EVENT_CONSOLE_UPDATE_SIMPLE
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EVENT_OBJECT_DESCRIPTIONCHANGE
EVENT_OBJECT_DESTROY
EVENT_OBJECT_FOCUS
EVENT_OBJECT_HELPCHANGE
EVENT_OBJECT_HIDE
EVENT_OBJECT_LOCATIONCHANGE
EVENT_OBJECT_NAMECHANGE
EVENT_OBJECT_PARENTCHANGE
EVENT_OBJECT_REORDER

EMR_PLGBLT
EMR_POLYBEZIER
EMR_POLYBEZIER16
EMR_POLYBEZIERTO
EMR_POLYBEZIERTO16
EMR_POLYDRAW
EMR_POLYDRAW16
EMR_POLYGON
EMR_POLYGON16
EMR_POLYLINE
EMR_POLYLINE16
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EMR_POLYTEXTOUTA
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EMR_REALIZEPALETTE
EMR_RECTANGLE
EMR_RESERVED_105
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EMR_RESIZEPALETTE
EMR_RESTOREDC
EMR_ROUNDRECT
EMR_SAVEDC
EMR_SCALEVIEWPORTEXTEX
EMR_SCALEWINDOWEXTEX
EMR_SELECTCLIPPATH
EMR_SELECTOBJECT
EMR_SELECTPALETTE
EVENT_OBJECT_SELECTION
EVENT_OBJECT_SELECTIONADD
EVENT_OBJECT_SELECTIONREMOVE
EVENT_OBJECT_SELECTIONWITHIN
EVENT_OBJECT_SHOW
EVENT_OBJECT_STATECHANGE
EVENT_OBJECT_VALUECHANGE
EVENT_SYSTEM_ALERT
EVENT_SYSTEM_CAPTUREEND
EVENT_SYSTEM_CAPTURESTART
EVENT_SYSTEM_CONTEXTHELPEND
EVENT_SYSTEM_CONTEXTHELPSTART
EVENT_SYSTEM_DIALOGEND
EVENT_SYSTEM_DIALOGSTART
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EVENT_SYSTEM_DRAGDROPSTART
EVENT_SYSTEM_FOREGROUND
EVENT_SYSTEM_MENUEND
EVENT_SYSTEM_MENUPOPUPEND
EVENT_SYSTEM_MENUPOPUPSTART
EVENT_SYSTEM_MENUSTART
EVENT_SYSTEM_MINIMIZEEND
EVENT_SYSTEM_MINIMIZESTART
EVENT_SYSTEM_MOVESIZEEND
EVENT_SYSTEM_MOVESIZESTART
EVENT_SYSTEM_SCROLLINGEND
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EVENT_SYSTEM_SOUND
EVENT_SYSTEM_SWITCHEND
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EWX_LOGOFF
EWX_POWEROFF
EWX_REBOOT
EWX_SHUTDOWN
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FALT
FAPPCOMMAND_KEY
FAPPCOMMAND_MASK
FNOINVERT
FONTMAPPER_MAX
FR_DIALOGTERM
FR_DOWN

FAPPCOMMAND_MOUSE
FAPPCOMMAND_OEM
FCONTROL
FE_FONTSMOOTHINGCLEARTYPE
FE_FONTSMOOTHINGDOCKING
FE_FONTSMOOTHINGORIENTATIONBGR
FE_FONTSMOOTHINGORIENTATIONRGB
FE_FONTSMOOTHINGSTANDARD
FEATURESETTING_CUSTPAPER
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FEATURESETTING_NEGATIVE
FEATURESETTING_NUP
FEATURESETTING_OUTPUT
FEATURESETTING_PRIVATE_BEGIN
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FEATURESETTING_PROTOCOL
FEATURESETTING_PSLEVEL
FF_DECORATIVE
FF_DONTCARE
FF_MODERN
FF_ROMAN
FF_SCRIPT
FF_SWISS
FIXED_PITCH
FKF_AVAILABLE
FKF_CLICKON
FKF_CONFIRMHOTKEY
FKF_FILTERKEYSON
FKF_HOTKEYACTIVE
FKF_HOTKEYSOUND
FKF_INDICATOR
FLASHW_ALL
FLASHW_CAPTION
FLASHW_STOP
FLASHW_TIMER
FLASHW_TIMERNOFG
FLASHW_TRAY
FLI_MASK
FLOODFILLBORDER
FLOODFILLSURFACE
FLUSHOUTPUT
FR_ENABLEHOOK
FR_ENABLETEMPLATE
FR_ENABLETEMPLATEHANDLE
FR_FINDNEXT
FR_HIDEMATCHCASE
FR_HIDEUPDOWN
FR_HIDEWHOLEWORD
FR_MATCHALEFHAMZA
FR_MATCHCASE
FR_MATCHDIAC
FR_MATCHKASHIDA
FR_NOMATCHCASE
FR_NOT_ENUM
FR_NOUPDOWN
FR_NOWHOLEWORD
FR_PRIVATE
FR_RAW
FR_REPLACE
FR_REPLACEALL
FR_SHOWHELP
FR_WHOLEWORD
FSB_ENCARTA_MODE
FSB_FLAT_MODE
FSB_REGULAR_MODE
FSHIFT
FVIRTKEY
FW_BLACK
FW_BOLD
FW_DEMIBOLD
FW_DONTCARE
FW_EXTRABOLD
FW_EXTRALIGHT
FW_HEAVY
FW_LIGHT
FW_MEDIUM
FW_NORMAL
FW_REGULAR
FW_SEMIBOLD
FW_THIN
FW_ULTRABOLD
FW_ULTRALIGHT

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GA_PARENT
GA_ROOT
GETPRINTINGOFFSET
GETSCALINGFACTOR

GA_ROOTOWNER
GB2312_CHARSET
GCL_CBCLSEXTRA
GCL_CBWNDEXTRA
GCL_HBRBACKGROUND
GCL_HCURSOR
GCL_HICON
GCL_HICONSM
GCL_HMODULE
GCL_MENUNAME
GCL_STYLE
GCL_WNDPROC
GCLP_HBRBACKGROUND
GCLP_HCURSOR
GCLP_HICON
GCLP_HICONSM
GCLP_HMODULE
GCLP_MENUNAME
GCLP_WNDPROC
GCP_DBCS
GCP_DIACRITIC
GCP_ERROR
GCP_GLYPHSHAPE
GCP_KASHIDA
GCP_LIGATE
GCP_REORDER
GCP_USEKERNING
GCPCLASS_ARABIC
GCPCLASS_HEBREW
GCPCLASS_LATIN
GCPCLASS_LATINNUMBER
GCPCLASS_LATINNUMERICSEPARATOR
GCPCLASS_LATINNUMERICTERMINATOR
GCPCLASS_LOCALNUMBER
GCPCLASS_NEUTRAL
GCPCLASS_NUMERICSEPARATOR
GCPCLASS_POSTBOUNDLTR
GCPCLASS_POSTBOUNDRTL
GCPCLASS_PREBOUNDLTR
GCPCLASS_PREBOUNDRTL
GCPGLYPH_LINKAFTER
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GCW_ATOM
GDICOMMENT_BEGINGROUP
GDICOMMENT_ENDGROUP
GDICOMMENT_IDENTIFIER
GETSETPAPERBINS
GETSETPAPERMETRICS
GETSETPRINTORIENT
GETSETSCREENPARAMS
GETTECHNOLGY
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GETTRACKKERNTABLE
GETVECTORBRUSHSIZE
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GGO_BEZIER
GGO_BITMAP
GGO_GLYPH_INDEX
GGO_GRAY2_BITMAP
GGO_GRAY4_BITMAP
GGO_GRAY8_BITMAP
GGO_METRICS
GGO_NATIVE
GGO_UNHINTED
GM_ADVANCED
GM_COMPATIBLE
GM_LAST
GMDI_GOINTOPOPUPS
GMDI_USEDISABLED
GMMP_USE_DISPLAY_POINTS
GMMP_USE_HIGH_RESOLUTION_POINTS
GMR_DAYSTATE
GMR_VISIBLE
GR_GDIOBJECTS
GR_USEROBJECTS
GRADIENT_FILL_OP_FLAG
GRADIENT_FILL_RECT_H
GRADIENT_FILL_RECT_V
GRADIENT_FILL_TRIANGLE
GRAY_BRUSH
GREEK_CHARSET
GS_8BIT_INDICES
GUI_16BITTASK
GUI_CARETBLINKING
GUI_INMENUMODE
GUI_INMOVESIZE
GUI_POPUPMENUMODE
GUI_SYSTEMMENUMODE
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GW_ENABLEDPOPUP
GW_HWNDFIRST

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GDICOMMENT_UNICODE_END
GDICOMMENT_UNICODE_STRING
GDICOMMENT_WINDOWS_METAFILE
GDT_ERROR
GDT_NONE
GDT_VALID
GDTR_MAX
GDTR_MIN
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GETCOLORTABLE
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GETEXTENDEDTEXTMETRICS
GETEXTENTTABLE
GETFACENAME
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GW_HWNDNEXT
GW_HWNDPREV
GW_MAX
GW_OWNER
GWL_EXSTYLE
GWL_HINSTANCE
GWL_HWNDPARENT
GWL_ID
GWL_STYLE
GWL_USERDATA
GWL_WNDPROC
GWLP_HINSTANCE
GWLP_HWNDPARENT
GWLP_ID
GWLP_USERDATA
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HANGUL_CHARSET
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HC_NOREM
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HCBT_ACTIVATE
HCBT_CLICKSKIPPED
HCBT_CREATEWND
HCBT_DESTROYWND
HCBT_KEYSKIPPED
HCBT_MINMAX
HCBT_MOVESIZE
HCBT_QS
HCBT_SETFOCUS
HCBT_SYSCOMMAND
HCF_AVAILABLE
HCF_CONFIRMHOTKEY
HCF_HIGHCONTRASTON
HCF_HOTKEYACTIVE
HCF_HOTKEYAVAILABLE
HELP_CONTENTS
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HELP_CONTEXTMENU
HELP_CONTEXTPOPUP
HELP_FINDER
HELP_FORCEFILE
HELP_HELPONHELP
HELP_INDEX
HELP_KEY
HELP_MULTIKEY
HELP_PARTIALKEY
HELP_QUIT
HELP_SETCONTENTS
HELP_SETINDEX
HELP_SETPOPUP_POS
HELP_SETWINPOS
HELP_TCARD
HELP_TCARD_DATA
HELP_TCARD_OTHER_CALLER
HELP_WM_HELP
HELPINFO_MENUITEM
HELPINFO_WINDOW
HHT_ABOVE
HHT_BELOW
HHT_NOWHERE

HCF_HOTKEYSOUND
HCF_INDICATOR
HDF_BITMAP
HDF_BITMAP_ON_RIGHT
HDF_CENTER
HDF_IMAGE
HDF_JUSTIFYMASK
HDF_LEFT
HDF_OWNERDRAW
HDF_RIGHT
HDF_RTLREADING
HDF_SORTDOWN
HDF_SORTUP
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HDFT_HASNOVALUE
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HDI_IMAGE
HDI_LPARAM
HDI_ORDER
HDI_TEXT
HDI_WIDTH
HDM_CLEARFILTER
HDM_CREATEDRAGIMAGE
HDM_DELETEITEM
HDM_EDITFILTER
HDM_FIRST
HDM_GETBITMAPMARGIN
HDM_GETIMAGELIST
HDM_GETITEM
HDM_GETITEMA
HDM_GETITEMCOUNT
HDM_GETITEMRECT
HDM_GETITEMW
HDM_GETORDERARRAY
HDM_GETUNICODEFORMAT
HDM_HITTEST
HDM_INSERTITEM
HDM_INSERTITEMA
HDM_INSERTITEMW
HDM_LAYOUT
HHT_ONDIVIDER
HHT_ONDIVOPEN
HHT_ONFILTER
HHT_ONFILTERBUTTON
HHT_ONHEADER
HHT_TOLEFT
HHT_TORIGHT
HICF_ACCELERATOR
HICF_ARROWKEYS
HICF_DUPACCEL
HICF_ENTERING
HICF_LEAVING
HICF_LMOUSE
HICF_MOUSE
HICF_OTHER
HICF_RESELECT
HICF_TOGGLEDROPDOWN
HIDE_WINDOW
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HIST_ADDTOFAVORITES
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HKCOMB_CA
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HKCOMB_SC
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HKL_NEXT
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HKM_GETHOTKEY
HKM_SETHOTKEY
HKM_SETRULES
HOLLOW_BRUSH
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HOTKEYF_ALT
HOTKEYF_CONTROL
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HOTKEYF_SHIFT
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HDM_ORDERTOINDEX
HDM_SETBITMAPMARGIN
HDM_SETFILTERCHANGETIMEOUT
HDM_SETHOTDIVIDER
HDM_SETIMAGELIST
HDM_SETITEM
HDM_SETITEMA
HDM_SETITEMW
HDM_SETORDERARRAY
HDM_SETUNICODEFORMAT
HDN_BEGINDRAG
HDN_BEGINTRACK
HDN_BEGINTRACKA
HDN_BEGINTRACKW
HDN_DIVIDERDBLCLICK
HDN_DIVIDERDBLCLICKA
HDN_DIVIDERDBLCLICKW
HDN_ENDDRAG
HDN_ENDTRACK
HDN_ENDTRACKA
HDN_ENDTRACKW
HDN_FILTERBTNCLICK
HDN_FILTERCHANGE
HDN_GETDISPINFO
HDN_GETDISPINFOA
HDN_GETDISPINFOW
HDN_ITEMCHANGED
HDN_ITEMCHANGEDA
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HDN_ITEMCLICKW
HDN_ITEMDBLCLICK
HDN_ITEMDBLCLICKA
HDN_ITEMDBLCLICKW
HDN_TRACK
HDN_TRACKA
HDN_TRACKW
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HDS_DRAGDROP
HDS_FILTERBAR
HDS_FLAT
HDS_FULLDRAG
HS_CROSS
HS_DIAGCROSS
HS_FDIAGONAL
HS_HORIZONTAL
HS_VERTICAL
HSHELL_ACCESSIBILITYSTATE
HSHELL_ACTIVATESHELLWINDOW
HSHELL_APPCOMMAND
HSHELL_ENDTASK
HSHELL_FLASH
HSHELL_GETMINRECT
HSHELL_HIGHBIT
HSHELL_LANGUAGE
HSHELL_REDRAW
HSHELL_RUDEAPPACTIVATED
HSHELL_SYSMENU
HSHELL_TASKMAN
HSHELL_WINDOWACTIVATED
HSHELL_WINDOWCREATED
HSHELL_WINDOWDESTROYED
HSHELL_WINDOWREPLACED
HSHELL_WINDOWREPLACING
HTBORDER
HTBOTTOM
HTBOTTOMLEFT
HTBOTTOMRIGHT
HTCAPTION
HTCLIENT
HTCLOSE
HTERROR
HTGROWBOX
HTHELP
HTHSCROLL
HTLEFT
HTMAXBUTTON
HTMENU
HTMINBUTTON
HTNOWHERE
HTOBJECT
HTREDUCE
HTRIGHT
HTSIZE
HTSIZEFIRST
HTSIZELAST
HTSYSMENU
HTTOP

HDS_HIDDEN
HDS_HORZ
HDS_HOTTRACK
HEBREW_CHARSET
HELP_COMMAND
HTTOPLEFT
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HTTRANSPARENT
HTVSCROLL
HTZOOM

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I_CHILDRENCALLBACK
I_GROUPIDCALLBACK
I_GROUPIDNONE
I_IMAGECALLBACK
I_IMAGENONE
I_INDENTCALLBACK
ICC_ANIMATE_CLASS
ICC_BAR_CLASSES
ICC_COOL_CLASSES
ICC_DATE_CLASSES
ICC_HOTKEY_CLASS
ICC_INTERNET_CLASSES
ICC_LINK_CLASS
ICC_LISTVIEW_CLASSES
ICC_NATIVEFNTCTL_CLASS
ICC_PAGESCROLLER_CLASS
ICC_PROGRESS_CLASS
ICC_STANDARD_CLASSES
ICC_TAB_CLASSES
ICC_TREEVIEW_CLASSES
ICC_UPDOWN_CLASS
ICC_USEREX_CLASSES
ICC_WIN95_CLASSES
ICM_ADDPROFILE
ICM_DELETEPROFILE
ICM_DONE_OUTSIDEDC
ICM_OFF
ICM_ON
ICM_QUERY
ICM_QUERYMATCH
ICM_QUERYPROFILE
ICM_REGISTERICMATCHER
ICM_SETDEFAULTPROFILE
ICM_UNREGISTERICMATCHER
ICON_BIG
ICON_SMALL
ICON_SMALL2
IDABORT
ILC_COLOR4
ILC_COLOR8
ILC_COLORDDB
ILC_MASK
ILC_MIRROR
ILC_PALETTE
ILC_PERITEMMIRROR
ILCF_MOVE
ILCF_SWAP
ILD_BLEND
ILD_BLEND25
ILD_BLEND50
ILD_DPISCALE
ILD_FOCUS
ILD_IMAGE
ILD_MASK
ILD_NORMAL
ILD_OVERLAYMASK
ILD_PRESERVEALPHA
ILD_ROP
ILD_SCALE
ILD_SELECTED
ILD_TRANSPARENT
ILLUMINANT_A
ILLUMINANT_B
ILLUMINANT_C
ILLUMINANT_D50
ILLUMINANT_D55
ILLUMINANT_D65
ILLUMINANT_D75
ILLUMINANT_DAYLIGHT
ILLUMINANT_DEVICE_DEFAULT
ILLUMINANT_F2
ILLUMINANT_FLUORESCENT
ILLUMINANT_MAX_INDEX
ILLUMINANT_NTSC
ILLUMINANT_TUNGSTEN
ILS_ALPHA

IDANI_CAPTION
IDANI_OPEN
IDB_HIST_LARGE_COLOR
IDB_HIST_SMALL_COLOR
IDB_STD_LARGE_COLOR
IDB_STD_SMALL_COLOR
IDB_VIEW_LARGE_COLOR
IDB_VIEW_SMALL_COLOR
IDCANCEL
IDCLOSE
IDCONTINUE
IDH_CANCEL
IDH_GENERIC_HELP_BUTTON
IDH_HELP
IDH_MISSING_CONTEXT
IDH_NO_HELP
IDH_OK
IDHELP
IDHOT_SNAPDESKTOP
IDHOT_SNAPWINDOW
IDIGNORE
IDNO
IDOK
IDRETRY
IDTIMEOUT
IDTRYAGAIN
IDYES
ILC_COLOR
ILC_COLOR16
ILC_COLOR24
ILC_COLOR32
ILS_GLOW
ILS_NORMAL
ILS_SATURATE
ILS_SHADOW
IMAGE_BITMAP
IMAGE_CURSOR
IMAGE_ENHMETAFILE
IMAGE_ICON
INDEXID_CONTAINER
INDEXID_OBJECT
INFOTIPSIZE
INPUT_HARDWARE
INPUT_KEYBOARD
INPUT_MOUSE
INPUTLANGCHANGE_BACKWARD
INPUTLANGCHANGE_FORWARD
INPUTLANGCHANGE_SYSCHARSET
INVALID_LINK_INDEX
IPM_CLEARADDRESS
IPM_GETADDRESS
IPM_ISBLANK
IPM_SETADDRESS
IPM_SETFOCUS
IPM_SETRANGE
IPN_FIELDCHANGED
ISMEX_CALLBACK
ISMEX_NOSEND
ISMEX_NOTIFY
ISMEX_REPLIED
ISMEX_SEND
ITALIC_FONTTYPE

J

JOHAB_CHARSET

K

KEYBOARD_OVERRUN_MAKE_CODE
KEYEVENTF_EXTENDEDKEY
KEYEVENTF_KEYUP
KEYEVENTF_SCANCODE
KEYEVENTF_UNICODE
KF_ALTDOWN
KF_DLGMODE
KF_EXTENDED
KF_MENUMODE
KF_UP
KL_NAMELENGTH
KLF_ACTIVATE
KLF_NOTELLSHELL
KLF_REORDER
KLF_REPLACELANG
KLF_RESET
KLF_SETFORPROCESS
KLF_SHIFTLOCK

KF_REPEAT
KLF_SUBSTITUTE_OK

L

L_MAX_URL_LENGTH
LAYOUT_BITMAPORIENTATIONPRESERVED
LAYOUT_BTT
LAYOUT_ORIENTATIONMASK
LAYOUT_RTL
LAYOUT_VBH
LB_ADDFILE
LB_ADDSTRING
LB_CTLCODE
LB_DELETESTRING
LB_DIR
LB_ERR
LB_ERRSPACE
LB_FINDSTRING
LB_FINDSTRINGEXACT
LB_GETANCHORINDEX
LB_GETCARETINDEX
LB_GETCOUNT
LB_GETCURSEL
LB_GETHORIZONTALEXTENT
LB_GETITEMDATA
LB_GETITEMHEIGHT
LB_GETITEMRECT
LB_GETLISTBOXINFO
LB_GETLOCALE
LB_GETSEL
LB_GETSELCOUNT
LB_GETSELITEMS
LB_GETTEXT
LB_GETTEXTLEN
LB_GETTOPINDEX
LB_INITSTORAGE
LB_INSERTSTRING
LB_ITEMFROMPOINT
LB_MSGMAX
LB_MULTIPLEADDSTRING
LB_OKAY
LB_RESETCONTENT
LB_SELECTSTRING
LB_SELITEMRANGE
LB_SELITEMRANGEEX
LB_SETANCHORINDEX
LVM_EDITLABELW
LVM_ENABLEGROUPVIEW
LVM_ENSUREVISIBLE
LVM_FINDITEM
LVM_FINDITEMA
LVM_FINDITEMW
LVM_FIRST
LVM_GETBKCOLOR
LVM_GETBKIMAGE
LVM_GETBKIMAGEA
LVM_GETBKIMAGEW
LVM_GETCALLBACKMASK
LVM_GETCOLUMN
LVM_GETCOLUMNA
LVM_GETCOLUMNORDERARRAY
LVM_GETCOLUMNW
LVM_GETCOLUMNWIDTH
LVM_GETCOUNTPERPAGE
LVM_GETEDITCONTROL
LVM_GETEXTENDEDLISTVIEWSTYLE
LVM_GETGROUPINFO
LVM_GETGROUPMETRICS
LVM_GETHEADER
LVM_GETHOTCURSOR
LVM_GETHOTITEM
LVM_GETHOVERTIME
LVM_GETIMAGELIST
LVM_GETINSERTMARK
LVM_GETINSERTMARKCOLOR
LVM_GETINSERTMARKRECT
LVM_GETISEARCHSTRING
LVM_GETISEARCHSTRINGA
LVM_GETISEARCHSTRINGW
LVM_GETITEM
LVM_GETITEMA
LVM_GETITEMCOUNT
LVM_GETITEMPOSITION
LVM_GETITEMRECT
LVM_GETITEMSPACING
LVM_GETITEMSTATE
LVM_GETITEMTEXT
LVM_GETITEMTEXTA

LB_SETCARETINDEX
LB_SETCOLUMNWIDTH
LB_SETCOUNT
LB_SETCURSEL
LB_SETHORIZONTALEXTENT
LB_SETITEMDATA
LB_SETITEMHEIGHT
LB_SETLOCALE
LB_SETSEL
LB_SETTABSTOPS
LB_SETTOPINDEX
LBN_DBLCLK
LBN_ERRSPACE
LBN_KILLFOCUS
LBN_SELCANCEL
LBN_SELCHANGE
LBN_SETFOCUS
LBS_COMBOBOX
LBS_DISABLENOSCROLL
LBS_EXTENDEDSEL
LBS_HASSTRINGS
LBS_MULTICOLUMN
LBS_MULTIPLESEL
LBS_NODATA
LBS_NOINTEGRALHEIGHT
LBS_NOREDRAW
LBS_NOSEL
LBS_NOTIFY
LBS_OWNERDRAWFIXED
LBS_OWNERDRAWVARIABLE
LBS_SORT
LBS_STANDARD
LBS_USETABSTOPS
LBS_WANTKEYBOARDINPUT
LC_INTERIORS
LC_MARKER
LC_NONE
LC_POLYLINE
LC_POLYMARKER
LC_STYLED
LC_WIDE
LC_WIDESTYLED
LF_FACESIZE
LF_FULLFACESIZE
LIF_ITEMID
LIF_ITEMINDEX
LVM_GETITEMTEXTW
LVM_GETITEMW
LVM_GETNEXTITEM
LVM_GETNUMBEROFWORKAREAS
LVM_GETORIGIN
LVM_GETOUTLINECOLOR
LVM_GETSELECTEDCOLUMN
LVM_GETSELECTEDCOUNT
LVM_GETSELECTIONMARK
LVM_GETSTRINGWIDTH
LVM_GETSTRINGWIDTHA
LVM_GETSTRINGWIDTHW
LVM_GETSUBITEMRECT
LVM_GETTEXTBKCOLOR
LVM_GETTEXTCOLOR
LVM_GETTILEINFO
LVM_GETTILEVIEWINFO
LVM_GETTOOLTIPS
LVM_GETTOPINDEX
LVM_GETUNICODEFORMAT
LVM_GETVIEW
LVM_GETVIEWRECT
LVM_GETWORKAREAS
LVM_HASGROUP
LVM_HITTEST
LVM_INSERTCOLUMN
LVM_INSERTCOLUMNA
LVM_INSERTCOLUMNW
LVM_INSERTGROUP
LVM_INSERTGROUPSORTED
LVM_INSERTITEM
LVM_INSERTITEMA
LVM_INSERTITEMW
LVM_INSERTMARKHITTEST
LVM_ISGROUPVIEWENABLED
LVM_MAPIDTOINDEX
LVM_MAPINDEXTOID
LVM_MOVEGROUP
LVM_MOVEITEMTOGROUP
LVM_REDRAWITEMS
LVM_REMOVEALLGROUPS
LVM_REMOVEGROUP
LVM_SCROLL
LVM_SETBKCOLOR
LVM_SETBKIMAGE
LVM_SETBKIMAGEA

LIF_STATE
LIF_URL
LINECAPS
LIS_ENABLED
LIS_FOCUSED
LIS_VISITED
LLKHF_ALTDOWN
LLKHF_EXTENDED
LLKHF_INJECTED
LLKHF_UP
LLMHF_INJECTED
LM_GETIDEALHEIGHT
LM_GETITEM
LM_HITTEST
LM_SETITEM
LOGPIXELSX
LOGPIXELSY
LPD_DOUBLEBUFFER
LPD_SHARE_ACCUM
LPD_SHARE_DEPTH
LPD_SHARE_STENCIL
LPD_STEREO
LPD_SUPPORT_GDI
LPD_SUPPORT_OPENGL
LPD_SWAP_COPY
LPD_SWAP_EXCHANGE
LPD_TRANSPARENT
LPD_TYPE_COLORINDEX
LPD_TYPE_RGBA
LR_COLOR
LR_COPYDELETEORG
LR_COPYFROMRESOURCE
LR_COPYRETURNORG
LR_CREATEDIBSECTION
LR_DEFAULTCOLOR
LR_DEFAULTSIZE
LR_LOADFROMFILE
LR_LOADMAP3DCOLORS
LR_LOADTRANSPARENT
LR_MONOCHROME
LR_SHARED
LR_VGACOLOR
LSFW_LOCK
LSFW_UNLOCK
LTGRAY_BRUSH
LV_MAX_WORKAREAS
LVM_SETBKIMAGEW
LVM_SETCALLBACKMASK
LVM_SETCOLUMN
LVM_SETCOLUMNA
LVM_SETCOLUMNORDERARRAY
LVM_SETCOLUMNW
LVM_SETCOLUMNWIDTH
LVM_SETEXTENDEDLISTVIEWSTYLE
LVM_SETGROUPINFO
LVM_SETGROUPMETRICS
LVM_SETHOTCURSOR
LVM_SETHOTITEM
LVM_SETHOVERTIME
LVM_SETICONSPACING
LVM_SETIMAGELIST
LVM_SETINFOTIP
LVM_SETINSERTMARK
LVM_SETINSERTMARKCOLOR
LVM_SETITEM
LVM_SETITEMA
LVM_SETITEMCOUNT
LVM_SETITEMPOSITION
LVM_SETITEMPOSITION32
LVM_SETITEMSTATE
LVM_SETITEMTEXT
LVM_SETITEMTEXTA
LVM_SETITEMTEXTW
LVM_SETITEMW
LVM_SETOUTLINECOLOR
LVM_SETSELECTEDCOLUMN
LVM_SETSELECTIONMARK
LVM_SETTEXTBKCOLOR
LVM_SETTEXTCOLOR
LVM_SETTILEINFO
LVM_SETTILEVIEWINFO
LVM_SETTILEWIDTH
LVM_SETTOOLTIPS
LVM_SETUNICODEFORMAT
LVM_SETVIEW
LVM_SETWORKAREAS
LVM_SORTGROUPS
LVM_SORTITEMS
LVM_SORTITEMSEX
LVM_SUBITEMHITTEST
LVM_UPDATE
LVN_BEGINDRAG

LV_VIEW_DETAILS
LV_VIEW_ICON
LV_VIEW_LIST
LV_VIEW_MAX
LV_VIEW_SMALLICON
LV_VIEW_TILE
LVA_ALIGNLEFT
LVA_ALIGNTOP
LVA_DEFAULT
LVA_SNAPTOGRID
LVBKIF_FLAG_TILEOFFSET
LVBKIF_SOURCE_HBITMAP
LVBKIF_SOURCE_MASK
LVBKIF_SOURCE_NONE
LVBKIF_SOURCE_URL
LVBKIF_STYLE_MASK
LVBKIF_STYLE_NORMAL
LVBKIF_STYLE_TILE
LVBKIF_TYPE_WATERMARK
LVCDI_GROUP
LVCDI_ITEM
LVCDRF_NOGROUPFRAME
LVCDRF_NOSELECT
LVCF_FMT
LVCF_IMAGE
LVCF_ORDER
LVCF_SUBITEM
LVCF_TEXT
LVCF_WIDTH
LVCFMT_BITMAP_ON_RIGHT
LVCFMT_CENTER
LVCFMT_COL_HAS_IMAGES
LVCFMT_IMAGE
LVCFMT_JUSTIFYMASK
LVCFMT_LEFT
LVCFMT_RIGHT
LVFI_NEARESTXY
LVFI_PARAM
LVFI_PARTIAL
LVFI_STRING
LVFI_WRAP
LVGA_FOOTER_CENTER
LVGA_FOOTER_LEFT
LVGA_FOOTER_RIGHT
LVGA_HEADER_CENTER
LVGA_HEADER_LEFT
LVN_BEGINLABELEDIT
LVN_BEGINLABELEDITA
LVN_BEGINLABELEDITW
LVN_BEGINRDRAG
LVN_BEGINSCROLL
LVN_COLUMNCLICK
LVN_DELETEALLITEMS
LVN_DELETEITEM
LVN_ENDLABELEDIT
LVN_ENDLABELEDITA
LVN_ENDLABELEDITW
LVN_ENDSCROLL
LVN_GETDISPINFO
LVN_GETDISPINFOA
LVN_GETDISPINFOW
LVN_GETINFOTIP
LVN_GETINFOTIPA
LVN_GETINFOTIPW
LVN_HOTTRACK
LVN_INSERTITEM
LVN_ITEMACTIVATE
LVN_ITEMCHANGED
LVN_ITEMCHANGING
LVN_KEYDOWN
LVN_MARQUEEBEGIN
LVN_ODCACHEHINT
LVN_ODFINDITEM
LVN_ODFINDITEMA
LVN_ODFINDITEMW
LVN_ODSTATECHANGED
LVN_SETDISPINFO
LVN_SETDISPINFOA
LVN_SETDISPINFOW
LVNI_ABOVE
LVNI_ALL
LVNI_BELOW
LVNI_CUT
LVNI_DROPHILITED
LVNI_FOCUSED
LVNI_SELECTED
LVNI_TOLEFT
LVNI_TORIGHT
LVS_ALIGNLEFT
LVS_ALIGNMASK
LVS_ALIGNTOP
LVS_AUTOARRANGE

LVGA_HEADER_RIGHT
LVGF_ALIGN
LVGF_FOOTER
LVGF_GROUPID
LVGF_HEADER
LVGF_NONE
LVGF_STATE
LVGIT_UNFOLDED
LVGMF_BORDERCOLOR
LVGMF_BORDERSIZE
LVGMF_NONE
LVGMF_TEXTCOLOR
LVGS_COLLAPSED
LVGS_HIDDEN
LVGS_NORMAL
LVHT_ABOVE
LVHT_BELOW
LVHT_NOWHERE
LVHT_ONITEM
LVHT_ONITEMICON
LVHT_ONITEMLABEL
LVHT_ONITEMSTATEICON
LVHT_TOLEFT
LVHT_TORIGHT
LVIF_COLUMNS
LVIF_DI_SETITEM
LVIF_GROUPID
LVIF_IMAGE
LVIF_INDENT
LVIF_NORECOMPUTE
LVIF_PARAM
LVIF_STATE
LVIF_TEXT
LVIM_AFTER
LVIR_BOUNDS
LVIR_ICON
LVIR_LABEL
LVIR_SELECTBOUNDS
LVIS_ACTIVATING
LVIS_CUT
LVIS_DROPHILITED
LVIS_FOCUSED
LVIS_GLOW
LVIS_OVERLAYMASK
LVIS_SELECTED
LVIS_STATEIMAGEMASK
LVS_EDITLABELS
LVS_EX_BORDERSELECT
LVS_EX_CHECKBOXES
LVS_EX_DOUBLEBUFFER
LVS_EX_FLATSB
LVS_EX_FULLROWSELECT
LVS_EX_GRIDLINES
LVS_EX_HEADERDRAGDROP
LVS_EX_HIDELABELS
LVS_EX_INFOTIP
LVS_EX_LABELTIP
LVS_EX_MULTIWORKAREAS
LVS_EX_ONECLICKACTIVATE
LVS_EX_REGIONAL
LVS_EX_SIMPLESELECT
LVS_EX_SINGLEROW
LVS_EX_SNAPTOGRID
LVS_EX_SUBITEMIMAGES
LVS_EX_TRACKSELECT
LVS_EX_TWOCLICKACTIVATE
LVS_EX_UNDERLINECOLD
LVS_EX_UNDERLINEHOT
LVS_ICON
LVS_LIST
LVS_NOCOLUMNHEADER
LVS_NOLABELWRAP
LVS_NOSCROLL
LVS_NOSORTHEADER
LVS_OWNERDATA
LVS_OWNERDRAWFIXED
LVS_REPORT
LVS_SHAREIMAGELISTS
LVS_SHOWSELALWAYS
LVS_SINGLESEL
LVS_SMALLICON
LVS_SORTASCENDING
LVS_SORTDESCENDING
LVS_TYPEMASK
LVS_TYPESTYLEMASK
LVSCW_AUTOSIZE
LVSCW_AUTOSIZE_USEHEADER
LVSICF_NOINVALIDATEALL
LVSICF_NOSCROLL
LVSIL_NORMAL
LVSIL_SMALL
LVSIL_STATE

LVKF_ALT
LVKF_CONTROL
LVKF_SHIFT
LVM_APPROXIMATEVIEWRECT
LVM_ARRANGE
LVM_CANCELEDITLABEL
LVM_CREATEDRAGIMAGE
LVM_DELETEALLITEMS
LVM_DELETECOLUMN
LVM_DELETEITEM
LVM_EDITLABEL
LVM_EDITLABELA
LVTVIF_AUTOSIZE
LVTVIF_FIXEDHEIGHT
LVTVIF_FIXEDSIZE
LVTVIF_FIXEDWIDTH
LVTVIM_COLUMNS
LVTVIM_LABELMARGIN
LVTVIM_TILESIZE
LWA_ALPHA
LWA_COLORKEY
LWS_IGNORERETURN
LWS_TRANSPARENT

M

MA_ACTIVATE
MA_ACTIVATEANDEAT
MA_NOACTIVATE
MA_NOACTIVATEANDEAT
MAC_CHARSET
MAX_LINKID_TEXT
MAX_PATH
MAXSTRETCHBLTMODE
MB_ABORTRETRYIGNORE
MB_APPLMODAL
MB_CANCELTRYCONTINUE
MB_DEFAULT_DESKTOP_ONLY
MB_DEFBUTTON1
MB_DEFBUTTON2
MB_DEFBUTTON3
MB_DEFBUTTON4
MB_DEFMASK
MB_HELP
MB_ICONASTERISK
MB_ICONERROR
MB_ICONEXCLAMATION
MB_ICONHAND
MB_ICONINFORMATION
MB_ICONMASK
MB_ICONQUESTION
MB_ICONSTOP
MB_ICONWARNING
MB_MISCMASK
MB_MODEMASK
MB_NOFOCUS
MB_OK
META_SETVIEWPORTEXT
META_SETVIEWPORTORG
META_SETWINDOWEXT
META_SETWINDOWORG
META_STRETCHBLT
META_STRETCHDIB
META_TEXTOUT
METAFILE_DRIVER
METRICS_USEDEFAULT
MF_APPEND
MF_BITMAP
MF_BYCOMMAND
MF_BYPOSITION
MF_CHANGE
MF_CHECKED
MF_DEFAULT
MF_DELETE
MF_DISABLED
MF_ENABLED
MF_END
MF_GRAYED
MF_HELP
MF_HILITE
MF_INSERT
MF_MENUBARBREAK
MF_MENUBREAK
MF_MOUSESELECT
MF_OWNERDRAW
MF_POPUP
MF_REMOVE
MF_RIGHTJUSTIFY

MB_OKCANCEL
MB_RETRYCANCEL
MB_RIGHT
MB_RTLREADING
MB_SERVICE_NOTIFICATION
MB_SERVICE_NOTIFICATION_NT3X
MB_SETFOREGROUND
MB_SYSTEMMODAL
MB_TASKMODAL
MB_TOPMOST
MB_TYPEMASK
MB_USERICON
MB_YESNO
MB_YESNOCANCEL
MCHT_CALENDAR
MCHT_CALENDARBK
MCHT_CALENDARDATE
MCHT_CALENDARDATENEXT
MCHT_CALENDARDATEPREV
MCHT_CALENDARDAY
MCHT_CALENDARWEEKNUM
MCHT_NEXT
MCHT_NOWHERE
MCHT_PREV
MCHT_TITLE
MCHT_TITLEBK
MCHT_TITLEBTNNEXT
MCHT_TITLEBTNPREV
MCHT_TITLEMONTH
MCHT_TITLEYEAR
MCHT_TODAYLINK
MCM_FIRST
MCM_GETCOLOR
MCM_GETCURSEL
MCM_GETFIRSTDAYOFWEEK
MCM_GETMAXSELCOUNT
MCM_GETMAXTODAYWIDTH
MCM_GETMINREQRECT
MCM_GETMONTHDELTA
MCM_GETMONTHRANGE
MCM_GETRANGE
MCM_GETSELRANGE
MCM_GETTODAY
MCM_GETUNICODEFORMAT
MCM_HITTEST
MCM_SETCOLOR
MF_SEPARATOR
MF_STRING
MF_SYSMENU
MF_UNCHECKED
MF_UNHILITE
MF_USECHECKBITMAPS
MFCOMMENT
MFS_CHECKED
MFS_DEFAULT
MFS_DISABLED
MFS_ENABLED
MFS_GRAYED
MFS_HILITE
MFS_UNCHECKED
MFS_UNHILITE
MFT_BITMAP
MFT_MENUBARBREAK
MFT_MENUBREAK
MFT_OWNERDRAW
MFT_RADIOCHECK
MFT_RIGHTJUSTIFY
MFT_RIGHTORDER
MFT_SEPARATOR
MFT_STRING
MIIM_BITMAP
MIIM_CHECKMARKS
MIIM_DATA
MIIM_FTYPE
MIIM_ID
MIIM_STATE
MIIM_STRING
MIIM_SUBMENU
MIIM_TYPE
MIM_APPLYTOSUBMENUS
MIM_BACKGROUND
MIM_HELPID
MIM_MAXHEIGHT
MIM_MENUDATA
MIM_STYLE
MINSYSCOMMAND
MK_CONTROL
MK_LBUTTON
MK_MBUTTON
MK_RBUTTON
MK_SHIFT
MK_XBUTTON1

MCM_SETCURSEL
MCM_SETDAYSTATE
MCM_SETFIRSTDAYOFWEEK
MCM_SETMAXSELCOUNT
MCM_SETMONTHDELTA
MCM_SETRANGE
MCM_SETSELRANGE
MCM_SETTODAY
MCM_SETUNICODEFORMAT
MCN_GETDAYSTATE
MCN_SELCHANGE
MCN_SELECT
MCS_DAYSTATE
MCS_MULTISELECT
MCS_NOTODAY
MCS_NOTODAYCIRCLE
MCS_WEEKNUMBERS
MCSC_BACKGROUND
MCSC_MONTHBK
MCSC_TEXT
MCSC_TITLEBK
MCSC_TITLETEXT
MCSC_TRAILINGTEXT
MDIS_ALLCHILDSTYLES
MDITILE_HORIZONTAL
MDITILE_SKIPDISABLED
MDITILE_VERTICAL
MDITILE_ZORDER
META_ANIMATEPALETTE
META_ARC
META_BITBLT
META_CHORD
META_CREATEBRUSHINDIRECT
META_CREATEFONTINDIRECT
META_CREATEPALETTE
META_CREATEPATTERNBRUSH
META_CREATEPENINDIRECT
META_CREATEREGION
META_DELETEOBJECT
META_DIBBITBLT
META_DIBCREATEPATTERNBRUSH
META_DIBSTRETCHBLT
META_ELLIPSE
META_ESCAPE
META_EXCLUDECLIPRECT
META_EXTFLOODFILL
MK_XBUTTON2
MKF_AVAILABLE
MKF_CONFIRMHOTKEY
MKF_HOTKEYACTIVE
MKF_HOTKEYSOUND
MKF_INDICATOR
MKF_LEFTBUTTONDOWN
MKF_LEFTBUTTONSEL
MKF_MODIFIERS
MKF_MOUSEKEYSON
MKF_MOUSEMODE
MKF_REPLACENUMBERS
MKF_RIGHTBUTTONDOWN
MKF_RIGHTBUTTONSEL
MM_ANISOTROPIC
MM_HIENGLISH
MM_HIMETRIC
MM_ISOTROPIC
MM_LOENGLISH
MM_LOMETRIC
MM_MAX
MM_MAX_AXES_NAMELEN
MM_MAX_FIXEDSCALE
MM_MAX_NUMAXES
MM_MIN
MM_TEXT
MM_TWIPS
MN_GETHMENU
MNC_CLOSE
MNC_EXECUTE
MNC_IGNORE
MNC_SELECT
MND_CONTINUE
MND_ENDMENU
MNGO_NOERROR
MNGO_NOINTERFACE
MNGOF_BOTTOMGAP
MNGOF_TOPGAP
MNS_AUTODISMISS
MNS_CHECKORBMP
MNS_DRAGDROP
MNS_MODELESS
MNS_NOCHECK
MNS_NOTIFYBYPOS
MOD_ALT
MOD_CONTROL

META_EXTTEXTOUT
META_FILLREGION
META_FLOODFILL
META_FRAMEREGION
META_INTERSECTCLIPRECT
META_INVERTREGION
META_LINETO
META_MOVETO
META_OFFSETCLIPRGN
META_OFFSETVIEWPORTORG
META_OFFSETWINDOWORG
META_PAINTREGION
META_PATBLT
META_PIE
META_POLYGON
META_POLYLINE
META_POLYPOLYGON
META_REALIZEPALETTE
META_RECTANGLE
META_RESIZEPALETTE
META_RESTOREDC
META_ROUNDRECT
META_SAVEDC
META_SCALEVIEWPORTEXT
META_SCALEWINDOWEXT
META_SELECTCLIPREGION
META_SELECTOBJECT
META_SELECTPALETTE
META_SETBKCOLOR
META_SETBKMODE
META_SETDIBTODEV
META_SETLAYOUT
META_SETMAPMODE
META_SETMAPPERFLAGS
META_SETPALENTRIES
META_SETPIXEL
META_SETPOLYFILLMODE
META_SETRELABS
META_SETROP2
META_SETSTRETCHBLTMODE
META_SETTEXTALIGN
META_SETTEXTCHAREXTRA
META_SETTEXTCOLOR
META_SETTEXTJUSTIFICATION
MOD_SHIFT
MOD_WIN
MONITOR_DEFAULTTONEAREST
MONITOR_DEFAULTTONULL
MONITOR_DEFAULTTOPRIMARY
MONITORINFOF_PRIMARY
MONO_FONT
MOUSE_ATTRIBUTES_CHANGED
MOUSE_MOVE_ABSOLUTE
MOUSE_MOVE_RELATIVE
MOUSE_VIRTUAL_DESKTOP
MOUSEEVENTF_ABSOLUTE
MOUSEEVENTF_LEFTDOWN
MOUSEEVENTF_LEFTUP
MOUSEEVENTF_MIDDLEDOWN
MOUSEEVENTF_MIDDLEUP
MOUSEEVENTF_MOVE
MOUSEEVENTF_RIGHTDOWN
MOUSEEVENTF_RIGHTUP
MOUSEEVENTF_VIRTUALDESK
MOUSEEVENTF_WHEEL
MOUSEEVENTF_XDOWN
MOUSEEVENTF_XUP
MOUSETRAILS
MSGF_COMMCTRL_BEGINDRAG
MSGF_COMMCTRL_DRAGSELECT
MSGF_COMMCTRL_SIZEHEADER
MSGF_COMMCTRL_TOOLBARCUST
MSGF_DIALOGBOX
MSGF_MAX
MSGF_MENU
MSGF_MESSAGEBOX
MSGF_NEXTWINDOW
MSGF_SCROLLBAR
MSGF_USER
MWMO_ALERTABLE
MWMO_INPUTAVAILABLE
MWMO_WAITALL
MWT_IDENTITY
MWT_LEFTMULTIPLY
MWT_MAX
MWT_MIN
MWT_RIGHTMULTIPLY

N

NEWFRAME
NEXTBAND
NF_QUERY
NF_REQUERY
NFR_ANSI
NFR_UNICODE
NFS_ALL
NFS_BUTTON
NFS_EDIT
NFS_LISTCOMBO
NFS_STATIC
NFS_USEFONTASSOC
NM_CHAR
NM_CLICK
NM_CUSTOMDRAW
NM_DBLCLK
NM_HOVER
NM_KEYDOWN
NM_KILLFOCUS
NM_LDOWN
NM_NCHITTEST
NM_OUTOFMEMORY
NM_RCLICK
NM_RDBLCLK
NM_RDOWN
NM_RELEASEDCAPTURE
NM_RETURN
NM_SETCURSOR
NM_SETFOCUS
NM_THEMECHANGED
NM_TOOLTIPSCREATED
NONANTIALIASED_QUALITY
NTM_DSIG
NTM_MULTIPLEMASTER
NTM_NONNEGATIVE_AC
NTM_PS_OPENTYPE
NTM_TT_OPENTYPE
NTM_TYPE1
NULL
NULL_BRUSH
NULL_PEN
NULLREGION
NUMBRUSHES
NUMCOLORS
NUMFONTS
NUMMARKERS
NUMPENS
NUMRESERVED

O

OBJ_BITMAP
OBJ_BRUSH
OBJ_COLORSPACE
OBJ_DC
OBJ_ENHMETADC
OBJ_ENHMETAFILE
OBJ_EXTPEN
OBJ_FONT
OBJ_MEMDC
OBJ_METADC
OBJ_METAFILE
OBJ_PAL
OBJ_PEN
OBJ_REGION
OBM_BTNCORNERS
OBM_BTSIZE
OBM_CHECK
ODS_FOCUS
ODS_GRAYED
ODS_HOTLIGHT
ODS_INACTIVE
ODS_NOACCEL
ODS_NOFOCUSRECT
ODS_SELECTED
ODT_BUTTON
ODT_COMBOBOX
ODT_HEADER
ODT_LISTBOX
ODT_LISTVIEW
ODT_MENU
ODT_STATIC
ODT_TAB
OEM_CHARSET
OEM_FIXED_FONT

OBM_CHECKBOXES
OBM_CLOSE
OBM_COMBO
OBM_DNARROW
OBM_DNARROWD
OBM_DNARROWI
OBM_LFARROW
OBM_LFARROWD
OBM_LFARROWI
OBM_MNARROW
OBM_OLD_CLOSE
OBM_OLD_DNARROW
OBM_OLD_LFARROW
OBM_OLD_REDUCE
OBM_OLD_RESTORE
OBM_OLD_RGARROW
OBM_OLD_UPARROW
OBM_OLD_ZOOM
OBM_REDUCE
OBM_REDUCED
OBM_RESTORE
OBM_RESTORED
OBM_RGARROW
OBM_RGARROWD
OBM_RGARROWI
OBM_SIZE
OBM_UPARROW
OBM_UPARROWD
OBM_UPARROWI
OBM_ZOOM
OBM_ZOOMD
OCR_APPSTARTING
OCR_CROSS
OCR_HAND
OCR_IBEAM
OCR_ICOCUR
OCR_ICON
OCR_NO
OCR_NORMAL
OCR_SIZE
OCR_SIZEALL
OCR_SIZENESW
OCR_SIZENS
OCR_SIZENWSE
OCR_SIZEWE
OCR_UP
OFN_ALLOWMULTISELECT
OFN_CREATEPROMPT
OFN_DONTADDTORECENT
OFN_ENABLEHOOK
OFN_ENABLEINCLUDENOTIFY
OFN_ENABLESIZING
OFN_ENABLETEMPLATE
OFN_ENABLETEMPLATEHANDLE
OFN_EX_NOPLACESBAR
OFN_EXPLORER
OFN_EXTENSIONDIFFERENT
OFN_FILEMUSTEXIST
OFN_FORCESHOWHIDDEN
OFN_HIDEREADONLY
OFN_LONGNAMES
OFN_NOCHANGEDIR
OFN_NODEREFERENCELINKS
OFN_NOLONGNAMES
OFN_NONETWORKBUTTON
OFN_NOREADONLYRETURN
OFN_NOTESTFILECREATE
OFN_NOVALIDATE
OFN_OVERWRITEPROMPT
OFN_PATHMUSTEXIST
OFN_READONLY
OFN_SHAREAWARE
OFN_SHAREFALLTHROUGH
OFN_SHARENOWARN
OFN_SHAREWARN
OFN_SHOWHELP
OIC_BANG
OIC_ERROR
OIC_HAND
OIC_INFORMATION
OIC_NOTE
OIC_QUES
OIC_SAMPLE
OIC_WARNING
OIC_WINLOGO
OPAQUE
OPENCHANNEL
ORD_LANGDRIVER
OUT_CHARACTER_PRECIS
OUT_DEFAULT_PRECIS
OUT_DEVICE_PRECIS
OUT_OUTLINE_PRECIS

OCR_WAIT
ODA_DRAWENTIRE
ODA_FOCUS
ODA_SELECT
ODS_CHECKED
ODS_COMBOBOXEDIT
ODS_DEFAULT
ODS_DISABLED
OUT_PS_ONLY_PRECIS
OUT_RASTER_PRECIS
OUT_SCREEN_OUTLINE_PRECIS
OUT_STRING_PRECIS
OUT_STROKE_PRECIS
OUT_TT_ONLY_PRECIS
OUT_TT_PRECIS

P

PAN_ANY
PAN_ARMSTYLE_INDEX
PAN_BENT_ARMS_DOUBLE_SERIF
PAN_BENT_ARMS_HORZ
PAN_BENT_ARMS_SINGLE_SERIF
PAN_BENT_ARMS_VERT
PAN_BENT_ARMS_WEDGE
PAN_CONTRAST_HIGH
PAN_CONTRAST_INDEX
PAN_CONTRAST_LOW
PAN_CONTRAST_MEDIUM
PAN_CONTRAST_MEDIUM_HIGH
PAN_CONTRAST_MEDIUM_LOW
PAN_CONTRAST_NONE
PAN_CONTRAST_VERY_HIGH
PAN_CONTRAST_VERY_LOW
PAN_CULTURE_LATIN
PAN_FAMILY_DECORATIVE
PAN_FAMILY_PICTORIAL
PAN_FAMILY_SCRIPT
PAN_FAMILY_TEXT_DISPLAY
PAN_FAMILYTYPE_INDEX
PAN_LETT_NORMAL_BOXED
PAN_LETT_NORMAL_CONTACT
PAN_LETT_NORMAL_FLATTENED
PAN_LETT_NORMAL_OFF_CENTER
PAN_LETT_NORMAL_ROUNDED
PAN_LETT_NORMAL_SQUARE
PAN_LETT_NORMAL_WEIGHTED
PAN_LETT_OBLIQUE_BOXED
PAN_LETT_OBLIQUE_CONTACT
PAN_LETT_OBLIQUE_FLATTENED
PAN_LETT_OBLIQUE_OFF_CENTER
PAN_LETT_OBLIQUE_ROUNDED
PAN_LETT_OBLIQUE_SQUARE
PD_USEDEVMODECOPIES
PD_USEDEVMODECOPIESANDCOLLATE
PD_USELARGETEMPLATE
PDEVICESIZE
PFD_DEPTH_DONTCARE
PFD_DOUBLEBUFFER
PFD_DOUBLEBUFFER_DONTCARE
PFD_DRAW_TO_BITMAP
PFD_DRAW_TO_WINDOW
PFD_GENERIC_ACCELERATED
PFD_GENERIC_FORMAT
PFD_MAIN_PLANE
PFD_NEED_PALETTE
PFD_NEED_SYSTEM_PALETTE
PFD_OVERLAY_PLANE
PFD_STEREO
PFD_STEREO_DONTCARE
PFD_SUPPORT_DIRECTDRAW
PFD_SUPPORT_GDI
PFD_SUPPORT_OPENGL
PFD_SWAP_COPY
PFD_SWAP_EXCHANGE
PFD_SWAP_LAYER_BUFFERS
PFD_TYPE_COLORINDEX
PFD_TYPE_RGBA
PFD_UNDERLAY_PLANE
PGB_BOTTOMORRIGHT
PGB_TOPORLEFT
PGF_CALCHEIGHT
PGF_CALCWIDTH
PGF_DEPRESSED
PGF_GRAYED
PGF_HOT
PGF_INVISIBLE
PGF_NORMAL

PAN_LETT_OBLIQUE_WEIGHTED
PAN_LETTERFORM_INDEX
PAN_MIDLINE_CONSTANT_POINTED
PAN_MIDLINE_CONSTANT_SERIFED
PAN_MIDLINE_CONSTANT_TRIMMED
PAN_MIDLINE_HIGH_POINTED
PAN_MIDLINE_HIGH_SERIFED
PAN_MIDLINE_HIGH_TRIMMED
PAN_MIDLINE_INDEX
PAN_MIDLINE_LOW_POINTED
PAN_MIDLINE_LOW_SERIFED
PAN_MIDLINE_LOW_TRIMMED
PAN_MIDLINE_STANDARD_POINTED
PAN_MIDLINE_STANDARD_SERIFED
PAN_MIDLINE_STANDARD_TRIMMED
PAN_NO_FIT
PAN_PROP_CONDENSED
PAN_PROP_EVEN_WIDTH
PAN_PROP_EXPANDED
PAN_PROP_MODERN
PAN_PROP_MONOSPACED
PAN_PROP_OLD_STYLE
PAN_PROP_VERY_CONDENSED
PAN_PROP_VERY_EXPANDED
PAN_PROPORTION_INDEX
PAN_SERIF_BONE
PAN_SERIF_COVE
PAN_SERIF_EXAGGERATED
PAN_SERIF_FLARED
PAN_SERIF_NORMAL_SANS
PAN_SERIF_OBTUSE_COVE
PAN_SERIF_OBTUSE_SANS
PAN_SERIF_OBTUSE_SQUARE_COVE
PAN_SERIF_PERP_SANS
PAN_SERIF_ROUNDED
PAN_SERIF_SQUARE
PAN_SERIF_SQUARE_COVE
PAN_SERIF_THIN
PAN_SERIF_TRIANGLE
PAN_SERIFSTYLE_INDEX
PAN_STRAIGHT_ARMS_DOUBLE_SERIF
PAN_STRAIGHT_ARMS_HORZ
PAN_STRAIGHT_ARMS_SINGLE_SERIF
PAN_STRAIGHT_ARMS_VERT
PAN_STRAIGHT_ARMS_WEDGE
PAN_STROKE_GRADUAL_DIAG
PGF_SCROLLDOWN
PGF_SCROLLLEFT
PGF_SCROLLRIGHT
PGF_SCROLLUP
PGK_CONTROL
PGK_MENU
PGK_SHIFT
PGM_FIRST
PGM_FORWARDMOUSE
PGM_GETBKCOLOR
PGM_GETBORDER
PGM_GETBUTTONSIZE
PGM_GETBUTTONSTATE
PGM_GETDROPTARGET
PGM_GETPOS
PGM_RECALCSIZE
PGM_SETBKCOLOR
PGM_SETBORDER
PGM_SETBUTTONSIZE
PGM_SETCHILD
PGM_SETPOS
PGN_CALCSIZE
PGN_HOTITEMCHANGE
PGN_SCROLL
PGS_AUTOSCROLL
PGS_DRAGNDROP
PGS_HORZ
PGS_VERT
PHYSICALHEIGHT
PHYSICALOFFSETX
PHYSICALOFFSETY
PHYSICALWIDTH
PLANES
PM_NOREMOVE
PM_NOYIELD
PM_REMOVE
PMB_ACTIVE
POLYFILL_LAST
POLYGONALCAPS
POSTSCRIPT_DATA
POSTSCRIPT_IDENTIFY
POSTSCRIPT_IGNORE
POSTSCRIPT_INJECTION
POSTSCRIPT_PASSTHROUGH
PR_JOBSTATUS
PRF_CHECKVISIBLE

PAN_STROKE_GRADUAL_HORZ
PAN_STROKE_GRADUAL_TRAN
PAN_STROKE_GRADUAL_VERT
PAN_STROKE_INSTANT_VERT
PAN_STROKE_RAPID_HORZ
PAN_STROKE_RAPID_VERT
PAN_STROKEVARIATION_INDEX
PAN_WEIGHT_BLACK
PAN_WEIGHT_BOLD
PAN_WEIGHT_BOOK
PAN_WEIGHT_DEMI
PAN_WEIGHT_HEAVY
PAN_WEIGHT_INDEX
PAN_WEIGHT_LIGHT
PAN_WEIGHT_MEDIUM
PAN_WEIGHT_NORD
PAN_WEIGHT_THIN
PAN_WEIGHT_VERY_LIGHT
PAN_XHEIGHT_CONSTANT_LARGE
PAN_XHEIGHT_CONSTANT_SMALL
PAN_XHEIGHT_CONSTANT_STD
PAN_XHEIGHT_DUCKING_LARGE
PAN_XHEIGHT_DUCKING_SMALL
PAN_XHEIGHT_DUCKING_STD
PAN_XHEIGHT_INDEX
PANOSE_COUNT
PASSTHROUGH
PBM_DELTAPOS
PBM_GETPOS
PBM_GETRANGE
PBM_SETBARCOLOR
PBM_SETBKCOLOR
PBM_SETMARQUEE
PBM_SETPOS
PBM_SETRANGE
PBM_SETRANGE32
PBM_SETSTEP
PBM_STEPIT
PBS_MARQUEE
PBS_SMOOTH
PBS_VERTICAL
PBT_APMBATTERYLOW
PBT_APMOEMEVENT
PBT_APMPOWERSTATUSCHANGE
PBT_APMQUERYSTANDBY
PBT_APMQUERYSTANDBYFAILED
PRF_CHILDREN
PRF_CLIENT
PRF_ERASEBKGND
PRF_NONCLIENT
PRF_OWNED
PRINTER_FONTTYPE
PRINTRATEUNIT_CPS
PRINTRATEUNIT_IPM
PRINTRATEUNIT_LPM
PRINTRATEUNIT_PPM
PROOF_QUALITY
PS_ALTERNATE
PS_COSMETIC
PS_DASH
PS_DASHDOT
PS_DASHDOTDOT
PS_DOT
PS_ENDCAP_FLAT
PS_ENDCAP_MASK
PS_ENDCAP_ROUND
PS_ENDCAP_SQUARE
PS_GEOMETRIC
PS_INSIDEFRAME
PS_JOIN_BEVEL
PS_JOIN_MASK
PS_JOIN_MITER
PS_JOIN_ROUND
PS_NULL
PS_SOLID
PS_STYLE_MASK
PS_TYPE_MASK
PS_USERSTYLE
PSD_DEFAULTMINMARGINS
PSD_DISABLEMARGINS
PSD_DISABLEORIENTATION
PSD_DISABLEPAGEPAINTING
PSD_DISABLEPAPER
PSD_DISABLEPRINTER
PSD_ENABLEPAGEPAINTHOOK
PSD_ENABLEPAGESETUPHOOK
PSD_ENABLEPAGESETUPTEMPLATE
PSD_ENABLEPAGESETUPTEMPLATEHANDLE
PSD_INHUNDREDTHSOFMILLIMETERS
PSD_INTHOUSANDTHSOFINCHES
PSD_INWININIINTLMEASURE
PSD_MARGINS

PBT_APMQUERYSUSPEND
PBT_APMQUERYSUSPENDFAILED
PBT_APMRESUMEAUTOMATIC
PBT_APMRESUMECRITICAL
PBT_APMRESUMESTANDBY
PBT_APMRESUMESUSPEND
PBT_APMSTANDBY
PBT_APMSUSPEND
PBTF_APMRESUMEFROMFAILURE
PC_EXPLICIT
PC_INTERIORS
PC_NOCOLLAPSE
PC_NONE
PC_PATHS
PC_POLYGON
PC_POLYPOLYGON
PC_RECTANGLE
PC_RESERVED
PC_SCANLINE
PC_STYLED
PC_TRAPEZOID
PC_WIDE
PC_WIDESTYLED
PC_WINDPOLYGON
PD_ALLPAGES
PD_COLLATE
PD_CURRENTPAGE
PD_DISABLEPRINTTOFILE
PD_ENABLEPRINTHOOK
PD_ENABLEPRINTTEMPLATE
PD_ENABLEPRINTTEMPLATEHANDLE
PD_ENABLESETUPHOOK
PD_ENABLESETUPTEMPLATE
PD_ENABLESETUPTEMPLATEHANDLE
PD_EXCLUSIONFLAGS
PD_HIDEPRINTTOFILE
PD_NOCURRENTPAGE
PD_NONETWORKBUTTON
PD_NOPAGENUMS
PD_NOSELECTION
PD_NOWARNING
PD_PAGENUMS
PD_PRINTSETUP
PD_PRINTTOFILE
PD_RESULT_APPLY
PD_RESULT_CANCEL
PSD_MINMARGINS
PSD_NONETWORKBUTTON
PSD_NOWARNING
PSD_RETURNDEFAULT
PSD_SHOWHELP
PSIDENT_GDICENTRIC
PSIDENT_PSCENTRIC
PSINJECT_BEGINDEFAULTS
PSINJECT_BEGINPAGESETUP
PSINJECT_BEGINPROLOG
PSINJECT_BEGINSETUP
PSINJECT_BEGINSTREAM
PSINJECT_BOUNDINGBOX
PSINJECT_COMMENTS
PSINJECT_DOCNEEDEDRES
PSINJECT_DOCSUPPLIEDRES
PSINJECT_DOCUMENTPROCESSCOLORS
PSINJECT_DOCUMENTPROCESSCOLORSATEND
PSINJECT_ENDDEFAULTS
PSINJECT_ENDPAGECOMMENTS
PSINJECT_ENDPAGESETUP
PSINJECT_ENDPROLOG
PSINJECT_ENDSETUP
PSINJECT_ENDSTREAM
PSINJECT_EOF
PSINJECT_ORIENTATION
PSINJECT_PAGEBBOX
PSINJECT_PAGENUMBER
PSINJECT_PAGEORDER
PSINJECT_PAGES
PSINJECT_PAGESATEND
PSINJECT_PAGETRAILER
PSINJECT_PLATECOLOR
PSINJECT_PSADOBE
PSINJECT_SHOWPAGE
PSINJECT_TRAILER
PSINJECT_VMRESTORE
PSINJECT_VMSAVE
PSPROTOCOL_ASCII
PSPROTOCOL_BCP
PSPROTOCOL_BINARY
PSPROTOCOL_TBCP
PT_BEZIERTO
PT_CLOSEFIGURE
PT_LINETO
PT_MOVETO

PD_RESULT_PRINT
PD_RETURNDC
PD_RETURNDEFAULT
PD_RETURNIC
PD_SELECTION
PD_SHOWHELP
PW_CLIENTONLY
PWR_CRITICALRESUME
PWR_FAIL
PWR_OK
PWR_SUSPENDREQUEST
PWR_SUSPENDRESUME

Q

QDI_DIBTOSCREEN
QDI_GETDIBITS
QDI_SETDIBITS
QDI_STRETCHDIB
QS_ALLEVENTS
QS_ALLINPUT
QS_ALLPOSTMESSAGE
QS_HOTKEY
QS_INPUT
QS_KEY
QS_MOUSE
QS_MOUSEBUTTON
QS_MOUSEMOVE
QS_PAINT
QS_POSTMESSAGE
QS_RAWINPUT
QS_SENDMESSAGE
QS_TIMER
QUERYDIBSUPPORT
QUERYESCSUPPORT

R

R2_BLACK
R2_COPYPEN
R2_LAST
R2_MASKNOTPEN
R2_MASKPEN
R2_MASKPENNOT
R2_MERGENOTPEN
R2_MERGEPEN
R2_MERGEPENNOT
R2_NOP
R2_NOT
R2_NOTCOPYPEN
R2_NOTMASKPEN
R2_NOTMERGEPEN
R2_NOTXORPEN
R2_WHITE
R2_XORPEN
RASTER_FONTTYPE
RASTERCAPS
RB_BEGINDRAG
RB_DELETEBAND
RB_DRAGMOVE
RB_ENDDRAG
RB_GETBANDBORDERS
RB_GETBANDCOUNT
RBN_ENDDRAG
RBN_GETOBJECT
RBN_HEIGHTCHANGE
RBN_LAYOUTCHANGED
RBN_MINMAX
RBNM_ID
RBNM_LPARAM
RBNM_STYLE
RBS_AUTOSIZE
RBS_BANDBORDERS
RBS_DBLCLKTOGGLE
RBS_FIXEDORDER
RBS_REGISTERDROP
RBS_TOOLTIPS
RBS_VARHEIGHT
RBS_VERTICALGRIPPER
RBSTR_CHANGERECT
RC_BANDING
RC_BIGFONT
RC_BITBLT
RC_BITMAP64
RC_DEVBITS
RC_DI_BITMAP
RC_DIBTODEV
RC_FLOODFILL

RB_GETBANDINFO
RB_GETBANDINFOA
RB_GETBANDINFOW
RB_GETBANDMARGINS
RB_GETBARHEIGHT
RB_GETBARINFO
RB_GETBKCOLOR
RB_GETCOLORSCHEME
RB_GETDROPTARGET
RB_GETPALETTE
RB_GETRECT
RB_GETROWCOUNT
RB_GETROWHEIGHT
RB_GETTEXTCOLOR
RB_GETTOOLTIPS
RB_GETUNICODEFORMAT
RB_HITTEST
RB_IDTOINDEX
RB_INSERTBAND
RB_INSERTBANDA
RB_INSERTBANDW
RB_MAXIMIZEBAND
RB_MINIMIZEBAND
RB_MOVEBAND
RB_PUSHCHEVRON
RB_SETBANDINFO
RB_SETBANDINFOA
RB_SETBANDINFOW
RB_SETBARINFO
RB_SETBKCOLOR
RB_SETCOLORSCHEME
RB_SETPALETTE
RB_SETPARENT
RB_SETTEXTCOLOR
RB_SETTOOLTIPS
RB_SETUNICODEFORMAT
RB_SETWINDOWTHEME
RB_SHOWBAND
RB_SIZETORECT
RBAB_ADDBAND
RBAB_AUTOSIZE
RBBIM_BACKGROUND
RBBIM_CHILD
RBBIM_CHILDSIZE
RBBIM_COLORS
RBBIM_HEADERSIZE
RC_GDI20_OUTPUT
RC_GDI20_STATE
RC_OP_DX_OUTPUT
RC_PALETTE
RC_SAVEBITMAP
RC_SCALING
RC_STRETCHBLT
RC_STRETCHDIB
RDH_RECTANGLES
RDW_ALLCHILDREN
RDW_ERASE
RDW_ERASENOW
RDW_FRAME
RDW_INTERNALPAINT
RDW_INVALIDATE
RDW_NOCHILDREN
RDW_NOERASE
RDW_NOFRAME
RDW_NOINTERNALPAINT
RDW_UPDATENOW
RDW_VALIDATE
REGULAR_FONTTYPE
RELATIVE
RES_CURSOR
RES_ICON
RESTORE_CTM
RGN_AND
RGN_COPY
RGN_DIFF
RGN_ERROR
RGN_MAX
RGN_MIN
RGN_OR
RGN_XOR
RI_KEY_BREAK
RI_KEY_E0
RI_KEY_E1
RI_KEY_MAKE
RI_KEY_TERMSRV_SET_LED
RI_KEY_TERMSRV_SHADOW
RI_MOUSE_BUTTON_1_DOWN
RI_MOUSE_BUTTON_1_UP
RI_MOUSE_BUTTON_2_DOWN
RI_MOUSE_BUTTON_2_UP
RI_MOUSE_BUTTON_3_DOWN
RI_MOUSE_BUTTON_3_UP

RBBIM_ID
RBBIM_IDEALSIZE
RBBIM_IMAGE
RBBIM_LPARAM
RBBIM_SIZE
RBBIM_STYLE
RBBIM_TEXT
RBBS_BREAK
RBBS_CHILDEDGE
RBBS_FIXEDBMP
RBBS_FIXEDSIZE
RBBS_GRIPPERALWAYS
RBBS_HIDDEN
RBBS_HIDETITLE
RBBS_NOGRIPPER
RBBS_NOVERT
RBBS_TOPALIGN
RBBS_USECHEVRON
RBBS_VARIABLEHEIGHT
RBHT_CAPTION
RBHT_CHEVRON
RBHT_CLIENT
RBHT_GRABBER
RBHT_NOWHERE
RBIM_IMAGELIST
RBN_AUTOBREAK
RBN_AUTOSIZE
RBN_BEGINDRAG
RBN_CHEVRONPUSHED
RBN_CHILDSIZE
RBN_DELETEDBAND
RBN_DELETINGBAND
RI_MOUSE_BUTTON_4_DOWN
RI_MOUSE_BUTTON_4_UP
RI_MOUSE_BUTTON_5_DOWN
RI_MOUSE_BUTTON_5_UP
RI_MOUSE_LEFT_BUTTON_DOWN
RI_MOUSE_LEFT_BUTTON_UP
RI_MOUSE_MIDDLE_BUTTON_DOWN
RI_MOUSE_MIDDLE_BUTTON_UP
RI_MOUSE_RIGHT_BUTTON_DOWN
RI_MOUSE_RIGHT_BUTTON_UP
RI_MOUSE_WHEEL
RID_HEADER
RID_INPUT
RIDEV_APPKEYS
RIDEV_CAPTUREMOUSE
RIDEV_EXCLUDE
RIDEV_EXMODEMASK
RIDEV_INPUTSINK
RIDEV_NOHOTKEYS
RIDEV_NOLEGACY
RIDEV_PAGEONLY
RIDEV_REMOVE
RIDI_DEVICEINFO
RIDI_DEVICENAME
RIDI_PREPARSEDDATA
RIM_INPUT
RIM_INPUTSINK
RIM_TYPEHID
RIM_TYPEKEYBOARD
RIM_TYPEMOUSE
RUSSIAN_CHARSET

S

SAVE_CTM
SB_BOTH
SB_BOTTOM
SB_CONST_ALPHA
SB_CTL
SB_ENDSCROLL
SB_GETBORDERS
SB_GETICON
SB_GETPARTS
SB_GETRECT
SB_GETTEXT
SPI_GETFILTERKEYS
SPI_GETFLATMENU
SPI_GETFOCUSBORDERHEIGHT
SPI_GETFOCUSBORDERWIDTH
SPI_GETFONTSMOOTHING
SPI_GETFONTSMOOTHINGCONTRAST
SPI_GETFONTSMOOTHINGORIENTATION
SPI_GETFONTSMOOTHINGTYPE
SPI_GETFOREGROUNDFLASHCOUNT
SPI_GETFOREGROUNDLOCKTIMEOUT
SPI_GETGRADIENTCAPTIONS

SB_GETTEXTA
SB_GETTEXTLENGTH
SB_GETTEXTLENGTHA
SB_GETTEXTLENGTHW
SB_GETTEXTW
SB_GETTIPTEXTA
SB_GETTIPTEXTW
SB_GETUNICODEFORMAT
SB_GRAD_RECT
SB_GRAD_TRI
SB_HORZ
SB_ISSIMPLE
SB_LEFT
SB_LINEDOWN
SB_LINELEFT
SB_LINERIGHT
SB_LINEUP
SB_NONE
SB_PAGEDOWN
SB_PAGELEFT
SB_PAGERIGHT
SB_PAGEUP
SB_PIXEL_ALPHA
SB_PREMULT_ALPHA
SB_RIGHT
SB_SETBKCOLOR
SB_SETICON
SB_SETMINHEIGHT
SB_SETPARTS
SB_SETTEXT
SB_SETTEXTA
SB_SETTEXTW
SB_SETTIPTEXTA
SB_SETTIPTEXTW
SB_SETUNICODEFORMAT
SB_SIMPLE
SB_SIMPLEID
SB_THUMBPOSITION
SB_THUMBTRACK
SB_TOP
SB_VERT
SBARS_SIZEGRIP
SBARS_TOOLTIPS
SBM_ENABLE_ARROWS
SBM_GETPOS
SBM_GETRANGE
SPI_GETGRIDGRANULARITY
SPI_GETHIGHCONTRAST
SPI_GETHOTTRACKING
SPI_GETICONMETRICS
SPI_GETICONTITLELOGFONT
SPI_GETICONTITLEWRAP
SPI_GETKEYBOARDCUES
SPI_GETKEYBOARDDELAY
SPI_GETKEYBOARDPREF
SPI_GETKEYBOARDSPEED
SPI_GETLISTBOXSMOOTHSCROLLING
SPI_GETLOWPOWERACTIVE
SPI_GETLOWPOWERTIMEOUT
SPI_GETMENUANIMATION
SPI_GETMENUDROPALIGNMENT
SPI_GETMENUFADE
SPI_GETMENUSHOWDELAY
SPI_GETMENUUNDERLINES
SPI_GETMINIMIZEDMETRICS
SPI_GETMOUSE
SPI_GETMOUSECLICKLOCK
SPI_GETMOUSECLICKLOCKTIME
SPI_GETMOUSEHOVERHEIGHT
SPI_GETMOUSEHOVERTIME
SPI_GETMOUSEHOVERWIDTH
SPI_GETMOUSEKEYS
SPI_GETMOUSESONAR
SPI_GETMOUSESPEED
SPI_GETMOUSETRAILS
SPI_GETMOUSEVANISH
SPI_GETNONCLIENTMETRICS
SPI_GETPOWEROFFACTIVE
SPI_GETPOWEROFFTIMEOUT
SPI_GETSCREENREADER
SPI_GETSCREENSAVEACTIVE
SPI_GETSCREENSAVERRUNNING
SPI_GETSCREENSAVETIMEOUT
SPI_GETSELECTIONFADE
SPI_GETSERIALKEYS
SPI_GETSHOWIMEUI
SPI_GETSHOWSOUNDS
SPI_GETSNAPTODEFBUTTON
SPI_GETSOUNDSENTRY
SPI_GETSTICKYKEYS
SPI_GETTOGGLEKEYS
SPI_GETTOOLTIPANIMATION

SBM_GETSCROLLBARINFO
SBM_GETSCROLLINFO
SBM_SETPOS
SBM_SETRANGE
SBM_SETRANGEREDRAW
SBM_SETSCROLLINFO
SBN_SIMPLEMODECHANGE
SBS_BOTTOMALIGN
SBS_HORZ
SBS_LEFTALIGN
SBS_RIGHTALIGN
SBS_SIZEBOX
SBS_SIZEBOXBOTTOMRIGHTALIGN
SBS_SIZEBOXTOPLEFTALIGN
SBS_SIZEGRIP
SBS_TOPALIGN
SBS_VERT
SBT_NOBORDERS
SBT_NOTABPARSING
SBT_OWNERDRAW
SBT_POPOUT
SBT_RTLREADING
SBT_TOOLTIPS
SC_ARRANGE
SC_CLOSE
SC_CONTEXTHELP
SC_DEFAULT
SC_HOTKEY
SC_HSCROLL
SC_ICON
SC_KEYMENU
SC_MAXIMIZE
SC_MINIMIZE
SC_MONITORPOWER
SC_MOUSEMENU
SC_MOVE
SC_NEXTWINDOW
SC_PREVWINDOW
SC_RESTORE
SC_SCREENSAVE
SC_SEPARATOR
SC_SIZE
SC_TASKLIST
SC_VSCROLL
SC_ZOOM
SCALINGFACTORX
SPI_GETTOOLTIPFADE
SPI_GETUIEFFECTS
SPI_GETWHEELSCROLLLINES
SPI_GETWINDOWSEXTENSION
SPI_GETWORKAREA
SPI_ICONHORIZONTALSPACING
SPI_ICONVERTICALSPACING
SPI_LANGDRIVER
SPI_SCREENSAVERRUNNING
SPI_SETACCESSTIMEOUT
SPI_SETACTIVEWINDOWTRACKING
SPI_SETACTIVEWNDTRKTIMEOUT
SPI_SETACTIVEWNDTRKZORDER
SPI_SETANIMATION
SPI_SETBEEP
SPI_SETBLOCKSENDINPUTRESETS
SPI_SETBORDER
SPI_SETCARETWIDTH
SPI_SETCOMBOBOXANIMATION
SPI_SETCURSORS
SPI_SETCURSORSHADOW
SPI_SETDEFAULTINPUTLANG
SPI_SETDESKPATTERN
SPI_SETDESKWALLPAPER
SPI_SETDOUBLECLICKTIME
SPI_SETDOUBLECLKHEIGHT
SPI_SETDOUBLECLKWIDTH
SPI_SETDRAGFULLWINDOWS
SPI_SETDRAGHEIGHT
SPI_SETDRAGWIDTH
SPI_SETDROPSHADOW
SPI_SETFASTTASKSWITCH
SPI_SETFILTERKEYS
SPI_SETFLATMENU
SPI_SETFOCUSBORDERHEIGHT
SPI_SETFOCUSBORDERWIDTH
SPI_SETFONTSMOOTHING
SPI_SETFONTSMOOTHINGCONTRAST
SPI_SETFONTSMOOTHINGORIENTATION
SPI_SETFONTSMOOTHINGTYPE
SPI_SETFOREGROUNDFLASHCOUNT
SPI_SETFOREGROUNDLOCKTIMEOUT
SPI_SETGRADIENTCAPTIONS
SPI_SETGRIDGRANULARITY
SPI_SETHANDHELD
SPI_SETHIGHCONTRAST

SCALINGFACTORY
SCREEN_FONTTYPE
SELECTPAPERSOURCE
SERKF_AVAILABLE
SERKF_INDICATOR
SERKF_SERIALKEYSON
SET_ARC_DIRECTION
SET_BACKGROUND_COLOR
SET_BOUNDS
SET_CLIP_BOX
SET_MIRROR_MODE
SET_POLY_MODE
SET_SCREEN_ANGLE
SET_SPREAD
SETABORTPROC
SETALLJUSTVALUES
SETCHARSET
SETCOLORTABLE
SETCOPYCOUNT
SETDIBSCALING
SETICMPROFILE_EMBEDED
SETKERNTRACK
SETLINECAP
SETLINEJOIN
SETMITERLIMIT
SHADEBLENDCAPS
SHIFTJIS_CHARSET
SHOW_FULLSCREEN
SHOW_ICONWINDOW
SHOW_OPENNOACTIVATE
SHOW_OPENWINDOW
SIF_ALL
SIF_DISABLENOSCROLL
SIF_PAGE
SIF_POS
SIF_RANGE
SIF_TRACKPOS
SIMPLEREGION
SIMULATED_FONTTYPE
SIZE_MAXHIDE
SIZE_MAXIMIZED
SIZE_MAXSHOW
SIZE_MINIMIZED
SIZE_RESTORED
SIZEFULLSCREEN
SIZEICONIC
SPI_SETHOTTRACKING
SPI_SETICONMETRICS
SPI_SETICONS
SPI_SETICONTITLELOGFONT
SPI_SETICONTITLEWRAP
SPI_SETKEYBOARDCUES
SPI_SETKEYBOARDDELAY
SPI_SETKEYBOARDPREF
SPI_SETKEYBOARDSPEED
SPI_SETLANGTOGGLE
SPI_SETLISTBOXSMOOTHSCROLLING
SPI_SETLOWPOWERACTIVE
SPI_SETLOWPOWERTIMEOUT
SPI_SETMENUANIMATION
SPI_SETMENUDROPALIGNMENT
SPI_SETMENUFADE
SPI_SETMENUSHOWDELAY
SPI_SETMENUUNDERLINES
SPI_SETMINIMIZEDMETRICS
SPI_SETMOUSE
SPI_SETMOUSEBUTTONSWAP
SPI_SETMOUSECLICKLOCK
SPI_SETMOUSECLICKLOCKTIME
SPI_SETMOUSEHOVERHEIGHT
SPI_SETMOUSEHOVERTIME
SPI_SETMOUSEHOVERWIDTH
SPI_SETMOUSEKEYS
SPI_SETMOUSESONAR
SPI_SETMOUSESPEED
SPI_SETMOUSETRAILS
SPI_SETMOUSEVANISH
SPI_SETNONCLIENTMETRICS
SPI_SETPENWINDOWS
SPI_SETPOWEROFFACTIVE
SPI_SETPOWEROFFTIMEOUT
SPI_SETSCREENREADER
SPI_SETSCREENSAVEACTIVE
SPI_SETSCREENSAVERRUNNING
SPI_SETSCREENSAVETIMEOUT
SPI_SETSELECTIONFADE
SPI_SETSERIALKEYS
SPI_SETSHOWIMEUI
SPI_SETSHOWSOUNDS
SPI_SETSNAPTODEFBUTTON
SPI_SETSOUNDSENTRY
SPI_SETSTICKYKEYS

SIZENORMAL
SIZEPALETTE
SIZEZOOMHIDE
SIZEZOOMSHOW
SKF_AUDIBLEFEEDBACK
SKF_AVAILABLE
SKF_CONFIRMHOTKEY
SKF_HOTKEYACTIVE
SKF_HOTKEYSOUND
SKF_INDICATOR
SKF_LALTLATCHED
SKF_LALTLOCKED
SKF_LCTLLATCHED
SKF_LCTLLOCKED
SKF_LSHIFTLATCHED
SKF_LSHIFTLOCKED
SKF_LWINLATCHED
SKF_LWINLOCKED
SKF_RALTLATCHED
SKF_RALTLOCKED
SKF_RCTLLATCHED
SKF_RCTLLOCKED
SKF_RSHIFTLATCHED
SKF_RSHIFTLOCKED
SKF_RWINLATCHED
SKF_RWINLOCKED
SKF_STICKYKEYSON
SKF_TRISTATE
SKF_TWOKEYSOFF
SLE_ERROR
SLE_MINORERROR
SLE_WARNING
SM_ARRANGE
SM_CLEANBOOT
SM_CMETRICS
SM_CMONITORS
SM_CMOUSEBUTTONS
SM_CXBORDER
SM_CXCURSOR
SM_CXDLGFRAME
SM_CXDOUBLECLK
SM_CXDRAG
SM_CXEDGE
SM_CXFIXEDFRAME
SM_CXFOCUSBORDER
SM_CXFRAME
SPI_SETTOGGLEKEYS
SPI_SETTOOLTIPANIMATION
SPI_SETTOOLTIPFADE
SPI_SETUIEFFECTS
SPI_SETWHEELSCROLLLINES
SPI_SETWORKAREA
SPIF_SENDCHANGE
SPIF_SENDWININICHANGE
SPIF_UPDATEINIFILE
SS_BITMAP
SS_BLACKFRAME
SS_BLACKRECT
SS_CENTER
SS_CENTERIMAGE
SS_EDITCONTROL
SS_ELLIPSISMASK
SS_ENDELLIPSIS
SS_ENHMETAFILE
SS_ETCHEDFRAME
SS_ETCHEDHORZ
SS_ETCHEDVERT
SS_GRAYFRAME
SS_GRAYRECT
SS_ICON
SS_LEFT
SS_LEFTNOWORDWRAP
SS_NOPREFIX
SS_NOTIFY
SS_OWNERDRAW
SS_PATHELLIPSIS
SS_REALSIZECONTROL
SS_REALSIZEIMAGE
SS_RIGHT
SS_RIGHTJUST
SS_SIMPLE
SS_SUNKEN
SS_TYPEMASK
SS_USERITEM
SS_WHITEFRAME
SS_WHITERECT
SS_WORDELLIPSIS
SSF_AVAILABLE
SSF_INDICATOR
SSF_SOUNDSENTRYON
SSGF_DISPLAY
SSGF_NONE

SM_CXFULLSCREEN
SM_CXHSCROLL
SM_CXHTHUMB
SM_CXICON
SM_CXICONSPACING
SM_CXMAXIMIZED
SM_CXMAXTRACK
SM_CXMENUCHECK
SM_CXMENUSIZE
SM_CXMIN
SM_CXMINIMIZED
SM_CXMINSPACING
SM_CXMINTRACK
SM_CXSCREEN
SM_CXSIZE
SM_CXSIZEFRAME
SM_CXSMICON
SM_CXSMSIZE
SM_CXVIRTUALSCREEN
SM_CXVSCROLL
SM_CYBORDER
SM_CYCAPTION
SM_CYCURSOR
SM_CYDLGFRAME
SM_CYDOUBLECLK
SM_CYDRAG
SM_CYEDGE
SM_CYFIXEDFRAME
SM_CYFOCUSBORDER
SM_CYFRAME
SM_CYFULLSCREEN
SM_CYHSCROLL
SM_CYICON
SM_CYICONSPACING
SM_CYKANJIWINDOW
SM_CYMAXIMIZED
SM_CYMAXTRACK
SM_CYMENU
SM_CYMENUCHECK
SM_CYMENUSIZE
SM_CYMIN
SM_CYMINIMIZED
SM_CYMINSPACING
SM_CYMINTRACK
SM_CYSCREEN
SM_CYSIZE
SSTF_BORDER
SSTF_CHARS
SSTF_DISPLAY
SSTF_NONE
SSWF_CUSTOM
SSWF_DISPLAY
SSWF_NONE
SSWF_TITLE
SSWF_WINDOW
START_PAGE_GENERAL
STARTDOC
STATE_SYSTEM_ALERT_HIGH
STATE_SYSTEM_ALERT_LOW
STATE_SYSTEM_ALERT_MEDIUM
STATE_SYSTEM_ANIMATED
STATE_SYSTEM_BUSY
STATE_SYSTEM_CHECKED
STATE_SYSTEM_COLLAPSED
STATE_SYSTEM_DEFAULT
STATE_SYSTEM_EXPANDED
STATE_SYSTEM_EXTSELECTABLE
STATE_SYSTEM_FLOATING
STATE_SYSTEM_FOCUSABLE
STATE_SYSTEM_FOCUSED
STATE_SYSTEM_HOTTRACKED
STATE_SYSTEM_INDETERMINATE
STATE_SYSTEM_INVISIBLE
STATE_SYSTEM_LINKED
STATE_SYSTEM_MARQUEED
STATE_SYSTEM_MIXED
STATE_SYSTEM_MOVEABLE
STATE_SYSTEM_MULTISELECTABLE
STATE_SYSTEM_OFFSCREEN
STATE_SYSTEM_PRESSED
STATE_SYSTEM_PROTECTED
STATE_SYSTEM_READONLY
STATE_SYSTEM_SELECTABLE
STATE_SYSTEM_SELECTED
STATE_SYSTEM_SELFVOICING
STATE_SYSTEM_SIZEABLE
STATE_SYSTEM_TRAVERSED
STATE_SYSTEM_UNAVAILABLE
STATE_SYSTEM_VALID
STD_COPY
STD_CUT
STD_DELETE

SM_CYSIZEFRAME
SM_CYSMCAPTION
SM_CYSMICON
SM_CYSMSIZE
SM_CYVIRTUALSCREEN
SM_CYVSCROLL
SM_CYVTHUMB
SM_DBCSENABLED
SM_DEBUG
SM_IMMENABLED
SM_MEDIACENTER
SM_MENUDROPALIGNMENT
SM_MIDEASTENABLED
SM_MOUSEPRESENT
SM_MOUSEWHEELPRESENT
SM_NETWORK
SM_PENWINDOWS
SM_REMOTECONTROL
SM_REMOTESESSION
SM_RESERVED1
SM_RESERVED2
SM_RESERVED3
SM_RESERVED4
SM_SAMEDISPLAYFORMAT
SM_SECURE
SM_SHOWSOUNDS
SM_SHUTTINGDOWN
SM_SLOWMACHINE
SM_SWAPBUTTON
SM_TABLETPC
SM_XVIRTUALSCREEN
SM_YVIRTUALSCREEN
SMTO_ABORTIFHUNG
SMTO_BLOCK
SMTO_NORMAL
SMTO_NOTIMEOUTIFNOTHUNG
SOUND_SYSTEM_APPEND
SOUND_SYSTEM_APPSTART
SOUND_SYSTEM_BEEP
SOUND_SYSTEM_ERROR
SOUND_SYSTEM_FAULT
SOUND_SYSTEM_INFORMATION
SOUND_SYSTEM_MAXIMIZE
SOUND_SYSTEM_MENUCOMMAND
SOUND_SYSTEM_MENUPOPUP
SOUND_SYSTEM_MINIMIZE
STD_FILENEW
STD_FILEOPEN
STD_FILESAVE
STD_FIND
STD_HELP
STD_PASTE
STD_PRINT
STD_PRINTPRE
STD_PROPERTIES
STD_REDOW
STD_REPLACE
STD_UNDO
STM_GETICON
STM_GETIMAGE
STM_MSGMAX
STM_SETICON
STM_SETIMAGE
STN_CLICKED
STN_DBLCLK
STN_DISABLE
STN_ENABLE
STOCK_LAST
STRETCH_ANDSCANS
STRETCH_DELETESCANS
STRETCH_HALFTONE
STRETCH_ORSCANS
STRETCHBLT
STRICT
SW_ERASE
SW_FORCEMINIMIZE
SW_HIDE
SW_INVALIDATE
SW_MAX
SW_MAXIMIZE
SW_MINIMIZE
SW_NORMAL
SW_OTHERUNZOOM
SW_OTHERZOOM
SW_PARENTCLOSING
SW_PARENTOPENING
SW_RESTORE
SW_SCROLLCHILDREN
SW_SHOW
SW_SHOWDEFAULT
SW_SHOWMAXIMIZED
SW_SHOWMINIMIZED

SOUND_SYSTEM_QUESTION
SOUND_SYSTEM_RESTOREDOWN
SOUND_SYSTEM_RESTOREUP
SOUND_SYSTEM_SHUTDOWN
SOUND_SYSTEM_STARTUP
SOUND_SYSTEM_WARNING
SP_APPABORT
SP_ERROR
SP_NOTREPORTED
SP_OUTOFDISK
SP_OUTOFMEMORY
SP_USERABORT
SPCLPASSTHROUGH2
SPI_GETACCESSTIMEOUT
SPI_GETACTIVEWINDOWTRACKING
SPI_GETACTIVEWNDTRKTIMEOUT
SPI_GETACTIVEWNDTRKZORDER
SPI_GETANIMATION
SPI_GETBEEP
SPI_GETBLOCKSENDINPUTRESETS
SPI_GETBORDER
SPI_GETCARETWIDTH
SPI_GETCOMBOBOXANIMATION
SPI_GETCURSORSHADOW
SPI_GETDEFAULTINPUTLANG
SPI_GETDESKWALLPAPER
SPI_GETDRAGFULLWINDOWS
SPI_GETDROPSHADOW
SPI_GETFASTTASKSWITCH
SW_SHOWMINNOACTIVE
SW_SHOWNA
SW_SHOWNOACTIVATE
SW_SHOWNORMAL
SW_SMOOTHSCROLL
SWP_ASYNCWINDOWPOS
SWP_DEFERERASE
SWP_DRAWFRAME
SWP_FRAMECHANGED
SWP_HIDEWINDOW
SWP_NOACTIVATE
SWP_NOCOPYBITS
SWP_NOMOVE
SWP_NOOWNERZORDER
SWP_NOREDRAW
SWP_NOREPOSITION
SWP_NOSENDCHANGING
SWP_NOSIZE
SWP_NOZORDER
SWP_SHOWWINDOW
SYMBOL_CHARSET
SYSPAL_ERROR
SYSPAL_NOSTATIC
SYSPAL_NOSTATIC256
SYSPAL_STATIC
SYSRGN
SYSTEM_FIXED_FONT
SYSTEM_FONT

T

TA_BASELINE
TA_BOTTOM
TA_CENTER
TA_LEFT
TA_MASK
TA_NOUPDATECP
TA_RIGHT
TA_RTLREADING
TA_TOP
TA_UPDATECP
TB_ADDBITMAP
TB_ADDBUTTONS
TB_ADDBUTTONSA
TB_ADDBUTTONSW
TCN_KEYDOWN
TCN_SELCHANGE
TCN_SELCHANGING
TCS_BOTTOM
TCS_BUTTONS
TCS_EX_FLATSEPARATORS
TCS_EX_REGISTERDROP
TCS_FIXEDWIDTH
TCS_FLATBUTTONS
TCS_FOCUSNEVER
TCS_FOCUSONBUTTONDOWN
TCS_FORCEICONLEFT
TCS_FORCELABELLEFT
TCS_HOTTRACK

TB_ADDSTRING
TB_ADDSTRINGA
TB_ADDSTRINGW
TB_AUTOSIZE
TB_BOTTOM
TB_BUTTONCOUNT
TB_BUTTONSTRUCTSIZE
TB_CHANGEBITMAP
TB_CHECKBUTTON
TB_COMMANDTOINDEX
TB_CUSTOMIZE
TB_DELETEBUTTON
TB_ENABLEBUTTON
TB_ENDTRACK
TB_GETANCHORHIGHLIGHT
TB_GETBITMAP
TB_GETBITMAPFLAGS
TB_GETBUTTON
TB_GETBUTTONINFO
TB_GETBUTTONINFOA
TB_GETBUTTONINFOW
TB_GETBUTTONSIZE
TB_GETBUTTONTEXT
TB_GETBUTTONTEXTA
TB_GETBUTTONTEXTW
TB_GETCOLORSCHEME
TB_GETDISABLEDIMAGELIST
TB_GETEXTENDEDSTYLE
TB_GETHOTIMAGELIST
TB_GETHOTITEM
TB_GETIMAGELIST
TB_GETINSERTMARK
TB_GETINSERTMARKCOLOR
TB_GETITEMRECT
TB_GETMAXSIZE
TB_GETMETRICS
TB_GETOBJECT
TB_GETPADDING
TB_GETRECT
TB_GETROWS
TB_GETSTATE
TB_GETSTRING
TB_GETSTRINGA
TB_GETSTRINGW
TB_GETSTYLE
TB_GETTEXTROWS
TCS_MULTILINE
TCS_MULTISELECT
TCS_OWNERDRAWFIXED
TCS_RAGGEDRIGHT
TCS_RIGHT
TCS_RIGHTJUSTIFY
TCS_SCROLLOPPOSITE
TCS_SINGLELINE
TCS_TABS
TCS_TOOLTIPS
TCS_VERTICAL
TECHNOLOGY
TEXTCAPS
THAI_CHARSET
TKF_AVAILABLE
TKF_CONFIRMHOTKEY
TKF_HOTKEYACTIVE
TKF_HOTKEYSOUND
TKF_INDICATOR
TKF_TOGGLEKEYSON
TM_MULTICODEPAGE
TM_MULTILEVELUNDO
TM_PLAINTEXT
TM_RICHTEXT
TM_SINGLECODEPAGE
TM_SINGLELEVELUNDO
TME_CANCEL
TME_HOVER
TME_LEAVE
TME_NONCLIENT
TME_QUERY
TMPF_DEVICE
TMPF_FIXED_PITCH
TMPF_TRUETYPE
TMPF_VECTOR
TPM_BOTTOMALIGN
TPM_CENTERALIGN
TPM_HORIZONTAL
TPM_HORNEGANIMATION
TPM_HORPOSANIMATION
TPM_LAYOUTRTL
TPM_LEFTALIGN
TPM_LEFTBUTTON
TPM_NOANIMATION
TPM_NONOTIFY
TPM_RECURSE

TB_GETTOOLTIPS
TB_GETUNICODEFORMAT
TB_HIDEBUTTON
TB_HITTEST
TB_INDETERMINATE
TB_INSERTBUTTON
TB_INSERTBUTTONA
TB_INSERTBUTTONW
TB_INSERTMARKHITTEST
TB_ISBUTTONCHECKED
TB_ISBUTTONENABLED
TB_ISBUTTONHIDDEN
TB_ISBUTTONHIGHLIGHTED
TB_ISBUTTONINDETERMINATE
TB_ISBUTTONPRESSED
TB_LINEDOWN
TB_LINEUP
TB_LOADIMAGES
TB_MAPACCELERATOR
TB_MAPACCELERATORA
TB_MAPACCELERATORW
TB_MARKBUTTON
TB_MOVEBUTTON
TB_PAGEDOWN
TB_PAGEUP
TB_PRESSBUTTON
TB_REPLACEBITMAP
TB_SAVERESTORE
TB_SAVERESTOREA
TB_SAVERESTOREW
TB_SETANCHORHIGHLIGHT
TB_SETBITMAPSIZE
TB_SETBUTTONINFO
TB_SETBUTTONINFOA
TB_SETBUTTONINFOW
TB_SETBUTTONSIZE
TB_SETBUTTONWIDTH
TB_SETCMDID
TB_SETCOLORSCHEME
TB_SETDISABLEDIMAGELIST
TB_SETDRAWTEXTFLAGS
TB_SETEXTENDEDSTYLE
TB_SETHOTIMAGELIST
TB_SETHOTITEM
TB_SETIMAGELIST
TB_SETINDENT
TPM_RETURNCMD
TPM_RIGHTALIGN
TPM_RIGHTBUTTON
TPM_TOPALIGN
TPM_VCENTERALIGN
TPM_VERNEGANIMATION
TPM_VERPOSANIMATION
TPM_VERTICAL
TRANSFORM_CTM
TRANSPARENT
TRUE
TRUETYPE_FONTTYPE
TT_AVAILABLE
TT_ENABLED
TT_POLYGON_TYPE
TT_PRIM_CSPLINE
TT_PRIM_LINE
TT_PRIM_QSPLINE
TTDT_AUTOMATIC
TTDT_AUTOPOP
TTDT_INITIAL
TTDT_RESHOW
TTF_ABSOLUTE
TTF_CENTERTIP
TTF_DI_SETITEM
TTF_IDISHWND
TTF_PARSELINKS
TTF_RTLREADING
TTF_SUBCLASS
TTF_TRACK
TTF_TRANSPARENT
TTI_ERROR
TTI_INFO
TTI_NONE
TTI_WARNING
TTM_ACTIVATE
TTM_ADDTOOL
TTM_ADDTOOLA
TTM_ADDTOOLW
TTM_ADJUSTRECT
TTM_DELTOOL
TTM_DELTOOLA
TTM_DELTOOLW
TTM_ENUMTOOLS
TTM_ENUMTOOLSA
TTM_ENUMTOOLSW

TB_SETINSERTMARK
TB_SETINSERTMARKCOLOR
TB_SETMAXTEXTROWS
TB_SETMETRICS
TB_SETPADDING
TB_SETPARENT
TB_SETROWS
TB_SETSTATE
TB_SETSTYLE
TB_SETTOOLTIPS
TB_SETUNICODEFORMAT
TB_SETWINDOWTHEME
TB_THUMBPOSITION
TB_THUMBTRACK
TB_TOP
TBBF_LARGE
TBCD_CHANNEL
TBCD_THUMB
TBCD_TICS
TBCDRF_BLENDICON
TBCDRF_HILITEHOTTRACK
TBCDRF_NOBACKGROUND
TBCDRF_NOEDGES
TBCDRF_NOETCHEDEFFECT
TBCDRF_NOMARK
TBCDRF_NOOFFSET
TBDDRET_DEFAULT
TBDDRET_NODEFAULT
TBDDRET_TREATPRESSED
TBIF_BYINDEX
TBIF_COMMAND
TBIF_IMAGE
TBIF_LPARAM
TBIF_SIZE
TBIF_STATE
TBIF_STYLE
TBIF_TEXT
TBIMHT_AFTER
TBIMHT_BACKGROUND
TBM_CLEARSEL
TBM_CLEARTICS
TBM_GETBUDDY
TBM_GETCHANNELRECT
TBM_GETLINESIZE
TBM_GETNUMTICS
TBM_GETPAGESIZE
TTM_GETBUBBLESIZE
TTM_GETCURRENTTOOL
TTM_GETCURRENTTOOLA
TTM_GETCURRENTTOOLW
TTM_GETDELAYTIME
TTM_GETMARGIN
TTM_GETMAXTIPWIDTH
TTM_GETTEXT
TTM_GETTEXTA
TTM_GETTEXTW
TTM_GETTIPBKCOLOR
TTM_GETTIPTEXTCOLOR
TTM_GETTITLE
TTM_GETTOOLCOUNT
TTM_GETTOOLINFO
TTM_GETTOOLINFOA
TTM_GETTOOLINFOW
TTM_HITTEST
TTM_HITTESTA
TTM_HITTESTW
TTM_NEWTOOLRECT
TTM_NEWTOOLRECTA
TTM_NEWTOOLRECTW
TTM_POP
TTM_POPUP
TTM_RELAYEVENT
TTM_SETDELAYTIME
TTM_SETMARGIN
TTM_SETMAXTIPWIDTH
TTM_SETTIPBKCOLOR
TTM_SETTIPTEXTCOLOR
TTM_SETTITLE
TTM_SETTITLEA
TTM_SETTITLEW
TTM_SETTOOLINFO
TTM_SETTOOLINFOA
TTM_SETTOOLINFOW
TTM_SETWINDOWTHEME
TTM_TRACKACTIVATE
TTM_TRACKPOSITION
TTM_UPDATE
TTM_UPDATETIPTEXT
TTM_UPDATETIPTEXTA
TTM_UPDATETIPTEXTW
TTM_WINDOWFROMPOINT
TTN_GETDISPINFO

TBM_GETPOS
TBM_GETPTICS
TBM_GETRANGEMAX
TBM_GETRANGEMIN
TBM_GETSELEND
TBM_GETSELSTART
TBM_GETTHUMBLENGTH
TBM_GETTHUMBRECT
TBM_GETTIC
TBM_GETTICPOS
TBM_GETTOOLTIPS
TBM_GETUNICODEFORMAT
TBM_SETBUDDY
TBM_SETLINESIZE
TBM_SETPAGESIZE
TBM_SETPOS
TBM_SETRANGE
TBM_SETRANGEMAX
TBM_SETRANGEMIN
TBM_SETSEL
TBM_SETSELEND
TBM_SETSELSTART
TBM_SETTHUMBLENGTH
TBM_SETTIC
TBM_SETTICFREQ
TBM_SETTIPSIDE
TBM_SETTOOLTIPS
TBM_SETUNICODEFORMAT
TBMF_BARPAD
TBMF_BUTTONSPACING
TBMF_PAD
TBN_BEGINADJUST
TBN_BEGINDRAG
TBN_CUSTHELP
TBN_DELETINGBUTTON
TBN_DRAGOUT
TBN_DROPDOWN
TBN_ENDADJUST
TBN_ENDDRAG
TBN_GETBUTTONINFO
TBN_GETBUTTONINFOA
TBN_GETBUTTONINFOW
TBN_GETDISPINFO
TBN_GETDISPINFOA
TBN_GETDISPINFOW
TBN_GETINFOTIP
TTN_GETDISPINFOA
TTN_GETDISPINFOW
TTN_LINKCLICK
TTN_NEEDTEXT
TTN_NEEDTEXTA
TTN_NEEDTEXTW
TTN_POP
TTN_SHOW
TTS_ALWAYSTIP
TTS_BALLOON
TTS_CLOSE
TTS_NOANIMATE
TTS_NOFADE
TTS_NOPREFIX
TURKISH_CHARSET
TV_FIRST
TVC_BYKEYBOARD
TVC_BYMOUSE
TVC_UNKNOWN
TVCDRF_NOIMAGES
TVE_COLLAPSE
TVE_COLLAPSERESET
TVE_EXPAND
TVE_EXPANDPARTIAL
TVE_TOGGLE
TVGN_CARET
TVGN_CHILD
TVGN_DROPHILITE
TVGN_FIRSTVISIBLE
TVGN_LASTVISIBLE
TVGN_NEXT
TVGN_NEXTVISIBLE
TVGN_PARENT
TVGN_PREVIOUS
TVGN_PREVIOUSVISIBLE
TVGN_ROOT
TVHT_ABOVE
TVHT_BELOW
TVHT_NOWHERE
TVHT_ONITEMBUTTON
TVHT_ONITEMICON
TVHT_ONITEMINDENT
TVHT_ONITEMLABEL
TVHT_ONITEMRIGHT
TVHT_ONITEMSTATEICON
TVHT_TOLEFT

TBN_GETINFOTIPA
TBN_GETINFOTIPW
TBN_GETOBJECT
TBN_HOTITEMCHANGE
TBN_INITCUSTOMIZE
TBN_QUERYDELETE
TBN_QUERYINSERT
TBN_RESET
TBN_RESTORE
TBN_SAVE
TBN_TOOLBARCHANGE
TBNF_DI_SETITEM
TBNF_IMAGE
TBNF_TEXT
TBNRF_ENDCUSTOMIZE
TBNRF_HIDEHELP
TBS_AUTOTICKS
TBS_BOTH
TBS_BOTTOM
TBS_DOWNISLEFT
TBS_ENABLESELRANGE
TBS_FIXEDLENGTH
TBS_HORZ
TBS_LEFT
TBS_NOTHUMB
TBS_NOTICKS
TBS_REVERSED
TBS_RIGHT
TBS_TOOLTIPS
TBS_TOP
TBS_VERT
TBSTATE_CHECKED
TBSTATE_ELLIPSES
TBSTATE_ENABLED
TBSTATE_HIDDEN
TBSTATE_INDETERMINATE
TBSTATE_MARKED
TBSTATE_PRESSED
TBSTATE_WRAP
TBSTYLE_ALTDRAG
TBSTYLE_AUTOSIZE
TBSTYLE_BUTTON
TBSTYLE_CHECK
TBSTYLE_CHECKGROUP
TBSTYLE_CUSTOMERASE
TBSTYLE_DROPDOWN
TVHT_TORIGHT
TVIF_CHILDREN
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DataHub™ APIs for C++, Java, and .NET

Version 7.3

An open set of application programming interfaces used to connect custom programs to Cogent DataHub™ software, using DHTP.

Table of Contents

Introduction

These three APIs share, as much as possible, common methods and syntax. For this reason they are distributed in one package and documented in a single book.

- **The DataHub API for C++** lets you write programs in C++ that connect to a DataHub instance over TCP, namely LAN, WAN, or the Internet.
- **The DataHub API for Java** lets you write programs in Java that connect to a DataHub instance over TCP, namely LAN, WAN, or the Internet.
- **The DataHub API for .NET** lets you write programs in .NET that connect to a DataHub instance over TCP, namely LAN, WAN, or the Internet. This API is implemented in C#, but can be used with any .NET language.

Preliminaries

The DataHub APIs for C++, Java, and .NET are made up of two classes, `DataHubConnector` and `DataHubPoint` whose methods allow you to interface with the DataHub program.

System Requirements

The DataHub APIs for C++, Java, and .NET are compatible with:

- Windows XP Home & Professional
- Windows 2000
- Windows NT 4.0 - All Service Packs should be installed.

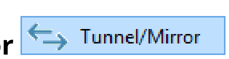
Installation

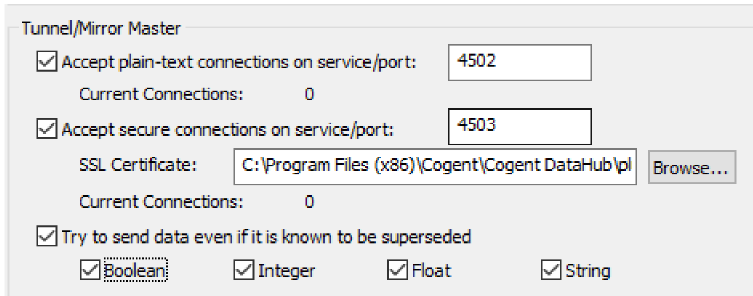
To install the DataHub APIs for C++, Java, and .NET from an archive downloaded from the Cogent web site, follow these steps:

1. Double-click on the program archive `DataHubAPI-7.3-`*`xxxxxx`*`-Windows.exe`.
2. Follow the instructions.

DataHub Configuration

The DataHub instance must be configured to act as a Tunnel/Mirror Master as follows:

1. Right click on the DataHub system-tray icon and choose **Properties**.
2. In the Properties window, select **Tunnel/Mirror** 



3. In the **Tunnelling Master** section, you can configure plain-text or secure tunnelling. Ensure that at least one of these is checked. If you want to change any of the other defaults, please refer to Tunnel/Mirror in the Cogent DataHub manual for more information.

   To optimize throughput, un-check the **Try to send data even if it is known to be superseded** option. This will allow the DataHub instance to drop stale values for points which have already changed before the client has been notified of the original change. The latest value will always be transmitted.

4. Click **OK** to close the Properties window.

C++ Programming

The C++ API is intended for application programmers who are working in an unmanaged C ++ environment in Windows MFC, Windows ATL, Linux, or QNX.

To optimize throughput between your program and DataHub instance when using the C++ API, you can use the **sendBinaryPointMessages** method.

Include Statement for Windows:

```
#include <DataHubConnector.h>
```

Include Statement for Linux, QNX4, and QNX6:

```
#include <cogent/DataHubConnector.h>
```

Java Programming

The Java API implements the `DataHubConnector` class as the basic class used to communicate with the DataHub instance. Programmers writing stand-alone applications need only the `DataHubConnector` and `DataHubPoint` classes.

Java Class Overview

The following classes are included in the Java API installation. They are informally arranged here to give some idea of the interrelationships:

Classes used for general programming

- **`DataHubConnector`** provides connectivity to the DataHub instance.
  - **`DataHubEventConsumer`** implements callbacks for `DataHubConnector`.
    - **`DataHubEventDispatcher`** is an interface that extends `DataHubEventConsumer` class, and is used by the `DataHubBaseApplet` class (see below).
- **`DataHubPoint`** represents DataHub point objects.

Classes used for web programming

- **`DataHubBaseApplet`** is the applet that makes connections to the DataHub instance. It provides access to all the data in a single domain. There need be only one `DataHubBaseApplet` per HTML page, because indivual connections are made using `DataHubListener` (see below). The following two classes extend the `DataHubBaseApplet` class:
  - **`DataHubViewer`** displays a table of all the data in the domain. It implements `DataHubEventConsumer`.
  - **`DataHubLink`** is used to instantiate a `DataHubBaseApplet` for supporting `DataHubListener` widgets. It embeds a small text message "Powered by Cogent" in the page, and it's color: red, yellow, or green, indicates the status of the link.
- **`DataHubListener`** is an applet that gets data from a specific point or points in the DataHub instance. It is a parasite in the sense that it relies on the connection to the DataHub instance provided by a `DataHubBaseApplet`. You can use any number of `DataHubListeners` per HTML page, without noticably affecting the rate of data throughput to the page. The following three widgets are extended from `DataHubListener`:
  - **`DataHubLabel`** displays the value of a DataHub point.
  - **`DataHubEntryField`** is an entry field for changing the value of a DataHub point.
  - **`DataHubButton`** sends a value for a DataHub point.
  - **`DataHubToggleButton`** toggles a DataHub point between two values.
  - **`DataHubCheckBox`** toggles a DataHub point between two values.
  - **`DataHubRadioButton`** A special button, used in a `DataHubRadioGroup`.
  - **`DataHubRadioGroup`** A group of `DataHubRadioButtons` that provides a way to select one of several mutually-exclusive values for a DataHub point.
  - **`DataHubSlider`** changes the value of a DataHub point by sliding a pointer.
  - **`DataHubSpinner`** sets the value of a DataHub point using up and down arrows.
  - **`DataHubProgressBar`** gives a graphical representation of the value of a DataHub point.
- **`DataHubDummy`** is provided as a convenience to the HTML programmer.

For internal use

- **`DataHubRendezvous`** provides a meeting point for the `DataHubBaseApplet` and all of the `DataHubListener` widgets on the page. It is for internal use, providing static data that gets initialized before any applet starts, giving all the applets a means of finding one another.

Import Statements

```
import cogent.*;
```

or

```
import cogent.DataHubConnector;
import cogent.DataHubPoint;
```

.NET Programming

The .NET API is written in C#, and implements the `DataHubConnector` class. You can compile the file `DHNetAPI.cs` to create a .NET library that can be used by any .NET language, such as Visual Basic .NET.

The .NET installation includes a test program that can be used to connect to a DataHub instance to view data graphically. The two data sets supported are the "DataSim" data generated by the local DataSim program, or the "test" data generated by the Internet data set at http://developers.cogentrts.com. The .NET test program will arrange its graph based on the domain name chosen.

Requirement Statement

```
using Cogent.DataHubAPI;
```

Example Programs

There are example programs for the DataHub APIs for C++, Java, and .NET that ship with the installation archive. If you go to the Windows **Start** menu and choose **Cogent**, you'll see **.Net Test Application** and **C++ Test Application** options. The source code for these applications is here (32-bit/64-bit versions of the DataHub program):

```
C:\Program Files (x86)\Cogent\API\
```

```
C:\Program Files\Cogent\API\
```

The DataHubConnector Class

Overview

Syntax

For C++ (Windows MFC, QNX, Linux):

```
class CDataHubConnector : public CWnd
```

For C++ (Windows ATL):

```
class CDataHubConnector : public
            CWindowImpl<CDataHubConnector,CWindow,CFrameWinTraits>
```

For Java:

```
public class DataHubConnector
```

For C#:

```
public class DataHubConnector
```

Remarks

This class provides the base functionality for a client to connect to the DataHub instance. The constructor for this class is `DataHubConnector`. The destructor for this class is `~DataHubConnector`. The methods for this class are arranged by category in the Categorized List of Methods, and alphabetically in the `DataHubConnector` Methods reference.

Requirement Statements

For C++:

```
#include <CDataHubConnector.h>
```

For Java:

```
import cogent.DataHubConnector;
```

For C#:

```
using Cogent.DataHubAPI;
```

Categorized List of Methods

These are most of the methods of the `DataHubConnector` class. The remaining methods, which are used for making callbacks, are presented in the following section.

Status Functions

getCnxState - retrieves the operational state of the connector object.
getCnxStateString - retrieves a string corresponding to the operational state.
getCnxSubStateString - provides detailed information on the connection state (C++ only).
getErrString - retrieves the last error string (C++ only).

Connection Control

setReconnectionDelay - sets the delay time between reconnection attempts.
getReconnectionDelay - retrieves the delay time between reconnection attempts.
startReconnectionTimer - starts the delay timer for reconnection attempts.
cancelReconnectionTimer - stops the delay timer for reconnection attempts.
setHeartbeatTimes - sets the period of the heartbeat and timeout timers.
getHeartbeat - retrieves the heartbeat timer period.
getTimeout - retrieves the timeout timer period.
startHeartbeatTimers - starts the heartbeat and timeout timers.
cancelHeartbeatTimers - cancels the heartbeat and timeout timers.
activeHeartbeatTimers - determines if both heartbeat timers are active.
setConnectionParms - sets the connection parameters.
getHostName - retrieves the host name connection parameter.
getServiceName - retrieves the port service name connection parameter (C++ only).
isConnecting - indicates whether a connection attempt is in progress.
isConnected - indicates whether a connection has been established.
openConnection - attempts to establish a connection to the DataHub instance.
retryConnection - opens a new connection to the DataHub instance (C++ only).
closeConnection - closes the connection to the DataHub instance.
shutdown - prepares for an application shutdown or disconnect (Java and C# only).

Messages

sendLispMessage - sends a message to the DataHub instance (C++ only).
writeCommand - sends a command to DataHub instance (Java and C# only).
escapedString - prepares a string for use with writeCommand (Java and C# only).

Point Handling

initializePointCache - initializes local point cache usage.
lookupPoint - accesses a point from the point cache.
registerDomain - registers to receive updates from domain points.
setDefaultDomain - sets the default domain.
getDefaultDomain - returns the current default domain.
registerPoint - registers to receive updates from a DataHub point.
unregisterPoint - stops receiving updates from a DataHub point.
createPoint - creates a DataHub point.
writePoint - writes a new value to a DataHub point.

`readPoint` - gets the value of a DataHub point.
`setPointLock` - sets the lock attributes of a DataHub point.
`setPointSecurity` - sets the security attributes of a DataHub point.
`appendPointValue` - appends a string to a DataHub point.
`addPointValue` - adds a specified amount to a DataHub point value.
`multiplyPointValue` - multiplies a DataHub point value by a specified amount.
`dividePointValue` - divides the value of the named point by the specified value.

Making Callbacks

There are several callbacks associated with the `DataHubConnector` class. In C++ these are methods of the `DataHubConnector` class itself, while in Java and .NET they are methods of a separate interface, the `DataHubEventConsumer` interface.

Status Changes

`onStatusChange` - a virtual method invoked on change of status.

Connections

`onConnectionSuccess` - a virtual method invoked when a connection is established.
`onAlive` - a virtual method invoked on receipt of a heartbeat from the DataHub instance.
`onConnectionFailure` - a virtual method invoked when a connection or attempt to connect fails.

Message Receipts

`onAsyncMessage` - a virtual method invoked on receipt of a DataHub message.
`onSuccess` - a virtual method invoked on receipt of a success message.
`onError` - a virtual method invoked on receipt of an error message.

Point Changes

`onPointChange` - a virtual method invoked on receipt of a point value change.
`onPointEcho` - a virtual method invoked on receipt of a locally changed point value.

The DataHubPoint Class

The DataHubPoint class represents a DataHub point object.

Overview

Syntax

For C++:

```
class CDataHubPoint
```

For Java:

```
public class DataHubPoint
```

For C#:

```
public class DataHubPoint
```

Remarks

DataHub point objects are the fundamental objects used to write, receive and manipulate data in the DataHub instance, via the DataHubConnector class. The DataHubPoint class provides a rich set of facilities to create, modify and inspect these objects.

DataHub points possess the following properties:

value
: A value whose type is one of PT_TYPE_STRING, PT_TYPE_REAL (a double) or PT_TYPE_INT32 (an int). The value is stored in a corresponding format, and can be converted by the various utilities to access the value.

quality
: Indicates whether the DataHub instance has been updated with actual data or if a point is uninitialized. This is typically either PT_QUALITY_GOOD or PT_QUALITY_BAD. Connection status can also affect the point quality.

confidence
: A user defined value, typically in the range of 0-100%. This can be used to model 'aging' of a point, and support 'fuzzy math' algorithms.

timestamp
: Tags the real-time origin of the point as it is distributed. Typically this is set by the software module originating the value of a point. It is modelled as seconds and nanoseconds, providing a resolution that is limited only by the OS.

userdata
: Allows the user to associate with a specific point whatever object may be useful to the application. This is primarily used by the point cache cability provided by the

DataHubConnector class (see initializePointCache).

`locked`
: Controls access to the point.

`security`
: Controls access to the point.

`flags`
: For internal use.

Requirement Statements

For C++:

```
#include <CDataHubPoint.h>
```

For Java:

```
import cogent.DataHubPoint;
```

For C#:

```
using Cogent.DataHubAPI;
```

See also

Categorized List of Methods, DataHubConnector

Categorized List of Methods

Constructors/Destructors

`DataHubPoint` - constructs a DataHubPoint object in various ways.
`~DataHubPoint` - destroys a DataHubPoint object.

General Methods

`clear` - clears the point.
`getName` - retrieves the point name.
`setName` - assigns a name to the point.
`qualifyName` - creates a point name string qualified by a domain name.
`unqualifyName` - removes the domain name qualifier from a point name.

Point Data Access Methods

`getType` - retrieves the point data type.
`setValue` - sets the point data to the specified type and value.
`setValueFromString` - sets the point data to the value represented by a string.
`getDoubleValue` - retrieves the point data as a double-typed value.

`getIntValue` - retrieves the point data as an int-typed value.
`getStringValue` - retrieves the point data as a string.

Point Information Access Methods

`setInfo` - sets the information properties of a point.
`setQuality` - sets the point quality.
`getQuality` - retrieves the point quality.
`getQualityString` - generates a string representing the point quality.
`setConfidence` - sets the user's confidence in a point.
`getConfidence` - retrieves the user's point confidence.
`setTimeStamp` - sets the point timestamp in various ways.
`getSeconds` - retrieves the timestamp seconds component.
`getNanoseconds` - retrieves the timestamp nanoseconds component.
`getDateString` - generates a 'standard' timestamp data/time representation.
`getListeners` - retrieves listeners on the point (Java only).
`removeListener` - removes a listener from the point (Java only).
`setLocked` - sets the locked property of the point.
`getLocked` - retrieves the locked property of the point.
`setSecurity` - sets the security property of the point.
`getSecurity` - retrieves the security property of the point.
`setFlags` - sets the flags property of the point.
`getFlags` - retrieves the flags property of the point.
`setUserdata` - associates the point with a user object.
`getUserdata` - retrieves the user object associated with the point.

Operators

`operator=` - assigns a new value to a DataHubPoint object (C++ only).

Appendix A. GNU General Public License

Version 2, June 1991

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Version 2.1, February 1999

Preamble

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That's all there is to it!

DataHubConnector Methods

These are the methods associated with the DataHubConnector class, listed alphabetically. To see the same methods grouped according to how they are used, please refer to the Categorized List of Methods.

DataHubConnector

`DataHubConnector` — creates a DataHubConnector object.

Synopsis

For C++:

`CDataHubConnector``();`

`void;`

For Java:

`DataHubConnector``(`*`parent`*`);`

`DataHubEventDispatcher` *`parent`*`;`

For C#:

`DataHubConnector``(`*`parent`*`);`

`DataHubEventConsumer` *`parent`*`;`

Parameters

`parent`
The parent for this object.

Description

Creates a `DataHubConnector` object.

See Also

`DataHubConnector` Class, Categorized List of Methods

~DataHubConnector

~DataHubConnector — destroys a DataHubConnector object.

Synopsis

For C++:

```
~DataHubConnector();

void;
```

For Java, and C#:

None.

Description

Destroys a DataHubConnector object.

See Also

DataHubConnector Class, Categorized List of Methods

activeHeartbeatTimers

`activeHeartbeatTimers` — determines if both heartbeat timers are active.

Synopsis

For C++ and C#:

```
bool activeHeartbeatTimers();

void;
```

For Java:

```
boolean activeHeartbeatTimers();

void;
```

Returns

TRUE if both heartbeat timers are active, FALSE otherwise.

Description

This method is used to determine if both heartbeat timers were successfully started. The heartbeat timers are normally started when a connection has been established (see `startHeartbeatTimers`). You may wish to check that the heartbeat mechanism is active before registering a domain or points.

See Also

`startHeartbeatTimers`, `cancelHeartbeatTimers`, `setHeartbeatTimes`

Example

```
void DataGenerator::onConnectionSuccess (LPCTSTR host, int port)
{
    _super::onConnectionSuccess (host, port); // starts the
                                              // heartbeat timers

    // proceed to start heartbeat and specify domain
    int domain_flags = DHC_FLAG_REG_FUTURE|
                       DHC_FLAG_REG_QUALIFY|
                       DHC_FLAG_REG_ONCEONLY;

    if (activeHeartbeatTimers()) // started the heartbeat timers
    {
```

```
        if (registerDomain (m_DomainName,
                            (DHC_tRegFlags)domain_flags) == ST_OK)
        {
            RegisterPoints();
        }
    }
}
```

addPointValue

addPointValue — adds a specified amount to a DataHub point value.

Synopsis

For C++:

```
ST_STATUS addPointValue(point, value);

CDataHubPoint& point;
double value;

ST_STATUS addPointValue(pointname, value);

LPCTSTR pointname;
double value;
```

For Java and C#:

```
Exception addPointValue(point, value);

DataHubPoint point;
double value;

Exception addPointValue(pointname, value);

String pointname;
double value;
```

Parameters

point

A DataHubPoint object. The name, seconds and nanoseconds members must be valid.

pointname

The name of the point. The point timestamp is automatically set to the current time.

value

The value to add to the current point value.

Returns

For C++:

- ST_OK if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the onSuccess or onError message handlers.

- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

Adds the specified value to the current value of the DataHub point. If the DataHub point is not of a numeric type, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: `ST_WRONG_TYPE`
msg: `"Wrong type"`

If the DataHub point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: `ST_NO_POINT`
msg: `"Point does not exist"`

Examples

```
addPointValue(_T("intPoint1"), 1.0);
```

```
CDataHubPoint point;
point.name = "realPoint2";
setPointTimeStamp (&point);
addPointValue(&point, 1.234);
```

See Also

`appendPointValue`, `multiplyPointValue`, `dividePointValue`, `writePoint`

appendPointValue

appendPointValue — appends a string to a DataHub point.

Synopsis

For C++:

```
ST_STATUS appendPointValue(point, str);

CDataHub& point;
LPCTSTR str;

ST_STATUS appendPointValue(pointname, str);

LPCTSTR pointname;
LPCTSTR str;
```

For Java and C#:

```
Exception appendPointValue(point, str);

DataHub point;
String str;

Exception appendPointValue(pointname, str);

String pointname;
String str;
```

Parameters

point
: A pointer structure of type `DataHubPoint`. The name, seconds and nanoseconds members must be valid.

pointname
: The name of the point. The point timestamp is automatically set to the current time.

str
: A string to append to the current point string value.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.

- ST_NO_TASK if a connection to the DataHub instance does not exist.
- ST_ERROR if the connection socket is unable to send the message.

Description

This method appends the specified string to the current string value of the DataHub point. If the DataHub point is not a string type (PT_TYPE_STRING), then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_WRONG_TYPE
msg: "Wrong type"

If the DataHub point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_NO_POINT
msg: "Point does not exist"

Examples

```
appendPointValue(_T("strPoint1"), _T("this"));
```

```
CDataHubPoint point;
point.name = "strPoint1";
setPointTimeStamp (&point);
appendPointValue(&point, _T(" and that"));
```

See Also

addPointValue, multiplyPointValue, dividePointValue, writePoint

cancelHeartbeatTimers

`cancelHeartbeatTimers` — cancels the heartbeat and timeout timers.

Synopsis

For C++, Java, and C#:

```
void cancelHeartbeatTimers();

void;
```

Description

See `setHeartbeatTimes` for more details on the timeout timer feature.

See Also

`setHeartbeatTimes`, `startHeartbeatTimers`

cancelReconnectionTimer

`cancelReconnectionTimer` — stops the delay timer for reconnection attempts.

Synopsis

For C++, Java, and C#:

```
void cancelReconnectionTimer();

void;
```

Description

This method cancels the reconnection delay timer. The default behaviour of the `onConnectionSuccess` method is to make a call to `cancelReconnectionTimer`. See `setReconnectionDelay` for more details.

closeConnection

`closeConnection` — closes the connection to the DataHub instance.

Synopsis

For C++:

```
void closeConnection();

void;
```

For Java and C#:

```
void closeConnection(reason);

String reason;
```

Description

This method closes the connection to the DataHub instance.

See Also

`openConnection`, `retryConnection`, `isConnecting`, `isConnected`

createPoint

`createPoint` — creates a DataHub point.

Synopsis

For C++:

```
ST_STATUS createPoint(point);

CDataHubPoint& point;

ST_STATUS createPoint(pointname);

LPCTSTR pointname;
```

For Java and C#:

```
Exception createPoint(point);

DataHubPoint point;

Exception createPoint(pointname);

String pointname;
```

Parameters

point
: A `DataHubPoint` object. The name member must be valid.

pointname
: The name of the point.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

This method creates a DataHub point. The point quality is set to `PT_QUALITY_BAD` and the timestamp is set to `0`. The point type and value are undefined.

See Also

registerPoint, unregisterPoint

dividePointValue

`CDataHubConnector: dividePointValue` — divides the value of the named point by the specified value.

Synopsis

For C++:

```
ST_STATUS dividePointValue(point, value);

CDataHubPoint& point;
double value;

ST_STATUS dividePointValue(pointname, value);

LPCTSTR pointname;
double value;
```

For Java and C#:

```
Exception dividePointValue(point, value);

DataHubPoint point;
double value;

Exception dividePointValue(pointname, value);

String pointname;
double value;
```

Parameters

point
: A `DataHubPoint` object. The name, seconds and nanoseconds members must be valid.

pointname
: The name of the point. The point timestamp is automatically set to the current time.

value
: The value by which to divide the current point value.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.

- ST_NO_TASK if a connection to the DataHub instance does not exist.
- ST_ERROR if the connection socket is unable to send the message.

Description

This method divides the current value of the DataHub point by the specified value. If the DataHub point is not of a numeric type, then DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_WRONG_TYPE
msg: "Wrong type"

If the DataHub point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_NO_POINT
msg: "Point does not exist"

Examples

```
dividePointValue(_T("intPoint1"), 1.0);
```

```
CDataHubPoint point;
point.name = "realPoint2";
setPointTimeStamp (&point);
dividePointValue(&point, 1.234);
```

See Also

appendPointValue, addPointValue, multiplyPointValue, writePoint

escapedString

escapedString — prepares a string for use with writeCommand (Java and C# only).

Synopsis

For Java:

```
String escapedString(str, quoted);

String str;
boolean quoted;

String escapedString(str, quoted, special_only);

String str;
boolean quoted;
boolean special_only;
```

For C#:

```
String escapedString(str, quoted);

String str;
bool quoted;

String escapedString(str, quoted, special_only);

String str;
bool quoted;
bool special_only;
```

Parameters

This has not yet been documented.

Returns

This has not yet been documented.

Description

This method prepares a string for use with `writeCommand`.

See Also

`writeCommand`

getCnxState

getCnxState — retrieves the operational state of the connector object.

Synopsis

For C++, Java, and C#:

```
DHC_tState getCnxState();

void;
```

Returns

The current state of the connector object, a member of DHC_tState as defined below.

Description

Retrieves the state of the DataHub connector object. The state is primarily informational, since the user cannot directly change it.

State	Description
DHC_STATE_NONE	This is the initial (0) state, and is immediately changed to DHC_STATE_IDLE within the constructor unless a fundamental initialization error has occurred (eg. Window creation).
DHC_STATE_IDLE	A connection has never been attempted.
DHC_STATE_INITIALIZED	Internal initialization completed (by the first attempt to connect) and ready to connect.
DHC_STATE_CONNECTING	Currently in the process of connecting. See getCnxSubStateString for detailed connection sub-state.
DHC_STATE_CONNECTING_CLOSING	This is a transient internal state used to force closure of an open connection before attempting to reconnect.
DHC_STATE_CONNECTED	A DataHub connection exists.
DHC_STATE_ERROR	An error was detected. See getErrString. This is generally a transient state, since the default behaviour is to attempt to reconnect.
DHC_STATE_RETRY_DELAY	The reconnection timer is active and after which an attempt will be made to reconnect (see setReconnectionDelay).

See Also

onStatusChange, getCnxStateString, getCnxSubStateString, isConnecting, isConnected, getErrString, getReconnectionDelay, setReconnectionDelay

getCnxStateString

`getCnxStateString` — retrieves a string corresponding to the operational state.

Synopsis

For C++:

```
CString getCnxStateString();
```

```
void;
```

For Java and C#:

```
String getCnxStateString();
```

```
void;
```

Returns

The string corresponding to the operational state of the object (as returned by `getCnxState`).

Description

This method retrieves a string corresponding to the operational state.

See Also

`getCnxState`

getCnxSubStateString

`getCnxSubStateString` — provides detailed information on the connection state (C++ only).

Synopsis

For C++:

```
CString getCnxSubStateString();

void;
```

Returns

A string containing a short description of the connection status.

Description

This method provides some additional insight into the status of the DataHub connection. A new status string may be obtained on each `onStatusChange`, along with the main `getCnxStateString`, and used for logging or otherwise indicating the connection sequence.

See Also

`onStatusChange` `getCnxStateString`, `getCnxState`

getDefaultDomain

getDefaultDomain — returns the current default domain.

Synopsis

For C++:

```
LPCTSTR getDefaultDomain();
```

```
void;
```

For Java, and C#:

```
String getDefaultDomain();
```

```
void;
```

Returns

The domain name string, or NULL[1] if none has been set.

Description

This method accesses the domain name string specified by the setDefaultDomain method. The value returned is based on a local (client) copy, and is therefore not dependent on the connection status.

See Also

setDefaultDomain

[1] null in Java and C#.

getErrString

`getErrString` — retrieves the last error string (C++ only).

Synopsis

For C++:

```
LPCTSTR getErrString ();
```

```
void;
```

Returns

The string corresponding to the last error detected.

See Also

onError

getHeartbeat

`getHeartbeat` — retrieves the heartbeat timer period.

Synopsis

For C++, Java, and C#:

```
long getHeartbeat();
```

```
void;
```

Returns

The period in milliseconds of the heartbeat timer.

Description

See `setHeartbeatTimes` for more details on the heartbeat timer feature.

See Also

`setHeartbeatTimes`, `getTimeout`

getHostName

`getHostName` — retrieves the host name connection parameter.

Synopsis

For C++:

```
CString getHostName();

void;
```

For Java and C#:

```
String getHostName();

void;
```

Returns

A string containing the currently set host name.

Description

This method retrieves the host name string set by the `setConnectionParms` command, or an empty string if it has never been set. The value is not affected by `openConnection` or the status of the connection.

getPort

`getPort` — retrieves the port connection parameter.

Synopsis

For C++, Java, and C#:

```
int getPort();

void;
```

Returns

The connection port number.

Description

This method retrieves the port number set by the `setConnectionParms` command, or `0` if it has never been set. If `setConnectionParms` was used to specify a service name, then the port will be the result of an attempt to convert or look up the servicename specified. The value is not affected by `openConnection` or the status of the connection.

getReconnectionDelay

`getReconnectionDelay` — retrieves the delay time between reconnection attempts.

Synopsis

For C++, Java, and C#:

```
long getReconnectionDelay();

void;
```

Returns

The reconnection delay time setting, in milliseconds.

Description

See `setReconnectionDelay` for more details.

getServiceName

getServiceName — retrieves the port service name connection parameter (C++ only).

Synopsis

For C++:

```
CString getServiceName();

void;
```

Returns

A string containing the currently set port service name.

Description

This method retrieves the port service name string set by the setConnectionParms command, or an empty string if it has never been set. If setConnectionParms was used to set the port directly (as an integer), then the servicename will not have been set. The value is not affected by openConnection or the status of the connection.

getTimeout

`getTimeout` — retrieves the timeout timer period.

Synopsis

For C++, Java, and C#:

```
long getTimeout();

void;
```

Returns

The period in milliseconds of the timeout timer.

Description

See `setHeartbeatTimes` for more details on the timeout timer feature.

See Also

`setHeartbeatTimes`, `getHeartbeat`

initializePointCache

initializePointCache — initializes local point cache usage.

Synopsis

For C++:

```
ST_STATUS initializePointCache();

void;
```

For Java, and C#:

```
Exception initializePointCache();

void;
```

Returns

For C++:

ST_OK if the point cache was successfully initialized, otherwise ST_ERROR.

Description

The point cache is a list of all points received. It is automatically built and maintained as each point update is received from the DataHub instance. In order for a point to exist in the cache, a readPoint, registerPoint, or registerDomain was required to generate the point update. The value, type, and timestamp of the cached points is updated, but the point itself is persistent.

The point cache allows the user to associate data with the point (through its m_userdata member) and quickly access it when the point is updated (from onPointChange). The point cache also provides a way to synchronously read a current point value, avoiding the readPoint method which provides the point value asynchronously.

Example 1

This example illustrates use of the point cache to efficiently update a user interface control with the latest point value.

```
....
// during initialization, we register for all points
registerDomain("myDomain",
               DHC_FLAG_REG_FUTURE | DHC_FLAG_ONCEONLY_FUTURE);
....
```

```
// associate an MFC control with a point
//  perhaps this is called on user entering a desired point name
//  (don't forget to clear the previously associated point userdata!)
void onUiPointNameChanged(LPCTSTR pointname, CStatic *pValueWnd)
{
    DataHubPoint *ppoint = lookupPoint (pointname);
    if (ppoint)
    {
        ppoint->m_userdata = pointname;
    }
}
void onPointChange (DataHubPoint point)
{
    if (point.m_userdata)
    {
        // update the MFC control
        CStatic *pTxt = point.m_userdata;
        CString str;
        str.Format("%f", point.getDoubleValue());
        pTxt->SetWindowText(str);
    }
}
```

Example 2

This example illustrates use of the point cache to provide immediate access to a point value.

```
....
// part of the initialization code
registerDomain("myDomain",
                DHC_FLAG_REG_FUTURE | DHC_FLAG_ONCEONLY_FUTURE);
....

// read point value:
DataHubPoint *point = lookupPoint("IntPoint1");
int ival = point->getIntValue();
....
```

See Also

registerPoint, unregisterPoint, createPoint

isConnected

`isConnected` — indicates whether a connection has been established.

Synopsis

For C++ and C#:

```
bool isConnected();

void;
```

For Java:

```
boolean isConnected();

void;
```

Returns

TRUE if a connection to the DataHub instance has been established, FALSE otherwise.

See Also

`isConnecting`, `openConnection`, `retryConnection`, `closeConnection`

isConnecting

`isConnecting` — indicates whether a connection attempt is in progress.

Synopsis

For C++ and C#:

```
bool isConnecting();

void;
```

For Java:

```
boolean isConnecting();

void;
```

Returns

TRUE if the object is currently in the process of establishing a connection with the DataHub instance, FALSE otherwise.

See Also

`isConnected`, `openConnection`, `retryConnection`, `closeConnection`

lookupPoint

`lookupPoint` — accesses a point from the point cache.

Synopsis

For C++:

```
DataHubPoint* lookupPoint(pointname);
```

```
LPCTSTR pointname;
```

For Java, and C#:

```
DataHubPoint lookupPoint(pointname);
```

```
String pointname;
```

Parameters

pointname
The name of the point.

Returns

The corresponding point object in the point cache.

Description

This method returns a pointer to a cached `DataHubPoint` object matching the specified name object. If no object matching the name is in the cache, then `NULL`[1] is returned.

See Also

`initializePointCache`

[1] `null` in Java and C#.

multiplyPointValue

`multiplyPointValue` — multiplies a DataHub point value by a specified amount.

Synopsis

For C++:

```
ST_STATUS multiplyPointValue(point, value);

CDataHubPoint& point;
double value;

ST_STATUS multiplyPointValue(pointname, value);

LPCTSTR pointname;
double value;
```

For Java and C#:

```
Exception multiplyPointValue(point, value);

DataHubPoint point;
double value;

Exception multiplyPointValue(pointname, value);

String pointname;
double value;
```

Parameters

point
: A `DataHubPoint` object. The name, seconds and nanoseconds members must be valid.

pointname
: The name of the point. The point timestamp is automatically set to the current time.

value
: The value by which to multiply the current point value.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.

- ST_NO_TASK if a connection to the DataHub instance does not exist.
- ST_ERROR if the connection socket is unable to send the message.

Description

This method multiplies the current value of the DataHub point by the specified value. If the DataHub point is not of a numeric type, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_WRONG_TYPE
msg: "Wrong type"

If the DataHub point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_NO_POINT
msg: "Point does not exist"

Examples

```
multiplyPointValue(_T("intPoint1"), 1.0);
```

```
CDataHubPoint point;
point.name = "realPoint2";
setPointTimeStamp (&point);
multiplyPointValue(&point, 1.234);
```

See Also

appendPointValue, addPointValue, dividePointValue, writePoint

openConnection

`openConnection` — attempts to establish a connection to the DataHub instance.

Synopsis

For C++, Java, and C#:

```
void openConnection();

void;
```

Description

This method attempts to establish a connection to the DataHub instance, using the parameters set by `setConnectionParms`.

See Also

`retryConnection`, `closeConnection`, `isConnecting`, `isConnected`

readPoint

`readPoint` — gets the value of a DataHub point.

Synopsis

For C++:

```
ST_STATUS readPoint(point, create, force);

CDataHubPoint& point;
bool create=TRUE;
bool force=TRUE;

ST_STATUS readPoint(pointname, create, force);

LPCTSTR pointname;
bool create=TRUE;
bool force=TRUE;
```

For Java:

```
Exception readPoint(point);

DataHubPoint point;

Exception readPoint(point, create, force);

DataHubPoint point;
boolean create;
boolean force;

Exception readPoint(pointname);

String pointname;

Exception readPoint(pointname, create, force);

String pointname;
boolean create;
boolean force;
```

For C#:

```
Exception readPoint(point);

DataHubPoint point;

Exception readPoint(point, create, force);
```

```
DataHubPoint point;
bool create;
bool force;

Exception readPoint(pointname);

String pointname;

Exception readPoint(pointname, create, force);

String pointname;
bool create;
bool force;
```

Parameters

point
: A `DataHubPoint` object. The name member must be valid.

pointname
: The name of the point.

create
: If TRUE, then the point is created if it does not already exist. If FALSE and the point does not exist, then an error message will be generated.

force
: If a valid connection to the DataHub instance exists but the message is undeliverable immediately (due to the TCP buffer being full), then if the force parameter is TRUE, the message is queued and will be transmitted when possible.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

This method requests that the value of the specified point be transmitted. The point value is received as a point message, which causes the virtual method `onPointChange` to be called. The point value cannot be obtained synchronously.

If the *create* parameter is FALSE and the point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: `ST_NO_POINT`

msg: `"Point does not exist"`

Examples

```
readPointValue(_T("strPoint1"));
```

```
CDataHubPoint point;
point.name = "strPoint1";
readPoint(&point, FALSE);
```

See Also

writePoint

registerDomain

`registerDomain` — registers to receive updates from domain points.

Synopsis

For C++:

```
ST_STATUS registerDomain(domainname, flags);

LPCTSTR domainname;
int flags;
```

For Java and C#:

```
Exception registerDomain(domainname, flags);

String domainname;
int flags;
```

Parameters

domainname
The name of a domain.

flags
Specifies conditions and actions associated with registering the domain points, as follows (flags may be combined):

- `DHC_FLAG_REG_FUTURE`: points created in the future are also affected. If not set, then only those points existing (in the domain) at the time the command message is received by the DataHub instance are registered.
- `DHC_FLAG_REG_QUALIFY`: point names are to be transmitted with the domain name prepended to the point name, as *domainname*:*pointname*.
- `DHC_FLAG_REG_ONCEONLY`: the point values are transmitted only once, and the points remain unregistered. This mode is useful for obtaining an initial list of available points from which a selection is made of which ones to register.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

This method registers the client to receive updates from the DataHub instance when the value of any points in the specified domain change. The `onPointChange` method is called for each point update received. The `registerDomain` method may be called more than once, and on different domains.

Upon registering the domain, all points currently in that domain of the DataHub instance are immediately transmitted to the client. Points that are subsequently created will only be sent if the `DHC_FLAG_REG_FUTURE` flag is specified. The `DHC_FLAG_REG_QUALIFY` flag is useful for distinguishing points from different domains that have the same name.

In a typical scenario, either there is no need to register for all points, or the point names are not even known. In either case, you can use the `DHC_FLAG_REG_ONCEONLY` flag to generate an initial list of all available points in the specified domain. Then you can call `registerPoint` on any points of interest, as they are received in `onPointChange`.

See Also

`unregisterPoint`, `setDefaultDomain`, `registerPoint`

registerPoint

`registerPoint` — registers to receive updates from a DataHub point.

Synopsis

For C++:

```
ST_STATUS registerPoint(point, create);

CDataHubPoint& point;
bool create=TRUE;

ST_STATUS registerPoint(pointname, create);

LPCTSTR pointname;
bool create=TRUE;
```

For Java:

```
Exception registerPoint(point, create);

DataHubPoint point;
boolean create;

Exception registerPoint(pointname, create);

String pointname;
boolean create;
```

For C#:

```
Exception registerPoint(point, create);

DataHubPoint point;
bool create;

Exception registerPoint(pointname, create);

String pointname;
bool create;
```

Parameters

point
: A `DataHubPoint` object. The name member must be valid.

pointname
: The name of the point.

create

If TRUE, then the point is created if it does not already exist. If FALSE and the point does not exist, then an error message will be generated.

Returns

For C++:

- ST_OK if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the onSuccess or onError message handlers.
- ST_NO_TASK if a connection to the DataHub instance does not exist.
- ST_ERROR if the connection socket is unable to send the message.

Description

When a point is registered with the DataHub instance, any changes to the value of that point in the DataHub instance will cause the onPointChange method to be called. If the DataHub point does not exist, then DataHub instance will respond with an error, and onError will be called with the following arguments:

status: ST_NO_POINT
msg: "Point does not exist"

See Also

writePoint, unregisterPoint, createPoint, registerDomain

retryConnection

`retryConnection` — opens a new connection to the DataHub instance (C++ only).

Synopsis

For C++:

```
void retryConnection();
```

```
void;
```

Description

This method attempts to reestablish a connection to the DataHub instance.

See Also

`openConnection`, `closeConnection`, `isConnecting`, `isConnected`

sendBinaryPointMessages

`sendBinaryPointMessages` — formats data in binary mode (C++ only).

Synopsis

For C++:

ST_STATUS **sendBinaryPointMessages**(*enable*);

bool *enable*;

Parameters

enable
: TRUE enables binary mode, FALSE disables it.

Returns

- ST_OK if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- ST_NO_TASK if no connection to the DataHub instance is established.
- ST_TOO_LARGE if the message string exceeds the message buffer size.
- ST_ERROR if the format contains an error or if the connection socket is unable to send the message.

Description

This method tells the `CDataHubConnector` instance to format data in binary mode, and also to request binary mode transmissions from the DataHub instance. Binary messages are more CPU efficient than ASCII messages.

sendLispMessage

`sendLispMessage` — sends a message to the DataHub instance (C++ only).

Synopsis

For C++:

```
ST_STATUS sendLispMessage(force, format, ...);

bool force;
char* format;
...;
```

Parameters

force
: If a valid connection to the DataHub instance exists but the message is undeliverable immediately (due to the TCP buffer being full), then if the force parameter is `TRUE`, the message is queued and will be transmitted when possible.

format
: The text formatting string (see below).

...
: Parameters required by the specified format.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if no connection to the DataHub instance is established.
- `ST_TOO_LARGE` if the message string exceeds the message buffer size.
- `ST_ERROR` if the format contains an error or if the connection socket is unable to send the message.

Description

This method is used to format and send commands to the DataHub instance, and should only be used by those very familiar with the operation of the DataHub instance. The DataHub command set is described in the Using Commands chapter of the Cogent DataHub manual. To send a command to the the DataHub instance, it must be formatted such that strings and control characters are preserved through the message transfer and delivery process. The specialized format control specifiers of sendLispMessage make this easy to do.

The `writeCommand` method gives a similar functionality for Java and C#.

The format control string is similar to that used by `printf`, with the following differences:

- The %A field type specifier escapes all occurences of double quotes, i.e., substitutes `\"` for each occurence of `"`.
- The %a field type specifier escapes all occurences of the following characters in addition to the double quote: `\ CR LF FF TAB ( )`.
- The %s field type specifier escapes the same characters as %a, and also encloses the string in double quotes.
- The %d (or `%i`) field type specifier assumes a parameter of type `int`, or of type `long` if preceeded by an '`l`' type specifier (`%ld`). No other type length specifiers are supported.
- The `%f` and %g field type specifiers assume a parameter of type double. No type length specifiers are supported.
- Other field type specifiers such as %c, %p, %n, %o, %u, %x and %e are not supported.
- The '*' field width specifier is not supported.

The string parameters corresponding to the %s, %a or %A field type specifiers *must* be of type `char *`.

Example

```
void CSetpoint::BuildObjectHierarchy(LPCTSTR sDomain,
                                     LPCTSTR sAssembly)
{
    CT2A aDomain(sDomain);
    char *domain = aDomain;
    CT2A aAssembly(sAssembly);
    char *assembly = aAssembly;
    CT2A aName(sName);
    char *name = aName;

    // (assembly domain name)
    pCnx->sendLispMessage(TRUE, "(assembly %s CSetpoint)", domain);
    // (subassembly domain assemblyname subassemblyname instancename)
    pCnx->sendLispMessage(TRUE, "(subassembly %s %s CSetpoint %s)",
                                 domain, assembly, name);
    // (property domain attrname propid propname
    //  type rw dflt_value dflt_conf)
    pCnx->sendLispMessage(TRUE, "(property %s CSetpoint auto
                                 AutoMode int rw 0 100)", domain);
    pCnx->sendLispMessage(TRUE, "(property %s CSetpoint auto
```

```
                                  AutoTime r8 rw 0 100)", domain);
}
```

sendLogin

`sendLogin` — transmits the user name and password.

Synopsis

For C++:

```
void sendLogin();

void;
```

For Java and C#:

```
public void sendLogin();

void;
```

Description

This method transmits the user name and password previously set by a call to `setUsername` or `setConnectionParms`. The `sendLogin` method is normally called automatically when a successful connection is made to the DataHub instance, prior to the `onConnectionSuccess` user callback.

setConnectionParms

`setConnectionParms` — sets the connection parameters.

Synopsis

For C++:

```
void setConnectionParms(hostname, servicename);

LPCTSTR hostname;
LPCTSTR servicename;

void setConnectionParms(hostname, port);

LPCTSTR hostname;
int port;

void setConnectionParms(hostname, port, username, password);

LPCTSTR hostname;
int port;
LPCTSTR username;
LPCTSTR password;
```

For Java and C#:

```
void setConnectionParms(hostname, port);

String hostname;
int port;

void setConnectionParms(hostname, port, username, password);

String hostname;
int port;
String username;
String password;
```

Parameters

hostname
: The name of the host running the DataHub instance.

servicename
: The name of the port on which to connect.

port
: The connection port number.

username

The name of a user.

password

A password for that user.

Description

This method sets the connection parameters to be used by the `openConnection` method. The port may be specified as either a string or directly by its number. The string may represent the port number, which is simply converted to an integer, or the symbolic port servicename. *If* a servicename is specified, then a lookup is performed immediately, and the resulting port number may be verified by following with a call to `getPort`.

The expanded syntax allows for setting the user name and password. See `setUsername` for more details.

setDefaultDomain

`setDefaultDomain` — sets the default domain.

Synopsis

For C++:

```
ST_STATUS setDefaultDomain(domainname);
LPCTSTR domainname;
```

For Java and C#:

```
Exception setDefaultDomain(domainname);
String domainname;
```

Parameters

domainname
The name of the domain.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

This method sets the name of the DataHub domain to be automatically associated with all unqualified point names (i.e., point names that do not specify a domain). Since in many applications there is a single domain to which most if not all points belong, this feature makes point references simpler and shorter. Points in other domains can still be referenced by qualifying the point name with a specific domain name (see `qualifyName`).

If the DataHub instance is not connected at the time this method is called, then the domain will be transmitted when the connection is established.

See Also

`getDefaultDomain`, `qualifyName`

setHeartbeatTimes

`setHeartbeatTimes` — sets the period of the heartbeat timers.

Synopsis

For C++:

```
ST_STATUS setHeartbeatTimes(heartbeat_ms, timeout_ms);

long heartbeat_ms;
long timeout_ms;
```

For Java and C#:

```
Exception setHeartbeatTimes(heartbeat_ms, timeout_ms);

long heartbeat_ms;
long timeout_ms;
```

Parameters

heartbeat_ms
: The period in milliseconds for the heartbeat timer, or `0` if a timer will not be used.

timeout_ms
: The period in milliseconds for the timeout timer, or `0` if a timer will not be used.

Returns

For C++:

`ST_OK` if the timer values accepted, otherwise `ST_ERROR`. `ST_ERROR` can occur for the following reasons:

- The timeout timer value is not greater than heartbeat (if both values are greater than `0`).
- The timers were already active and either timer failed to restart.

Description

The DataHub instance and API provide two heartbeat services to ensure the integrity of the connection:

1. A local, internal timeout timer, which when it fires, will close the connection and generate an error.
2. A periodic 'alive' heartbeat message from the DataHub instance, which triggers the virtual method `onAlive`.

The timers can be started with `startHeartbeatTimers` once the respective periods have been set. If a timer is already running when `setHeartbeatTimes` is called, then that timer is restarted with the new period. If the timer is already running and the specified period is `0`, then the timer is stopped.

The timeout timer is automatically reset whenever there is any activity over the connection, including the heartbeat timer message.

See Also

`getHeartbeat`, `getTimeout`, `startHeartbeatTimers`, `cancelHeartbeatTimers`

setPointLock

`setPointLock` — sets the lock attributes of a DataHub point.

Synopsis

For C++:

```
ST_STATUS setPointLock(point, locked);

CDataHubPoint& point;
bool locked;

ST_STATUS setPointLock(pointname, locked);

LPCTSTR pointname;
bool locked;
```

For Java:

```
Exception setPointLock(point, locked);

DataHubPoint point;
boolean locked;

Exception setPointLock(pointname, locked);

String pointname;
boolean locked;
```

For C#:

```
Exception setPointLock(point, locked);

DataHubPoint point;
bool locked;

Exception setPointLock(pointname, locked);

String pointname;
bool locked;
```

Parameters

point
: A `DataHubPoint` object. The name and security members must be valid.

pointname
: The name of the point.

locked

If TRUE, the point will have its locked attribute set, otherwise the locked attribute is cleared.

Returns

For C++:

- ST_OK if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the onSuccess or onError message handlers.
- ST_NO_TASK if a connection to the DataHub instance does not exist.
- ST_ERROR if the connection socket is unable to send the message.

Description

This method sets the lock attributes of a DataHub point.

See Also

setPointSecurity

setPointSecurity

`setPointSecurity` — sets the security attributes of a DataHub point.

Synopsis

For C++:

```
ST_STATUS setPointSecurity(point, security);

CDataHubPoint& point;
int security;

ST_STATUS setPointSecurity(pointname, security);

LPCTSTR pointname;
int security;
```

For Java and C#:

```
Exception setPointSecurity(point, security);

CDataHubPoint& point;
int security;

Exception setPointSecurity(pointname, security);

String pointname;
int security;
```

Parameters

point
: A `DataHubPoint` object. The name and security members must be valid.

pointname
: The name of the point.

security
: The new security level to which the DataHub point will be set.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.

- ST_ERROR if the connection socket is unable to send the message.

Description

This method sets the security attributes of a DataHub point. An update to a DataHub point will be rejected unless the security level associated with the new point value is greater than or equal to the corresponding DataHub point. The default DataHub point security level is 0.

See Also

setPointLock

setReconnectionDelay

`setReconnectionDelay` — sets the delay time between reconnection attempts.

Synopsis

For C++, Java, and C#:

```
void setReconnectionDelay(recon_ms);
```

```
long recon_ms;
```

Parameters

recon_ms
The delay time, in milliseconds, after connection failure before another attempt is automatically made.

Description

The `DataHubConnector` class provides an internal facility to automatically attempt reconnection in event of a failure. The default `onConnectionFailure` method will trigger the reconnection timer.

When the timer fires, the `retryConnection` method is called to cancel the timer and attempt to connect.

See Also

`getReconnectionDelay`, `startReconnectionTimer`, `cancelReconnectionTimer`

setUsername

`setUsername` — stores a user name and password for this connection.

Synopsis

For C++:

```
void setUsername(username, password);

LPCTSTR username;
LPCTSTR password;
```

For Java and C#:

```
public void setUsername(username, password);

String username;
String password;
```

Parameters

username
: The name of a user.

password
: A password for that user.

Description

This method stores a user name and password for this connection, to be transmitted by a subsequent call to `sendLogin`. When a subsequent successful connection is made to the DataHub instance, `sendLogin` will be called prior to the `onConnectionSuccess` callback. The .Net and Java implementations of `setUsername` will disconnect from the DataHub instance if the connection is currently active. The C++ implementation will not. If either of the username or password parameters is `""` or `NULL`, then no username or password will be sent on the next successful connection.

See Also

`sendLogin`, `setConnectionParms`

shutdown

`shutdown` — prepares for an application shutdown or disconnect (Java and C# only).

Synopsis

For Java, and C#:

```
void shutdown(reason);

String reason;
```

Parameters

reason

A character string that may be passed to the `onConnectionFailure` callback indicating the reason for the shutdown. If *reason* is `null`, a default string will be used.

Description

This method cleans up all resources, timers and sockets associated with the connection in preparation for application shutdown or removal of the `DataHubConnector` object. The application should not call any methods of the object or access any of its members after this method call is made. The result of any access to the object after this call is undefined.

See Also

`onConnectionFailure`

startHeartbeatTimers

`startHeartbeatTimers` — starts the heartbeat and timeout timers.

Synopsis

For C++:

```
ST_STATUS startHeartbeatTimers();
```

```
void;
```

For Java and C#:

```
Exception startHeartbeatTimers();
```

```
void;
```

Returns

For C++:

`ST_OK` if the timers were successfully started, otherwise `ST_ERROR`.

Description

This method is used to start the two heartbeat timers. If a timer period has been set to `0`, then that heartbeat timer function is disabled. The default behaviour of the `onConnectionSuccess` method is to make a call to `startHeartbeatTimers`.

See Also

`setHeartbeatTimes`, `cancelHeartbeatTimers`, `onConnectionSuccess`

startReconnectionTimer

`startReconnectionTimer` — starts the delay timer for reconnection attempts.

Synopsis

For C++, Java, and C#:

```
void startReconnectionTimer();
```

```
void;
```

Description

This method is used to start the reconnection timer. The default behaviour of the `onConnectionFailure` method is to make a call to `startReconnectionTimer`. See `setReconnectionDelay` for more details.

unregisterPoint

`unregisterPoint` — stops receiving updates from a DataHub point.

Synopsis

For C++:

ST_STATUS **unregisterPoint**(*point*);

CDataHubPoint& *point*;

ST_STATUS **unregisterPoint**(*pointname*);

LPCTSTR *pointname*;

For Java and C#:

Exception **unregisterPoint**(*point*);

DataHubPoint *point*;

Exception **unregisterPoint**(*pointname*);

String *pointname*;

Parameters

point
: A `DataHubPoint` object. The name member must be valid.

pointname
: The name of the point.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

This method stops changes to the specified DataHub point from invoking the `onPointChange` method. If the DataHub point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: `ST_NO_POINT`
msg: `"Point does not exist"`

See Also

`writePoint`, `registerPoint`

writeCommand

`writeCommand` — sends a command to the DataHub instance (Java and C# only).

Synopsis

For Java and C#:

```
Exception writeCommand(command);

String command;
```

Parameters

command

A concatenation of `escapedString`s whose original format was a Lisp command.

Returns

This has not yet been documented.

Description

This method is used to send formatted commands to the DataHub instance, and should only be used by those very familiar with the operation of the DataHub program. The DataHub command set is described in the Using Commands chapter of the Cogent DataHub manual. To send a command to the DataHub instance, it must be formatted such that strings and control characters are preserved through the message transfer and delivery process. You must concatenate together the necessary command string, using the `escapedString` method to provide the necessary protection of strings.

The `sendLispMessage` method gives a similar functionality for C++.

See Also

`escapedString`

writePoint

`writePoint` — writes a new value to a DataHub point.

Synopsis

For C++:

```
ST_STATUS writePoint(point, create, force);

CDataHubPoint& point;
bool create=TRUE;
int force=FALSE;

ST_STATUS writePoint(pointname, value, create, force);

LPCTSTR pointname;
int value;
bool create=TRUE;
bool force=FALSE;

ST_STATUS writePoint(pointname, value, create, force);

LPCTSTR pointname;
double value;
bool create=TRUE;
bool force=FALSE;

ST_STATUS writePoint(pointname, value, create, force);

LPCTSTR pointname;
LPCTSTR value;
bool create=TRUE;
bool force=FALSE;
```

For Java:

```
Exception writePoint(point, create, force);

DataHubPoint point;
boolean create;
boolean force;

Exception writePoint(pointname, value, create, force);

String pointname;
String value;
boolean create;
```

```
boolean force;

Exception writePoint(pointname, value);

String pointname;
String value;

Exception writePoint(pointname, value, create, force);

String pointname;
double value;
boolean create;
boolean force;

Exception writePoint(pointname, value);

String pointname;
double value;

Exception writePoint(pointname, value, create, force);

String pointname;
int value;
boolean create;
boolean force;

Exception writePoint(pointname, value);

String pointname;
int value;

Exception writePoint(pointname, type, value_as_string, create, force);

String pointname;
int type;
String value_as_string;
boolean create;
boolean force;
```

For C#:

```
Exception writePoint(point, create, force);

DataHubPoint point;
bool create;
bool force;

Exception writePoint(pointname, value, create, force);

String pointname;
```

```
String value;
bool create;
bool force;

Exception writePoint(pointname, value);

String pointname;
String value;

Exception writePoint(pointname, value, create, force);

String pointname;
double value;
bool create;
bool force;

Exception writePoint(pointname, value);

String pointname;
double value;

Exception writePoint(pointname, value, create, force);

String pointname;
int value;
bool create;
bool force;

Exception writePoint(pointname, value);

String pointname;
int value;

Exception writePoint(pointname, type, value_as_string, create, force);

String pointname;
int type;
String value_as_string;
bool create;
bool force;
```

Parameters

point
: A `DataHubPoint` object. The name, type, value, seconds and nanoseconds members must be valid.

create
: If TRUE, then the point is created if it does not already exist. If FALSE and the point does not exist, then an error message will be generated.

force

If a valid connection to the DataHub instance exists but the message is undeliverable immediately (due to the TCP buffer being full), then if the force parameter is TRUE, the message is queued and will be transmitted when possible.

pointname

The name of the point. The point timestamp is automatically set to the current time.

value

The integer, double, or string value to write to the point. The type of the point in the DataHub instance will be changed accordingly.

Returns

For C++:

- `ST_OK` if the command was successfully sent to the DataHub instance. Since the command is sent asynchronously, the actual success or failure of the command must be determined through the `onSuccess` or `onError` message handlers.
- `ST_NO_TASK` if a connection to the DataHub instance does not exist.
- `ST_ERROR` if the connection socket is unable to send the message.

Description

This method writes the given point to the DataHub instance. If a `DataHubPoint` is used, then the point name, type, value, quality and timestamp members must be set. If the point is specified by name, then the type is determined by the specific overloaded method and the timestamp is set to the current time.

If a domain name has been associated with the client (see `setDefaultDomain`), then the point will be written to that domain, otherwise it will be written to the domain named `default`. In any case, the domain can always be overridden by qualifying the point name as *domain name*:*point name* (see `qualifyName`).

If the point has been registered (see `registerPoint`), and the DataHub point is successfully written, then the `onPointEcho` method will be invoked.

If the *create* parameter is FALSE and the point does not exist, then the DataHub instance will respond with an error, and onError will be called with the following arguments:

status: `ST_NO_POINT`
msg: `"Point does not exist"`

Examples

```
CDataHubPoint point;
point.name = "point1";
point.type = PT_TYPE_REAL;
```

```
point.quality = PT_QUALITY_GOOD;
point.value = 123.456;
setPointTimeStamp(&point);
// point must exist or error is generated
writePoint(&point, FALSE);
// write real-valued point, create if needed
writePoint(_T("point2"), 123.456);
```

See Also

readPoint

Callback Methods

These are the callback methods associated with the `DataHubConnector` class. For C++, they are methods of the `DataHubConnector` class itself. For Java and C#, they are methods of the `DataHubEventConsumer` interface.

onAlive

onAlive — a virtual method invoked on receipt of a heartbeat from the DataHub instance.

Synopsis

For C++, Java, and C#:

```
void onAlive();

void;
```

Description

This method is invoked upon receipt of the 'alive' hearbeat message from the DataHub instance. See `setHeartbeatTimes` for more details on this feature.

See Also

`setHeartbeatTimes`, `getHeartbeat`, `startHeartbeatTimers`, `cancelHeartbeatTimers`

onAsyncMessage

onAsyncMessage — a virtual method invoked on receipt of a DataHub message.

Synopsis

For C++:

```
virtual void onAsyncMessage(argc, argv);

int argc;
char** argv;
```

For Java and C#:

```
virtual void onAsyncMessage(arguments);

String[] arguments;
```

Parameters

argc
: The number of parameters in the DataHub message.

argv, *arguments*
: An array of strings which are the parameters in the DataHub message.

Description

This virtual method is invoked on receipt of a DataHub message. This method is only called if none of the other callbacks are called.

See Also

onStatusChange, onSuccess, onError, onConnectionSuccess, onConnectionFailure

onConnectionFailure

`onConnectionFailure` — a virtual method invoked when a connection or attempt to connect fails.

Synopsis

For C++:

```
virtual void onConnectionFailure(host, port, reason);

LPCTSTR host;
int port;
LPCTSTR reason;
```

For Java and C#:

```
virtual void onConnectionFailure(host, port, reason);

String host;
int port;
String reason;
```

Parameters

host
: The name of the host running the DataHub instance.

port
: The connection port number.

reason
: The reason for the failure.

Description

This virtual method is invoked when a connection or attempt to connect fails. The default behaviour is to make a call to `startReconnectionTimer`.

See Also

`onStatusChange`, `onConnectionSuccess`, `startReconnectionTimer`

onConnectionSuccess

`onConnectionSuccess` — a virtual method invoked when a connection is established.

Synopsis

For C++:

```
virtual void onConnectionSuccess(host, port);

LPCTSTR host;
int port;
```

For Java and C#:

```
virtual void onConnectionSuccess(host, port);

String host;
int port;
```

Parameters

host
: The name of the host running the DataHub instance.

port
: The connection port number.

Description

This virtual method is invoked when a connection is established. The default behaviour is to make a call to `cancelReconnectionTimer`.

See Also

`onStatusChange`, `onConnectionFailure`, `cancelReconnectionTimer`

onError

onError — a virtual method invoked on receipt of an error message.

Synopsis

For C++:

```
virtual void onError (status, err_str, cmd, parms);
```

```
ST_STATUS status;
LPCTSTR err_str;
LPCTSTR cmd;
LPCTSTR parms;
```

For Java and C#:

```
virtual void onError (status, err_str, cmd, parms);
```

```
int status;
String err_str;
String cmd;
String parms;
```

Parameters

status
: The status code returned by the the DataHub instance.

err_str
: The error string, providing more detailed information about the error.

cmd
: The original command sent to the DataHub instance to which this reply corresponds.

parms
: The list of parameters sent as part of the command, as a single space-separated string, or `NULL`[1] if none are returned. If the command involved multiple parameters, the list may be truncated.

Description

This virtual method is invoked on receipt of an error message.

See Also

getErrString, onSuccess, onConnectionSuccess, onConnectionFailure

[1] `null` in Java and C#.

onPointChange

`onPointChange` — a virtual method invoked on receipt of a point value change.

Synopsis

For C++:

```
virtual void onPointChange(point);

CDataHubPoint& point;
```

For Java and C#:

```
virtual void onPointChange(point);

DataHubPoint point;
```

Parameters

point
: A `DataHubPoint` object. The name member must be valid.

Description

This virtual method is invoked on receipt of a point value change.

See Also

`onPointEcho`

onPointEcho

`onPointEcho` — a virtual method invoked on receipt of a locally changed point value.

Synopsis

For C++:

```
virtual void onPointEcho(point);
```

```
CDataHubPoint& point;
```

For Java and C#:

```
virtual void onPointEcho(point);
```

```
DataHubPoint point;
```

Parameters

`point`
: A `DataHubPoint` object. The name member must be valid.

Description

This virtual method is invoked on receipt of a locally changed point value.

See Also

`onPointChange`

onStatusChange

`onStatusChange` — a virtual method invoked on change of status.

Synopsis

For C++, Java, and C#:

```
virtual void onStatusChange(prev_state, state);

DHC_tState prev_state;
DHC_tState state;
```

Parameters

prev_state
: The previous state.

state
: The current state.

Description

This is a virtual method which is invoked on change of status. See `getCnxState` for a definition of the possible states.

See Also

`getCnxState`

onSuccess

`onSuccess` — a virtual method invoked on receipt of a success message.

Synopsis

For C++:

```
virtual void onSuccess(cmd, parms);

LPCTSTR cmd;
LPCTSTR parms;
```

For Java and C#:

```
virtual void onSuccess(cmd, parms);

String cmd;
String parms;
```

Parameters

cmd
: The original command sent to the DataHub instance to which this reply corresponds.

parms
: The list of parameters sent as part of the command, as a single space-separated string, or `NULL`[1] if none are returned. If the command involved multiple parameters, the list may be truncated.

Description

This virtual method is invoked on receipt of a success message. When a client sends a command to the DataHub instance, it will respond with one of:

- information appropriate to the command
- a success message
- a failure message

If a command succeeds, the DataHub instance will either respond with information appropriate to the command, or it will send a success message if no information should be returned. If a command fails, the DataHub instance will always respond with a failure message.

A client has the choice of whether to receive the success messages. Commonly you don't want to expend the bandwidth by receiving success messages for every message you

[1] `null` in Java and C#.

send to the DataHub instance. A client can turn on and off the success messages by emitting the DataHub command `(acksuccess 0|1)`. This command does not have an associated API function wrapper, so you have to emit it using the sendLispMessage command, like this:

```
connection.sendLispMessage (true, "(acksuccess 1)");
```

The exact syntax of the call depends on whether you are using C++, .Net or Java.

See Also

`onStatusChange`, `onAsyncMessage`, `onError`, `onConnectionSuccess`, `onConnectionFailure`

DataHubPoint Methods

These are the methods associated with the DataHubPoint class, listed alphabetically. To see the same methods grouped according to how they are used, please refer to the Categorized List of Methods.

DataHubPoint

`DataHubPoint` — constructs a DataHubPoint object.

Synopsis

For C++:

```
CDataHubPoint();

void;

CDataHubPoint(point);

const CDataHubPoint& point;

CDataHubPoint(sname);

LPCTSTR sname;

CDataHubPoint(sname, itype, svalue, iconf, iquality, isecurity,
ilocked, iseconds, inanoseconds, iflags);

LPCTSTR sname;
int itype;
LPCTSTR svalue;
int iconf;
int iquality;
int isecurity;
int ilocked;
int iseconds;
int inanoseconds;
int iflags;
```

For Java, and C#:

```
DataHubPoint(sname);

String sname;

DataHubPoint(sname, itype, svalue, iconf, iquality, isecurity,
ilocked, iseconds, inanoseconds, iflags);

String sname;
int itype;
String svalue;
int iconf;
int iquality;
```

```
int isecurity;
int ilocked;
int iseconds;
int inanoseconds;
int iflags;
```

Parameters

point
: An existing point to be copied.

sname
: The point name. The `'.'` character may be used to separate name fields. A point name may be qualified by its corresponding domain as *domain*`:`*name*, otherwise it is treated by the DataHub instance as belonging to the current default domain. Point names must be matched exactly, i.e., the qualified and unqualified point names are not the same.

itype
: The type of the point: `PT_TYPE_STRING`, `PT_TYPE_INT32` or `PT_TYPE_REAL`.

svalue
: A string representing the value, to be converted according to the specified type.

iconf
: The point confidence, typically `0-100`.

iquality
: The point quality, typically `PT_QUALITY_GOOD` or `PT_QUALITY_BAD`.

isecurity
: The point security.

ilocked
: The locked flag for the point.

iseconds
: The seconds component of the initial timestamp (since Jan. 1, 1970).

inanoseconds
: The nanosecond component of the initial timestamp.

iflags
: The point flags.

Description

Constructs a new `DataHubPoint` object.

See Also

`DataHubPoint` Class, Categorized List of Methods

~DataHubPoint

`~DataHubPoint` — destroys a DataHubPoint object.

Synopsis

For C++:

```
~DataHubPoint();

void;
```

For Java, and C#:

None.

Description

Destroys a `DataHubPoint` object.

See Also

`DataHubPoint` Class, Categorized List of Methods

operator=

`operator=` — assigns a new value to a DataHubPoint object (C++ only).

Synopsis

For C++:

```
CDataHubPoint& operator=(point);

CDataHubPoint& point;
```

For Java, and C#:

None.

Parameters

point
A DataHubPoint object to be copied into this DataHubPoint object.

Description

Copies the name, value and information from the source object. Existing data in the destination object is cleared. A memory exception may occur due to allocation of the name and string type data.

See Also

`DataHubPoint` Class, Categorized List of Methods, `clear`

clear

`clear` — clears the point.

Synopsis

For C++, Java, and C#:

```
void clear();

void;
```

Description

Clears the point, releasing the current name and string values, if any. The cleared point is a valid point of type PT_TYPE_INT32, with value of 0 and PT_QUALITY_BAD.

copy

copy — copies the point data.

Synopsis

For C++:

```
void copy(point);
```

```
const CDataHubPoint& point;
```

For Java, and C#:

```
void copy(point);
```

```
DataHubPoint point;
```

Parameters

point
A `DataHubPoint` object to be copied into this `DataHubPoint` object.

Description

Please refer to the `operator=` method.

getConfidence

`getConfidence` — retrieves the user's point confidence.

Synopsis

For C++, Java, and C#:

```
int getConfidence();
void;
```

Returns

The confidence value of this point object.

getDateString

`getDateString` — generates a 'standard' timestamp data/time representation.

Synopsis

For C++:

```
CString getDateString();

void;
```

For C#:

```
String getDateString();

void;
```

Returns

A String object representing the current timestamp in exactly 26 characters as `Day Mmm dt hr:mn:sc yyyy\n`. For example `Wed Jan 02 02:03:55 1980\n`.

Description

A simple convenience function to generate a timestamp string.

getDoubleValue

`getDoubleValue` — retrieves the point data as a double-typed value.

Synopsis

For C++, Java, and C#:

```
double getDoubleValue();

void;
```

Returns

The current object value as a double.

Description

This method will convert the point value type if needed. If the string cannot be converted, `0.0` is returned. Strings representing hex, octal, or binary integers generate `0.0`.

getFlags

`getFlags` — retrieves the `flags` property of the point.

Synopsis

For C++, Java, and C#:

```
int getFlags();
```

```
void;
```

Returns

The current point flags.

getIntValue

`getIntValue` — retrieves the point data as an int-typed value.

Synopsis

For C++, Java, and C#:

```
int getIntValue();

void;
```

Returns

The current object value as an integer.

Description

This method will convert the point value type if needed. If the string cannot be converted, `0` is returned. Strings representing hex, octal, or binary integers generate `0`.

getListeners

`getListeners` — retrieves listeners on the point (Java only).

Synopsis

For Java only:

```
LinkedList getListeners();

void;
```

Returns

A list of the current listeners on the point.

getLocked

`getLocked` — retrieves the locked property of the point.

Synopsis

For C++ and C#:

```
bool getLocked();

void;
```

For Java:

```
boolean getLocked();

void;
```

Returns

The current locked status of the point.

getName

`getName` — retrieves the point name.

Synopsis

For C++:

```
CString getName();
```

```
void;
```

For Java, and C#:

```
String getName();
```

```
void;
```

Returns

The point name.

getNanoseconds

`getNanoseconds` — retrieves the timestamp nanoseconds component.

Synopsis

For C++, Java, and C#:

```
int getNanoseconds();

void;
```

Returns

The nanoseconds component of the timestamp.

getQuality

`getQuality` — retrieves the point quality.

Synopsis

For C++, Java, and C#:

```
int getQuality();
```

```
void;
```

Returns

The point quality.

getQualityString

`getQualityString` — generates a string representing the point quality.

Synopsis

For C++:

```
CString getQualityString();

void;
```

For Java, and C#:

```
String getQualityString();

void;
```

Returns

A string representing the quality assigned to the point.

getSeconds

`getSeconds` — retrieves the timestamp seconds component.

Synopsis

For C++, Java, and C#:

```
int getSeconds();
```

```
void;
```

Returns

The timestamp seconds component.

getSecurity

`getSecurity` — retrieves the security property of the point.

Synopsis

For C++, Java, and C#:

```
int getSecurity();
```

```
void;
```

Returns

The point security.

getStringValue

`getStringValue` — retrieves the point data as a string.

Synopsis

For C++:

```
CString getStringValue();
```

```
void;
```

For Java, and C#:

```
String getStringValue();
```

```
void;
```

Returns

A string representing the current point value.

Description

This method will convert the point value type if needed. Values of type `real` are converted using the `%g` format.

getType

getType — retrieves the point data type.

Synopsis

For C++, Java, and C#:

```
int getType();

void;
```

Returns

The point type, one of PT_TYPE_STRING, PT_TYPE_REAL, or PT_TYPE_INT32.

getUserdata

`getUserdata` — retrieves the user object associated with the point.

Synopsis

For C++, Java, and C#:

```
void* getUserdata();

void;
```

Returns

The user data previously set by `setUserData`.

qualifyName

`qualifyName` — creates a point name string qualified by a domain name.

Synopsis

For C++:

```
static CString qualifyName(domainname, pointname);

LPCTSTR domainname;
LPCTSTR pointname;
```

For Java and C#:

```
static String qualifyName(domainname, pointname);

String domainname;
String pointname;
```

Parameters

pointname
: The name of the point.

domainname
: The name of the domain containing the point.

Returns

A string with the correctly formatted qualified point name.

Description

This utility method is used to add the domain name qualifier to a point name, using the format *domainname*:*pointname*. If the point name is already qualified, then the domain name is replaced with the new *domainname* specified.

If `setDefaultDomain` is used, and the point belongs to that domain, then it is not necessary to qualify the point. A qualified point name is normally used to reference points from domains other than the application's default domain.

Examples

All of these would reference the same point:

1. `writePoint(_T("domain1:point1")), 1);`
2. `writePoint(CDataHubPoint::qualifyName(_T("domain1"),_T("point1")), 1);`

3.
```
setDefaultDomain(_T("domain1"));
writePoint(_T("point1"), 1);
```

See Also

setDefaultDomain, unqualifyName, writePoint, registerPoint

removeListener

`removeListener` — removes a listener from the point (Java only).

Synopsis

For Java only:

```
void removeListener(listener);
```

```
DataHubListener listener;
```

Parameters

listener
Not yet documented.

Returns

Not yet documented.

setConfidence

`setConfidence` — sets the user's confidence in a point.

Synopsis

For C++, Java, and C#:

```
void setConfidence(iconf);
```

```
int iconf;
```

Parameters

iconf
: The point confidence, typically `0`-100.

Description

Sets the user's confidence in a point. See `DataHubPoint`.

setInfo

setInfo — sets the information properties of a point.

Synopsis

For C++:

void **setInfo**(*point*);

CDataHubPoint& *point*;

void **setInfo**(*iconf*, *iquality*, *isecurity*, *ilocked*, *iseconds*, *inanoseconds*, *iflags*);

int *iconf*;
int *iquality*;
int *isecurity*;
int *ilocked*;
int *iseconds*;
int *inanoseconds*;
int *iflags*;

For Java, and C#:

void **setInfo**(*point*);

DataHubPoint *point*;

void **setInfo**(*iconf*, *iquality*, *isecurity*, *ilocked*, *iseconds*, *inanoseconds*, *iflags*);

int *iconf*;
int *iquality*;
int *isecurity*;
int *ilocked*;
int *iseconds*;
int *inanoseconds*;
int *iflags*;

Parameters

point
: An existing point from which to copy all the information values (not name, type or value).

iconf
: The point confidence, typically 0-100.

iquality

The point quality, typically `PT_QUALITY_GOOD` or `PT_QUALITY_BAD`.

isecurity

The point security.

ilocked

The locked flag for the point.

iseconds

The seconds component of the initial timestamp (since Jan. 1, 1970).

inanoseconds

The nanosecond component of the initial timestamp.

iflags

The point flags.

Description

Sets all the information properties of a point.

setLocked

`setLocked` — sets the locked property of the point.

Synopsis

For C++ and C#:

```
void setLocked(ilocked);

bool ilocked;
```

For Java:

```
void setLocked(ilocked);

boolean ilocked;
```

Parameters

ilocked
The locked flag for the point.

Description

Sets the locked property of the point.

setName

`setName` — assigns a name to the point.

Synopsis

For C++:

```
void setName(sname);

LPCTSTR sname;

void setName(sdomain, sname);

LPCTSTR sdomain;
LPCTSTR sname;
```

For Java, and C#:

```
void setName(sname);

String sname;
```

Parameters

sname
A string containing the name to be assigned to the point.

sdomain
A string containing the domain name.

Description

Assigns a name to the point. Any existing name is released. See notes regarding *sname* parameter of `DataHubPoint`. If a domain is specified, then the qualified point name is constructed.

setQuality

`setQuality` — sets the point quality.

Synopsis

For C++, Java, and C#:

```
void setQuality(iquality);

int iquality;
```

Parameters

`iquality`
: The point quality, typically `PT_QUALITY_GOOD` or `PT_QUALITY_BAD`.

Description

Sets the point quality.

setSecurity

`setSecurity` — sets the security property of the point.

Synopsis

For C++, Java, and C#:

```
void setSecurity(isecurity);
```

```
int isecurity;
```

Parameters

isecurity
The point security.

Description

Sets the security property of the point.

setTimeStamp

`setTimeStamp` — sets the point timestamp in various ways.

Synopsis

For C++, Java, and C#:

```
void setTimeStamp(seconds, nanoseconds);

int seconds;
int nanoseconds;

void setTimeStamp(datetime);

DATE datetime;

void setTimeStamp();

void;
```

Parameters

seconds
: The number of seconds since Jan 1, 1970.

nanoseconds
: The sub-second component of the timestamp, typically accurate to the extent permitted by the OS.

datetime
: Time expressed in the Microsoft `DATE` format, the number of days since Dec.30, 1899.

Description

The parameter-less version of this method will set the timestamp to the current OS time.

setFlags

`setFlags` — sets the flags property of the point.

Synopsis

For C++, Java, and C#:

```
void setFlags(flags);
```

```
int flags;
```

Parameters

iflags
: The point flags.

Description

Sets the flags property of the point.

setUserdata

`setUserdata` — associates the point with a user object.

Synopsis

For C++, Java, and C#:

```
void setUserdata(userdata);
```

```
void* userdata;
```

Parameters

userdata
: Any user-supplied data of size (void*).

Description

Sets the `userdata` property of a point. The user is free to set this to anything (of the appropriate size). When a point is updated in the `DataHubConnector` point cache, this property is maintained, providing the user with a facility for maintaining an association between a point and an object in the user's application space.

See Also

`getUserData`, `initializePointCache`

setValue

`setValue` — sets the point data to the specified type and value.

Synopsis

For C++:

```
void setValue(point);
CDataHubPoint& point;
void setValue(svalue);
LPCTSTR svalue;
void setValue(dvalue);
double dvalue;
void setValue(ivalue);
int ivalue;
```

For Java, and C#:

```
void setValue(svalue);
String svalue;
void setValue(dvalue);
double dvalue;
void setValue(ivalue);
int ivalue;
```

Parameters

point
: A `DataHubPoint` class object whose data type and value are to be copied into this DataHubPoint object.

svalue
: The desired string value.

dvalue
: The desired double value.

ivalue
The desired integer value.

Description

Sets the object's data value and sets the type accordingly.

setValueFromString

`setValueFromString` — sets the point data to the value represented by a string.

Synopsis

For C++:

```
void setValueFromString(svalue);

LPCTSTR svalue;

void setValueFromString(svalue, itype);

LPCTSTR svalue;
int itype;
```

For Java, and C#:

```
void setValueFromString(svalue);

String svalue;

void setValueFromString(svalue, itype);

String svalue;
int itype;
```

Parameters

sValue
: A string to be used to set the value.

itype
: The type of the point: `PT_TYPE_STRING`, `PT_TYPE_INT32` or `PT_TYPE_REAL`.

Description

If the type is specified, then the string is converted as required. If the type is not specified, then the method determines whether the string represents an integer or double value, converting to that type if possible.

unqualifyName

`unqualifyName` — removes the domain name qualifier from a point name.

Synopsis

For C++:

```
static CString unqualifyName(pointname);

LPCTSTR pointname;
```

For Java and C#:

```
static String unqualifyName(pointname);

String pointname;
```

Parameters

pointname
The name of the point.

Returns

The pointname with the domain name qualifier, if any, removed.

Description

This utility method is used to remove a domain name qualifier from a point name. See `qualifyName` for more information on qualifying a point name with a domain name.

See Also

`qualifyName`, `registerPoint`

DataHub™ API for Python

Table of Contents

Introduction

The DataHub™ API for Python is a Python implementation for connecting to Cogent DataHub software in real time via TCP. It is available in GitHub. Please see the README.md file for more information.

Namespace Documentation

DataHubConnection Namespace Reference

Classes

- class ChangeFlags
- class ConnectionOptions
- class DataHubConnection
- class DataHubConnectionStatus
- class DataHubConnectionType
- class DataHubStatus
- class DomainFlags
- class LogSeverity
- class MetadataFlags
- class ModelDomain
- class ModelEmitter
- class PointFlags
- class PointMetaInfo
- class PointRegister
- class PreciseTimer
- class Timer
- class VariantType

lispparse Namespace Reference

Classes

- class DataHubPoint
- class PointQuality
- class PointType

Functions

- SlEscapeChar (inbuf, offset, outbuf, outoffset)
- SlSkipTo (inbuf, offset, stops, maxbuf)
- SlSkipFast (inbuf, offset, stop, maxbuf)
- SlSkipToClosing (buffer, offset, maxbuf, opening, closing)
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- addArg (arglist, inbuf, offset, length)
- UT_LispParseSafe (buffer, offset, buflen, flags)
- parse (buffer)
- initialize_terminators ()
- escaped_string (string, quoted, terminators)
- escaped_string2 (string, quoted, terminators)
- escaped_string_with_options (string, quoted, special_only)
- escaped_string_auto (string, quoted)
- escaped_symbol (string)

Variables

- int UT_ParseFlagExpressions = 1
- NormalTerminators = set(['\\', ' ', '\t', '\n', '\f', '\r', '\'', '\"', '(', ')', '[', ']', '#', ';', '`', ',', '{', '}', chr(0), chr(0x1b)])
- SpecialTerminators = set(['\t', '\n', '\f', '\r', chr(0), chr(0x1b), '\\', '\"'])
- list BNormalTerminators = [False] * 128
- list BSpecialTerminators = [False] * 128
- list BSymbolTerminators = [False] * 128
- bool TerminatorsConfigured = False
- terminators_lock = threading.Lock()

Function Documentation

addArg()

```
lispparse.addArg ( arglist, inbuf, offset, length)
```

```
Adds an argument to the argument list.

Arguments:
    arglist: List of arguments.
    inbuf: Input buffer.
    offset: Starting offset in the input buffer.
    length: Length of the argument.
```

escaped_string()

```
lispparse.escaped_string ( string, quoted, terminators)
```

```
Escapes a string based on the provided terminators.
```

```
Arguments:
    string: Input string.
    quoted: Whether the string should be quoted.
    terminators: List of terminator characters.

Returns:
    str: Escaped string.
```

escaped_string2()

```
lispparse.escaped_string2 ( string, quoted, terminators)
```

```
Escapes a string based on the provided terminators
(alternative implementation).

Arguments:
    string: Input string.
    quoted: Whether the string should be quoted.
    terminators: List of terminator characters.

Returns:
    str: Escaped string.
```

escaped_string_auto()

```
lispparse.escaped_string_auto ( string, quoted)
```

```
Automatically escapes a string based on whether it is quoted.

Arguments:
    string: Input string.
    quoted: Whether the string should be quoted.

Returns:
    str: Escaped string.
```

escaped_string_with_options()

```
lispparse.escaped_string_with_options ( string, quoted, special_only)
```

```
Escapes a string with options for special terminators.

Arguments:
    string: Input string.
    quoted: Whether the string should be quoted.
    special_only: Whether to use special terminators only.
```

```
Returns:
    str: Escaped string.
```

escaped_symbol()

```
lispparse.escaped_symbol ( string)
```

```
Escapes a symbol.

Arguments:
    string: Input string.

Returns:
    str: Escaped symbol.
```

initialize_terminators()

```
lispparse.initialize_terminators ( )
```

```
Initializes the terminator tables.
```

parse()

```
lispparse.parse ( buffer)
```

```
Parses a buffer containing LISP expressions.

Arguments:
    buffer: Input buffer.

Returns:
    list: List of parsed expressions.
```

SlEscapeChar()

```
lispparse.SlEscapeChar ( inbuf, offset, outbuf, outoffset)
```

```
Escapes a character in the input buffer and writes it to the
output buffer.

Arguments:
    inbuf: Input buffer.
    offset: Offset in the input buffer.
    outbuf: Output buffer.
    outoffset: Offset in the output buffer.
```

```
Returns:
    int: Length of the escaped character.
```

SlSkipFast()

```
lispparse.SlSkipFast ( inbuf, offset, stop, maxbuf)
```

```
Skips characters in the input buffer quickly until a stop character
is found.

Arguments:
    inbuf: Input buffer.
    offset: Starting offset in the input buffer.
    stop: Stop character.
    maxbuf: Maximum buffer length.

Returns:
    int: Offset of the first stop character or maxbuf if not found.
```

SlSkipTo()

```
lispparse.SlSkipTo ( inbuf, offset, stops, maxbuf)
```

```
Skips characters in the input buffer until a stop character is found.

Arguments:
    inbuf: Input buffer.
    offset: Starting offset in the input buffer.
    stops: String of stop characters.
    maxbuf: Maximum buffer length.

Returns:
    int: Offset of the first stop character or None if not found.
```

SlSkipToClosing()

```
lispparse.SlSkipToClosing ( buffer, offset, maxbuf, opening, closing)
```

```
Skips characters in the buffer until the closing character is found.

Arguments:
    buffer: Input buffer.
    offset: Starting offset in the buffer.
    maxbuf: Maximum buffer length.
    opening: Opening character.
```

```
    closing: Closing character.

Returns:
    int: Offset of the closing character or None if not found.
```

SlSkipWhite()

```
lispparse.SlSkipWhite ( buffer, offset, maxbuf)
```

```
Skips whitespace characters in the buffer.

Arguments:
    buffer: Input buffer.
    offset: Starting offset in the buffer.
    maxbuf: Maximum buffer length.

Returns:
    int: Offset of the first non-whitespace character or
    None if not found.
```

UT_LispParseSafe()

```
lispparse.UT_LispParseSafe ( buffer, offset, buflen, flags)
```

```
Parses a LISP expression safely.

Arguments:
    buffer: Input buffer.
    offset: Starting offset in the buffer.
    buflen: Length of the buffer.
    flags: Parsing flags.

Returns:
    tuple: Offset of the first character after the expression and
    an array of arguments.
```

Variable Documentation

BNormalTerminators

```
list lispparse.BNormalTerminators = [False] * 128
```

BSpecialTerminators

```
list lispparse.BSpecialTerminators = [False] * 128
```

BSymbolTerminators

```
list lispparse.BSymbolTerminators = [False] * 128
```

NormalTerminators

```
lispparse.NormalTerminators = set(['\\', ' ', '\t', '\n', '\f', '\r',
'\'', '\"', '(', ')', '[', ']', '#', ';', '`', ',', '{', '}', chr(0),
chr(0x1b)])
```

SpecialTerminators

```
lispparse.SpecialTerminators = set(['\t', '\n', '\f', '\r', chr(0),
chr(0x1b), '\\', '\"'])
```

terminators_lock

```
lispparse.terminators_lock = threading.Lock()
```

TerminatorsConfigured

```
bool lispparse.TerminatorsConfigured = False
```

UT_ParseFlagExpressions

```
int lispparse.UT_ParseFlagExpressions = 1
```

PID Namespace Reference

Classes

- class MyConnection
- class PID

Functions

- qualify (client, pointname)
- str unqualifyName (str pointname)
- updateOnPointChange (point, name, pid, dhclient)
- pid_create_points (client, pid)
- output_point (pid, name, value)
- pid_calculate (pid)
- pid_calculate_procvar (pid)

- update_setpoint (pid)
- update_pids (pid)
- recalculate_dt (pid)
- change_controller (pid)
- change_procvar (pid)
- have_connection (client, allpids)
- lost_connection (client, allpids)
- register_pid (client, pid, is_register)
- reset_timer (loop, client, pid, timeoutSecs)
- delete_timer (timer)
- start_client (loop, host, port, domain, name, allpids)
- RegisterPointChangeCallback (pid, sym, dhclient)
- outputControlPoints (client, pid)
- main (loop)

Variables

- loop = asyncio.new_event_loop()

Function Documentation

change_controller()

```
PID.change_controller ( pid)
```

```
Change the manipulated variable (MV) for the PID controller.

Arguments:
    pid: The PID controller.
```

change_procvar()

```
PID.change_procvar ( pid)
```

```
Change the process variable (PV) for the PID controller.

Arguments:
    pid: The PID controller.
```

delete_timer()

```
PID.delete_timer ( timer)
```

```
Delete a timer.

Arguments:
    timer: The timer to delete.
```

have_connection()

```
PID.have_connection ( client, allpids)
```

```
Handle a successful connection.

Arguments:
    client: The DataHub client.
    allpids: List of all PID controllers.
```

lost_connection()

```
PID.lost_connection ( client, allpids)
```

```
Handle a lost connection.

Arguments:
    client: The DataHub client.
    allpids: List of all PID controllers.
```

main()

```
PID.main ( loop)
```

```
Main function to run the PID controllers.

Arguments:
    loop: The event loop.
```

output_point()

```
PID.output_point ( pid, name, value)
```

```
Output a point value.

Arguments:
    pid: The PID controller.
    name: The name of the point.
    value: The value to output.
```

outputControlPoints()

```
PID.outputControlPoints ( client, pid)
```

```
Output control points for the PID controller.

Arguments:
    client: The DataHub client.
    pid: The PID controller.
```

pid_calculate()

```
PID.pid_calculate ( pid)
```

```
Calculate the manipulated variable (MV) for the PID controller.

Arguments:
    pid: The PID controller.
Returns:
    float: The calculated MV.
```

pid_calculate_procvar()

```
PID.pid_calculate_procvar ( pid)
```

```
Calculate the process variable (PV) for the PID controller.

Arguments:
    pid: The PID controller.
Returns:
    float: The calculated PV.
```

pid_create_points()

```
PID.pid_create_points ( client, pid)
```

```
Create points for the PID controller.

Arguments:
    client: The DataHub client.
    pid: The PID controller.
```

qualify()

```
PID.qualify ( client, pointname)
```

```
Qualify a point name with the client's domain.
```

```
Arguments:
    client: The DataHub client.
    pointname: The point name to qualify.
Returns:
    str: The qualified point name.
```

recalculate_dt()

```
PID.recalculate_dt ( pid)
```

```
Recalculate the time delta (dt) for the PID controller.

Arguments:
    pid: The PID controller.
```

register_pid()

```
PID.register_pid ( client, pid, is_register)
```

```
Register or unregister points for the PID controller.

Arguments:
    client: The DataHub client.
    pid: The PID controller.
    is_register: Whether to register or unregister the points.
```

RegisterPointChangeCallback()

```
PID.RegisterPointChangeCallback ( pid, sym, dhclient)
```

```
Register a callback for point change events.

Arguments:
    pid: The PID controller.
    sym: The symbol name.
    dhclient: The DataHub client.
```

reset_timer()

```
PID.reset_timer ( loop, client, pid, timeoutSecs)
```

```
Reset the timers for the PID controller.

Arguments:
    loop: The event loop.
    client: The DataHub client.
```

```
    pid: The PID controller.
    timeoutSecs: The timeout in seconds.
```

start_client()

```
PID.start_client ( loop, host, port, domain, name, allpids)
```

```
Start a DataHub client.

Arguments:
    loop: The event loop.
    host: The host address.
    port: The port number.
    domain: The domain name.
    name: The name of the client.
    allpids: List of all PID controllers.
Returns:
    MyConnection: The started client.
```

unqualifyName()

```
str PID.unqualifyName (str pointname)
```

```
Remove the domain prefix from a point name.

    pointname: The qualified point name.
Returns:
    str: The unqualified point name.
```

update_pids()

```
PID.update_pids ( pid)
```

```
Update the PID controller.

Arguments:
    pid: The PID controller.
```

update_setpoint()

```
PID.update_setpoint ( pid)
```

```
Update the setpoint (SP) for the PID controller.

Arguments:
    pid: The PID controller.
```

updateOnPointChange()

```
PID.updateOnPointChange ( point, name, pid, dhclient)
```

```
Update PID attributes based on point changes.

Arguments:
    point: The point that changed.
    name: The name of the attribute to update.
    pid: The PID controller.
    dhclient: The DataHub client.
```

Variable Documentation

loop

```
PID.loop = asyncio.new_event_loop()
```

TrendChart Namespace Reference

Classes

- class MyConnection
- class Trace

Functions

- start_client (loop, host, port, name)
- lost_connection (client)
- have_connection (client)
- registerPoint (client, point_name, square=False, extend=False)
- on_point_changed (client, point)
- update_plot (client)
- main ()

Variables

- traceDictionary = dict()
- fig
- ax
- int window_size = 60
- current_time = datetime.now()
- start_time = current_time - timedelta(minutes=1)

Function Documentation

have_connection()

TrendChart.have_connection (client)

```
Register points with the DataHub client upon connection.

Arguments:
    client: The DataHub client.
```

lost_connection()

TrendChart.lost_connection (client)

```
Print out that the connection was lost.

Arguments:
    client: The DataHub client.
```

main()

TrendChart.main ( )

```
Main function to run everything.
```

on_point_changed()

TrendChart.on_point_changed (client, point)

```
Handle point change events and update trend data.

Arguments:
    client: The DataHub client.
    point: The point that changed.
```

registerPoint()

TrendChart.registerPoint (client, point_name, square = False , extend = False)

```
Register a point with the DataHub client.

Arguments:
    client: The DataHub client.
    point_name: The name of the point.
```

```
    square: Whether the trace should be a square wave.
    extend: Whether the trace should extend the last value.
```

start_client()

```
TrendChart.start_client ( loop, host, port, name)
```

```
Create and configure a DataHub client connection.

Arguments:
    loop: The event loop.
    host: The host address.
    port: The port number.
    name: The name of the connection.
Returns:
    MyConnection: The configured client connection.
```

update_plot()

```
TrendChart.update_plot ( client)
```

```
Update the plot with new data.

Arguments:
    client: The DataHub client.
```

Variable Documentation

ax

```
TrendChart.ax
```

current_time

```
TrendChart.current_time = datetime.now()
```

fig

```
TrendChart.fig
```

start_time

```
TrendChart.start_time = current_time - timedelta(minutes=1)
```

traceDictionary

```
TrendChart.traceDictionary = dict()
```

window_size

```
int TrendChart.window_size = 60
```

Class Documentation

DataHubConnection.ChangeFlags Class Reference

Static Public Attributes

- int ECHO = 0x0001
- int WAITING = 0x0002
- int FOREIGN = 0x0004
- int SYNCING = 0x0008

Detailed Description

```
IntFlag representing various change flags.
```

Member Data Documentation

ECHO

```
int DataHubConnection.ChangeFlags.ECHO = 0x0001[static]
```

FOREIGN

```
int DataHubConnection.ChangeFlags.FOREIGN = 0x0004[static]
```

SYNCING

```
int DataHubConnection.ChangeFlags.SYNCING = 0x0008[static]
```

WAITING

```
int DataHubConnection.ChangeFlags.WAITING = 0x0002[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.ConnectionOptions Class Reference

Public Member Functions

- __init__ (self)
- FullUsername (self)
- HasCredentials (self)

- HasProxyCredentials (self)
- HasParentSessionId (self)

Public Attributes

- Hostname = None
- Port = None
- WebPort = None
- IsHttps = None
- Domain = None
- Username = None
- Password = None
- ParentSessionId = UUID('00000000-0000-0000-0000-000000000000')
- DefaultDomain = None
- ProxyHostname = None
- ProxyPort = None
- ProxyUsername = None
- ProxyPassword = None
- int Heartbeat = 0
- int Timeout = 0
- int ReconnectDelay = 5000
- int DomainListDelay = 5000
- Organization = None
- IsSsl = None
- ClientCertificate = None
- AcceptInvalidCertificates = None

Detailed Description

```
Class to handle connection options.
```

Constructor & Destructor Documentation

__init__()

```
DataHubConnection.ConnectionOptions.__init__ ( self)
```

```
Initialize the ConnectionOptions object with default values.
```

Member Function Documentation

FullUsername()

```
DataHubConnection.ConnectionOptions.FullUsername ( self)
```

```
Get the full username including the domain.

Returns:
    str: The full username.
```

HasCredentials()

```
DataHubConnection.ConnectionOptions.HasCredentials ( self)
```

```
Check if the connection options have credentials.

Returns:
    bool: True if both username and password are set, False otherwise.
```

HasParentSessionId()

```
DataHubConnection.ConnectionOptions.HasParentSessionId ( self)
```

```
Check if the connection options have a parent session ID.

Returns:
    bool: True if the parent session ID is not the default value,
    False otherwise.
```

HasProxyCredentials()

```
DataHubConnection.ConnectionOptions.HasProxyCredentials ( self)
```

```
Check if the connection options have proxy credentials.

Returns:
    bool: True if both proxy username and proxy password are set,
    False otherwise.
```

Member Data Documentation

AcceptInvalidCertificates

```
DataHubConnection.ConnectionOptions.AcceptInvalidCertificates = None
```

ClientCertificate

```
DataHubConnection.ConnectionOptions.ClientCertificate = None
```

DefaultDomain

```
DataHubConnection.ConnectionOptions.DefaultDomain = None
```

Domain

```
DataHubConnection.ConnectionOptions.Domain = None
```

DomainListDelay

```
int DataHubConnection.ConnectionOptions.DomainListDelay = 5000
```

Heartbeat

```
int DataHubConnection.ConnectionOptions.Heartbeat = 0
```

Hostname

```
DataHubConnection.ConnectionOptions.Hostname = None
```

IsHttps

```
DataHubConnection.ConnectionOptions.IsHttps = None
```

IsSsl

```
DataHubConnection.ConnectionOptions.IsSsl = None
```

Organization

```
DataHubConnection.ConnectionOptions.Organization = None
```

ParentSessionId

```
DataHubConnection.ConnectionOptions.ParentSessionId =
UUID('00000000-0000-0000-0000-000000000000')
```

Password

```
DataHubConnection.ConnectionOptions.Password = None
```

Port

```
DataHubConnection.ConnectionOptions.Port = None
```

ProxyHostname

```
DataHubConnection.ConnectionOptions.ProxyHostname = None
```

ProxyPassword

```
DataHubConnection.ConnectionOptions.ProxyPassword = None
```

ProxyPort

```
DataHubConnection.ConnectionOptions.ProxyPort = None
```

ProxyUsername

```
DataHubConnection.ConnectionOptions.ProxyUsername = None
```

ReconnectDelay

```
int DataHubConnection.ConnectionOptions.ReconnectDelay = 5000
```

Timeout

```
int DataHubConnection.ConnectionOptions.Timeout = 0
```

Username

```
DataHubConnection.ConnectionOptions.Username = None
```

WebPort

```
DataHubConnection.ConnectionOptions.WebPort = None
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.DataHubConnection Class Reference

Public Member Functions

- __init__ (self, loop)

- performConnect (self)
- connect (self)
- defaultOnPointChange (self, point)
- runAllPointChangeMethods (self)
- log (self, severity, message)
- runPointChangeMethod (self, point)
- runCallback (self, callback)
- getCnxState (self)
- getCnxStateString (self)
- MarkAllPointsAsNotConnected (self)
- read_messages (self)
- message_writer (self)
- startDomainListTimer (self)
- cancelDomainListTimer (self)
- DomainListEventHandler (self)
- sendAlive (self)
- timeoutCheck (self)
- sendLogin (self)
- sendWantSuccess (self)
- appendPointValueMetaData (self, list sb, MetadataFlags valid_flags, Union[str, float, None] value, MetadataFlags flag)
- Optional[Exception] writeMetadata (self, str point_name, Optional[PointMetaInfo] metadata)
- Exception setDefaultDomain (self, str domain)
- sendHeartbeatTimes (self)
- startHeartbeatTimers (self)
- activeHeartbeatTimers (self)
- cancelHeartbeatTimers (self)
- setHeartbeatTimes (self, heartbeat_ms, timeout_ms)
- getPort (self)
- getHostName (self)
- getReconnectionDelay (self)
- getHeartbeat (self)
- getTimeout (self)
- setConnState (self, newstate)

- startReconnectionTimer (self)
- RetryEventHandler (self)
- setReconnectionDelay (self, recon_ms)
- cancelReconnectionTimer (self)
- setUsername (self, username, password)
- setSsl (self, isSSL, acceptInvalidCertificates, clientCertificate)
- setProxyParms (self, proxyHostname, proxyPort, proxyUsername, proxyPassword)
- setWebparms (self, httpPort, isHttps)
- setConnectionParms (self, hostname, port, username=None, password=None, parent_session_id=None)
- getPointCache (self)
- registerDomain (self, domainname, flags)
- registerPoint (self, point_or_name, create=False)
- unregisterPoint (self, point)
- LookupOrCreatePoint (self, point)
- lookupPoint (self, point)
- createPoint (self, point)
- sendCommand (self, message)
- preciseTimer (self, loop, delay, interval, callback, *args, **kwargs)
- Timer (self, loop, delay, interval, callback, *args, **kwargs)
- writePoint (self, pointname, value, type=None, seconds=None, nanoseconds=None, quality=None, create=None, force=None)
- performWritePoint (self, pointname, point_type, strval, seconds, nanoseconds, quality, create, force)
- initializePointCache (self, model=None)
- getDefaultDomain (self)
- shutdown (self)
- changeType (self, valueType, stringValue)
- mathPointValue (self, operation, pointname, value, sec, nsec)
- dividePointValue (self, point, value)
- multiplyPointValue (self, point, value)
- addPointValue (self, point, value)
- appendPointValue (self, point, value)
- setPointTimeStamp (point, datetime_obj)
- sendConnectionCommands (self)

- Connection_ConnectFailed (self, host, port)
- Connection_ConnectSucceeded (self, host, port)
- Connection_Connecting (self, host, port)
- closeConnection (self)

Public Attributes

- onConnected = None
- onDisconnected = None
- onPointChange = lambda x : self.defaultOnPointChange(x)
- onCommand = None
- onEcho = None
- onAsyncMessage = None
- onAlive = None
- onSuccess = None
- onError = None
- onLog = None
- onConnectionSuccess = None
- onConnectionFailure = None
- onConnecting = None
- onStatusChange = None
- data = bytearray()
- m_connstate = DataHubConnectionStatus.Idle
- ConnectionStatus = self.m_connstate
- m_aliveTimer = None
- m_retrytimer = None
- m_domainlisttimer = None
- Options = ConnectionOptions()
- loop = loop
- writer = None
- reader = None
- name = None
- m_datamodel = dict()
- message_queue = asyncio.Queue()
- m_timeoutTimer = None
- bool dataWasRead = False

Detailed Description

```
Represents a connection to the DataHub.

Attributes:
    onConnected: Callback for when the connection is established.
    onDisconnected: Callback for when the connection is disconnected.
    onPointChange: Callback for when a point changes.
    onCommand: Callback for when a command is received.
    onEcho: Callback for when an echo message is received.
    onAsyncMessage: Callback for when an asynchronous
    message is received.
    onAlive: Callback for when an alive message is received.
    onSuccess: Callback for when an operation is successful.
    onError: Callback for when an error occurs.
    onLog: Callback for logging messages.
    onConnectionSuccess: Callback for when the connection is
    successfully established.
    onConnectionFailure: Callback for when the connection fails.
    onConnecting: Callback for when the connection is in the
    process of connecting.
    onStatusChange: Callback for when the connection status changes.
    data: Bytearray to store data.
    m_connstate: Current connection state.
    ConnectionStatus: Alias for the current connection state.
    m_aliveTimer: Timer for the alive message.
    m_retrytimer: Timer for retrying the connection.
    m_domainlisttimer: Timer for domain list updates.
    Options: Connection options.
    loop: Event loop.
    writer: Stream writer.
    reader: Stream reader.
    name: Connection name.
    m_datamodel: Data model dictionary.
    message_queue: Queue for messages.
    m_timeoutTimer: Timer for connection timeout.
    dataWasRead: Flag indicating if data was read.
```

Constructor & Destructor Documentation

__init__()

`DataHubConnection.DataHubConnection.__init__ ( self, loop)`

```
Initialize the DataHubConnection object.

Arguments:
```

```
    loop: The event loop.
```

Reimplemented in PID.MyConnection, and TrendChart.MyConnection.

Member Function Documentation

activeHeartbeatTimers()

DataHubConnection.DataHubConnection.activeHeartbeatTimers (self)

```
Check if heartbeat timers are active.

Returns:
    bool: True if heartbeat timers are active, False otherwise.
```

addPointValue()

DataHubConnection.DataHubConnection.addPointValue (self, point, value)

```
Add a value to a point.

Arguments:
    point: The point to add to.
    value: The value to add.
Returns:
    The result of the mathPointValue function.
```

appendPointValue()

DataHubConnection.DataHubConnection.appendPointValue (self, point, value)

```
Append a value to a point.

Arguments:
    point: The point to append to.
    value: The value to append.
Returns:
    The result of the sendCommand function.
```

appendPointValueMetaData()

DataHubConnection.DataHubConnection.appendPointValueMetaData (self, list sb, MetadataFlags valid_flags, Union[str, float, None] value, MetadataFlags flag)

```
Append point value metadata to a list.

Arguments:
    sb: The list to append to.
    valid_flags: The valid metadata flags.
    value: The value to append.
    flag: The metadata flag.
```

cancelDomainListTimer()

DataHubConnection.DataHubConnection.cancelDomainListTimer (self)

```
Cancel the domain list timer.
```

cancelHeartbeatTimers()

DataHubConnection.DataHubConnection.cancelHeartbeatTimers (self)

```
Cancel the heartbeat timers.
```

cancelReconnectionTimer()

DataHubConnection.DataHubConnection.cancelReconnectionTimer (self)

```
Cancel the reconnection timer.
```

changeType()

DataHubConnection.DataHubConnection.changeType (self, valueType, stringValue)

```
Change the type of a value.

Arguments:
    valueType: The type to change to.
    stringValue: The value as a string.
Returns:
    The value converted to the specified type.
```

closeConnection()

DataHubConnection.DataHubConnection.closeConnection (self)

```
Close the connection.
```

connect()

`DataHubConnection.DataHubConnection.connect ( self)`

```
Start the reconnection timer and attempt to connect.
```

Connection_ConnectFailed()

`DataHubConnection.DataHubConnection.Connection_ConnectFailed ( self, host, port)`

```
Handle a failed connection attempt.

Arguments:
    host: The host that was attempted to connect to.
    port: The port that was attempted to connect to.
```

Connection_Connecting()

`DataHubConnection.DataHubConnection.Connection_Connecting ( self, host, port)`

```
Handle an ongoing connection attempt.

Arguments:
    host: The host that is being connected to.
    port: The port that is being connected to.
```

Connection_ConnectSucceeded()

`DataHubConnection.DataHubConnection.Connection_ConnectSucceeded ( self, host, port)`

```
Handle a successful connection attempt.

Arguments:
    host: The host that was connected to.
    port: The port that was connected to.
```

createPoint()

`DataHubConnection.DataHubConnection.createPoint ( self, point)`

```
Create a point.

Arguments:
    point: The point name.
Returns:
    DataHubPoint: The created point object.
```

defaultOnPointChange()

DataHubConnection.DataHubConnection.defaultOnPointChange (self, point)

```
Default handler for point change events.

Arguments:
    point: The point that changed.
```

dividePointValue()

DataHubConnection.DataHubConnection.dividePointValue (self, point, value)

```
Divide a point value.

Arguments:
    point: The point to divide.
    value: The value to divide by.
Returns:
    The result of the mathPointValue function.
Throws:
    TypeError: If the point is not of type DataHubPoint or str.
```

DomainListEventHandler()

DataHubConnection.DataHubConnection.DomainListEventHandler (self)

```
Handle the domain list event.
```

getCnxState()

DataHubConnection.DataHubConnection.getCnxState (self)

```
Get the current connection state.

Returns:
    DataHubConnectionStatus: The current connection state.
```

getCnxStateString()

DataHubConnection.DataHubConnection.getCnxStateString (self)

```
Get the current connection state as a string.
```

```
Returns:
    str: The current connection state as a string.
```

getDefaultDomain()

`DataHubConnection.DataHubConnection.getDefaultDomain ( self)`

```
Get the default domain.

Returns:
    The default domain.
```

getHeartbeat()

`DataHubConnection.DataHubConnection.getHeartbeat ( self)`

```
Get the heartbeat time.

Returns:
    int: The heartbeat time in milliseconds.
```

getHostName()

`DataHubConnection.DataHubConnection.getHostName ( self)`

```
Get the host name.

Returns:
    str: The host name.
```

getPointCache()

`DataHubConnection.DataHubConnection.getPointCache ( self)`

```
Get the point cache.

Returns:
    dict: The point cache.
```

getPort()

`DataHubConnection.DataHubConnection.getPort ( self)`

```
Get the port number.

Returns:
```

```
    int: The port number.
```

getReconnectionDelay()

DataHubConnection.DataHubConnection.getReconnectionDelay (self)

```
Get the reconnection delay.

Returns:
    int: The reconnection delay in milliseconds.
```

getTimeout()

DataHubConnection.DataHubConnection.getTimeout (self)

```
Get the timeout time.

Returns:
    int: The timeout time in milliseconds.
```

initializePointCache()

DataHubConnection.DataHubConnection.initializePointCache (self, model = None)

```
Initialize the point cache.

Arguments:
    model: The data model to use for initialization.
```

log()

DataHubConnection.DataHubConnection.log (self, severity, message)

```
Log a message with the given severity.

Arguments:
    severity: The severity of the log message.
    message: The log message.
```

LookupOrCreatePoint()

DataHubConnection.DataHubConnection.LookupOrCreatePoint (self, point)

```
Lookup or create a point.
```

```
Arguments:
    point: The point name.
Returns:
    DataHubPoint: The point object.
```

lookupPoint()

DataHubConnection.DataHubConnection.lookupPoint (self, point)

```
Lookup a point.

Arguments:
    point: The point name.
Returns:
    DataHubPoint: The point object.
```

MarkAllPointsAsNotConnected()

DataHubConnection.DataHubConnection.MarkAllPointsAsNotConnected (self)

```
Mark all points in the data model as not connected.
```

mathPointValue()

DataHubConnection.DataHubConnection.mathPointValue (self, operation, pointname, value, sec, nsec)

```
Perform a mathematical operation on a point value.

Arguments:
    operation: The operation to perform.
    pointname: The name of the point.
    value: The value to use in the operation.
    sec: The seconds part of the timestamp.
    nsec: The nanoseconds part of the timestamp.
Returns:
    The result of the sendCommand function.
```

message_writer()

DataHubConnection.DataHubConnection.message_writer (self)

```
Continuously sends messages from the queue to the socket.
```

multiplyPointValue()

DataHubConnection.DataHubConnection.multiplyPointValue (self, point, value)

```
Multiply a point value.

Arguments:
    point: The point to multiply.
    value: The value to multiply by.
Returns:
    The result of the mathPointValue function.
Throws:
    TypeError: If the point is not of type DataHubPoint or str.
```

performConnect()

DataHubConnection.DataHubConnection.performConnect (self)

```
Attempt to connect to the server and start reading/writing.
```

performWritePoint()

DataHubConnection.DataHubConnection.performWritePoint (self, pointname, point_type, strval, seconds, nanoseconds, quality, create, force)

```
Perform the actual write to a point. This is called by WritePoint.

Arguments:
    pointname: The name of the point.
    point_type: The type of the point.
    strval: The value to write.
    seconds: The seconds part of the timestamp.
    nanoseconds: The nanoseconds part of the timestamp.
    quality: The quality of the point.
    create: Whether to create the point if it doesn't exist.
    force: Whether to force the write.
Returns:
    The result of the sendCommand function.
```

preciseTimer()

DataHubConnection.DataHubConnection.preciseTimer (self, loop, delay, interval, callback, * args, ** kwargs)

```
Create a precise timer with no drift. The precise timer is
slower than the regular timer but is extremely accurate.
```

```
Arguments:
    loop: The event loop.
    delay: The initial delay in milliseconds.
    interval: The interval in milliseconds.
    callback: The callback function.
    *args: Additional arguments for the callback.
    **kwargs: Additional keyword arguments for the callback.
Returns:
    PreciseTimer: The created precise timer.
```

read_messages()

DataHubConnection.DataHubConnection.read_messages (self)

```
Continuously read messages from the server.
```

registerDomain()

DataHubConnection.DataHubConnection.registerDomain (self, domainname, flags)

```
Register a domain.

Arguments:
    domainname: The domain name.
    flags: The domain flags.
```

registerPoint()

DataHubConnection.DataHubConnection.registerPoint (self, point_or_name, create = False)

```
Register a point.

Arguments:
    point_or_name: The point or point name.
    create: Whether to create the point if it doesn't exist.
    Defaults to False.
```

RetryEventHandler()

DataHubConnection.DataHubConnection.RetryEventHandler (self)

```
Handle the retry event.
```

runAllPointChangeMethods()

```
DataHubConnection.DataHubConnection.runAllPointChangeMethods ( self)
```

```
Run point change methods for all points in the data model.
```

runCallback()

```
DataHubConnection.DataHubConnection.runCallback ( self, callback)
```

```
Run a callback if it is set.

Arguments:
    callback: The callback to run.
```

runPointChangeMethod()

```
DataHubConnection.DataHubConnection.runPointChangeMethod ( self,
point)
```

```
Run the point change method for a given point.

Arguments:
    point: The point that changed.
```

sendAlive()

```
DataHubConnection.DataHubConnection.sendAlive ( self)
```

```
Send an alive message to the server.
```

sendCommand()

```
DataHubConnection.DataHubConnection.sendCommand ( self, message)
```

```
Send a command to the server.

Arguments:
    message: The command message.
```

sendConnectionCommands()

```
DataHubConnection.DataHubConnection.sendConnectionCommands ( self)
```

```
Send the initial connection commands.
```

sendHeartbeatTimes()

`DataHubConnection.DataHubConnection.sendHeartbeatTimes ( self)`

```
Send heartbeat times to the server.
```

sendLogin()

`DataHubConnection.DataHubConnection.sendLogin ( self)`

```
Send login credentials to the server.
```

sendWantSuccess()

`DataHubConnection.DataHubConnection.sendWantSuccess ( self)`

```
Send a success acknowledgment request to the server.
```

setConnectionParms()

`DataHubConnection.DataHubConnection.setConnectionParms ( self, hostname, port, username = None , password = None , parent_session_id = None )`

```
Set connection parameters.

Arguments:
    hostname: The hostname.
    port: The port.
    username: The username. Defaults to None.
    password: The password. Defaults to None.
    parent_session_id: The parent session ID. Defaults to None.
```

setConnState()

`DataHubConnection.DataHubConnection.setConnState ( self, newstate)`

```
Set the connection state.

Arguments:
    newstate: The new connection state.
```

setDefaultDomain()

`Exception DataHubConnection.DataHubConnection.setDefaultDomain ( self, str domain)`

```
Set the default domain.

Arguments:
    domain: The domain to set as default.
Returns:
    Exception: An exception if the domain is invalid.
```

setHeartbeatTimes()

DataHubConnection.DataHubConnection.setHeartbeatTimes (self, heartbeat_ms, timeout_ms)

```
Set the heartbeat and timeout times.

Arguments:
    heartbeat_ms: The heartbeat time in milliseconds.
    timeout_ms: The timeout time in milliseconds.
```

setPointTimeStamp()

DataHubConnection.DataHubConnection.setPointTimeStamp (point, datetime_obj)

```
Set the timestamp of a point.

Arguments:
    point: The point to set the timestamp for.
    datetime_obj: The datetime object representing the timestamp.

Throws:
    TypeError: If the point is not of type DataHubPoint.
```

setProxyParms()

DataHubConnection.DataHubConnection.setProxyParms (self, proxyHostname, proxyPort, proxyUsername, proxyPassword)

```
Set proxy parameters.

Arguments:
    proxyHostname: The proxy hostname.
    proxyPort: The proxy port.
    proxyUsername: The proxy username.
    proxyPassword: The proxy password.
```

setReconnectionDelay()

```
DataHubConnection.DataHubConnection.setReconnectionDelay ( self,
recon_ms)
```

```
Set the reconnection delay.

Arguments:
    recon_ms: The reconnection delay in milliseconds.
```

setSsl()

```
DataHubConnection.DataHubConnection.setSsl ( self, isSSL,
acceptInvalidCertificates, clientCertificate)
```

```
Set SSL options.

Arguments:
    isSSL: Whether to use SSL.
    acceptInvalidCertificates: Whether to accept invalid certificates.
    clientCertificate: The client certificate.
```

setUsername()

```
DataHubConnection.DataHubConnection.setUsername ( self, username,
password)
```

```
Set the username and password.

Arguments:
    username: The username.
    password: The password.
```

setWebparms()

```
DataHubConnection.DataHubConnection.setWebparms ( self, httpPort,
isHttps)
```

```
Set web parameters.

Arguments:
    httpPort: The HTTP port.
    isHttps: Whether to use HTTPS.
```

shutdown()

```
DataHubConnection.DataHubConnection.shutdown ( self)
```

```
Shutdown the connection.
```

startDomainListTimer()

DataHubConnection.DataHubConnection.startDomainListTimer (self)

```
Start the domain list timer.
```

startHeartbeatTimers()

DataHubConnection.DataHubConnection.startHeartbeatTimers (self)

```
Start the heartbeat timers.
```

startReconnectionTimer()

DataHubConnection.DataHubConnection.startReconnectionTimer (self)

```
Start the reconnection timer.
```

timeoutCheck()

DataHubConnection.DataHubConnection.timeoutCheck (self)

```
Check for connection timeout.
```

Timer()

DataHubConnection.DataHubConnection.Timer (self, loop, delay, interval, callback, * args, ** kwargs)

```
Create a new timer. This timer is much quicker than the precise timer
but without the same accuracy.

Arguments:
    loop: The event loop.
    delay: The delay before the timer starts.
    interval: The interval between timer executions.
    callback: The callback function to execute.
    *args: Additional arguments for the callback.
    **kwargs: Additional keyword arguments for the callback.
Returns:
    Timer: The created timer.
```

unregisterPoint()

```
DataHubConnection.DataHubConnection.unregisterPoint ( self, point)
```

```
Unregister a point.

Arguments:
    point: The point or point name.
```

writeMetadata()

```
Optional[Exception] DataHubConnection.DataHubConnection.writeMetadata
( self, str point_name, Optional[PointMetaInfo] metadata)
```

```
Write metadata for a point.

Arguments:
    point_name: The name of the point.
    metadata: The metadata to write.
Returns:
    Optional[Exception]: An exception if an error occurs,
    otherwise None.
```

writePoint()

```
DataHubConnection.DataHubConnection.writePoint ( self, pointname,
value, type = None , seconds = None , nanoseconds = None , quality =
None , create = None , force = None )
```

```
Write a value to a point.

Arguments:
    pointname: The name of the point.
    value: The value to write.
    type: The type of the point.
    seconds: The seconds part of the timestamp.
    nanoseconds: The nanoseconds part of the timestamp.
    quality: The quality of the point.
    create: Whether to create the point if it doesn't exist.
    force: Whether to force the write.
```

Member Data Documentation

ConnectionStatus

```
DataHubConnection.DataHubConnection.ConnectionStatus =
self.m_connstate
```

data

```
DataHubConnection.DataHubConnection.data = bytearray()
```

dataWasRead

```
bool DataHubConnection.DataHubConnection.dataWasRead = False
```

loop

```
DataHubConnection.DataHubConnection.loop = loop
```

m_aliveTimer

```
DataHubConnection.DataHubConnection.m_aliveTimer = None
```

m_connstate

```
DataHubConnection.DataHubConnection.m_connstate =
DataHubConnectionStatus.Idle
```

m_datamodel

```
DataHubConnection.DataHubConnection.m_datamodel = dict()
```

m_domainlisttimer

```
DataHubConnection.DataHubConnection.m_domainlisttimer = None
```

m_retrytimer

```
DataHubConnection.DataHubConnection.m_retrytimer = None
```

m_timeoutTimer

```
DataHubConnection.DataHubConnection.m_timeoutTimer = None
```

message_queue

```
DataHubConnection.DataHubConnection.message_queue = asyncio.Queue()
```

name

```
DataHubConnection.DataHubConnection.name = None
```

onAlive

```
DataHubConnection.DataHubConnection.onAlive = None
```

onAsyncMessage

```
DataHubConnection.DataHubConnection.onAsyncMessage = None
```

onCommand

```
DataHubConnection.DataHubConnection.onCommand = None
```

onConnected

```
DataHubConnection.DataHubConnection.onConnected = None
```

onConnecting

```
DataHubConnection.DataHubConnection.onConnecting = None
```

onConnectionFailure

```
DataHubConnection.DataHubConnection.onConnectionFailure = None
```

onConnectionSuccess

```
DataHubConnection.DataHubConnection.onConnectionSuccess = None
```

onDisconnected

```
DataHubConnection.DataHubConnection.onDisconnected = None
```

onEcho

```
DataHubConnection.DataHubConnection.onEcho = None
```

onError

```
DataHubConnection.DataHubConnection.onError = None
```

onLog

```
DataHubConnection.DataHubConnection.onLog = None
```

onPointChange

```
DataHubConnection.DataHubConnection.onPointChange = lambda x :
self.defaultOnPointChange(x)
```

onStatusChange

```
DataHubConnection.DataHubConnection.onStatusChange = None
```

onSuccess

```
DataHubConnection.DataHubConnection.onSuccess = None
```

Options

```
DataHubConnection.DataHubConnection.Options = ConnectionOptions()
```

reader

```
DataHubConnection.DataHubConnection.reader = None
```

writer

```
DataHubConnection.DataHubConnection.writer = None
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.DataHubConnectionStatus Class Reference

Static Public Attributes

- int Idle = 0
- int Connecting = 1
- int Connected = 2
- int RetryWait = 3
- int Disconnected = 4
- int Terminated = 5

Detailed Description

```
Enum representing the status of a DataHub connection.
```

Member Data Documentation

Connected

```
int DataHubConnection.DataHubConnectionStatus.Connected = 2[static]
```

Connecting

```
int DataHubConnection.DataHubConnectionStatus.Connecting = 1[static]
```

Disconnected

```
int DataHubConnection.DataHubConnectionStatus.Disconnected = 4[static]
```

Idle

```
int DataHubConnection.DataHubConnectionStatus.Idle = 0[static]
```

RetryWait

```
int DataHubConnection.DataHubConnectionStatus.RetryWait = 3[static]
```

Terminated

```
int DataHubConnection.DataHubConnectionStatus.Terminated = 5[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.DataHubConnectionType Class Reference

Static Public Attributes

- int NoType = 0
- int TCP = 1
- int WebSocket = 2
- int WasmWebSocket = 3

Detailed Description

```
Enum representing the type of DataHub connection.
```

Member Data Documentation

NoType

```
int DataHubConnection.DataHubConnectionType.NoType = 0[static]
```

TCP

```
int DataHubConnection.DataHubConnectionType.TCP = 1[static]
```

WasmWebSocket

```
int DataHubConnection.DataHubConnectionType.WasmWebSocket = 3[static]
```

WebSocket

```
int DataHubConnection.DataHubConnectionType.WebSocket = 2[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

lispparse.DataHubPoint Class Reference

Public Member Functions

- __init__ (self, name, value, quality, timestamp, flags=0)
- setDomainName (self, name)
- AddOnPointChangeMethod (self, callback)
- RemoveOnPointChangeMethod (self, callback)
- __repr__ (self)
- setTimeStamp (self, windowstime=None, datetime_obj=None, seconds=None, nanoseconds=None)
- datetime_to_oatime (self, datetime_obj)
- unix_time_to_windows_time (self, seconds, nanoseconds)
- str unqualifyName (str pointname)
- tuple unqualifyNameWithDomain (str pointname)
- str qualifyName (self, str domainname, str pointname)
- bool IsQualifiedName (self, str name)
- getType (self)
- setValue (self, value)

- setValueFromString (self, value, type)
- getDoubleValue (self)
- getIntValue (self)
- getStringValue (self)
- setInfo (self, iconf, iquality, timestamp, flags)
- setQuality (self, iquality)
- getQuality (self)
- getQualityString (self)
- clear (self)
- getName (self)
- setName (self, name)
- setConfidence (self, iconfidence)
- getConfidence (self)
- setFlags (self, flags)
- getFlags (self)

Public Attributes

- name = name
- value = value
- int timestamp = timestamp
- int quality = quality
- int flags = flags
- DomainName = None
- confidence = None
- CanonicalType = None
- list OnPointChangeMethod = []
- ChangeFlags = None

Detailed Description

```
Class representing a datahub point.
```

Constructor & Destructor Documentation

__init__()

```
lispparse.DataHubPoint.__init__ ( self, name, value, quality,
timestamp, flags = 0 )
```

```
Initializes a DataHubPoint instance.

Arguments:
    name: Name of the point.
    value: Value of the point.
    quality: Quality of the point.
    timestamp: Timestamp of the point.
    flags: Flags associated with the point. Defaults to 0.
```

Member Function Documentation

__repr__()

lispparse.DataHubPoint.__repr__ (self)

```
Returns a string representation of the DataHubPoint instance.

Returns:
    str: String representation.
```

AddOnPointChangeMethod()

lispparse.DataHubPoint.AddOnPointChangeMethod (self, callback)

```
Adds a callback method for point change.

Arguments:
    callback: Callback function.
```

clear()

lispparse.DataHubPoint.clear (self)

```
Clears the point information.
```

datetime_to_oatime()

lispparse.DataHubPoint.datetime_to_oatime (self, datetime_obj)

```
Converts a datetime object to OLE Automation date format.

Arguments:
    datetime_obj: Datetime object.

Returns:
    float: OLE Automation date.
```

getConfidence()

lispparse.DataHubPoint.getConfidence (self)

```
Gets the confidence value of the point.

Returns:
    The confidence value.
```

getDoubleValue()

lispparse.DataHubPoint.getDoubleValue (self)

```
Gets the value as a double.

Returns:
    float: The value as a double.
```

getFlags()

lispparse.DataHubPoint.getFlags (self)

```
Gets the flags of the point.

Returns:
    The flags.
```

getIntValue()

lispparse.DataHubPoint.getIntValue (self)

```
Gets the value as an integer.

Returns:
    int: The value as an integer.
```

getName()

lispparse.DataHubPoint.getName (self)

```
Gets the name of the point.

Returns:
    str: The name of the point.
```

getQuality()

```
lispparse.DataHubPoint.getQuality ( self)
```

```
Gets the quality of the point.

Returns:
    The quality value.
```

getQualityString()

```
lispparse.DataHubPoint.getQualityString ( self)
```

```
Gets the quality of the point as a string.

Returns:
    str: The quality as a string.
```

getStringValue()

```
lispparse.DataHubPoint.getStringValue ( self)
```

```
Gets the value as a string.

Returns:
    str: The value as a string.
```

getType()

```
lispparse.DataHubPoint.getType ( self)
```

```
Gets the type of the value.

Returns:
    type: The type of the value.
```

IsQualifiedName()

```
bool lispparse.DataHubPoint.IsQualifiedName ( self, str name)
```

```
Checks if a point name is qualified.

Arguments:
    name: The point name to check.
Returns:
    bool: True if the name is qualified, False otherwise.
```

qualifyName()

```
str lispparse.DataHubPoint.qualifyName ( self, str domainname, str
pointname)
```

```
Combines a domain name and an unqualified point name into a
qualified point name.

Arguments:
    domainname: The domain name.
    pointname: The unqualified point name.
Returns:
    str: The qualified point name.
```

RemoveOnPointChangeMethod()

```
lispparse.DataHubPoint.RemoveOnPointChangeMethod ( self, callback)
```

```
Removes a callback method for point change.

Arguments:
    callback: Callback function.
```

setConfidence()

```
lispparse.DataHubPoint.setConfidence ( self, iconfidence)
```

```
Sets the confidence value of the point.

Arguments:
    iconfidence: The confidence value.
```

setDomainName()

```
lispparse.DataHubPoint.setDomainName ( self, name)
```

```
Sets the domain name of the point.

Arguments:
    name: Domain name.
```

setFlags()

```
lispparse.DataHubPoint.setFlags ( self, flags)
```

```
Sets the flags of the point.

Arguments:
```

```
    flags: The flags to set.
```

setInfo()

```
lispparse.DataHubPoint.setInfo ( self, iconf, iquality, timestamp,
flags)
```

```
Sets the information for the point.

Arguments:
    iconf: The confidence value.
    iquality: The quality value.
    timestamp: The timestamp.
    flags: The flags.
```

setName()

```
lispparse.DataHubPoint.setName ( self, name)
```

```
Sets the name of the point.

Arguments:
    name: The name to set.
```

setQuality()

```
lispparse.DataHubPoint.setQuality ( self, iquality)
```

```
Sets the quality of the point.

Arguments:
    iquality: The quality value.
```

setTimeStamp()

```
lispparse.DataHubPoint.setTimeStamp ( self, windowstime = None ,
datetime_obj = None , seconds = None , nanoseconds = None )
```

```
Sets the timestamp of the point.

Arguments:
    windowstime: Windows time. Defaults to None.
    datetime_obj: Datetime object. Defaults to None.
    seconds: Unix time seconds. Defaults to None.
    nanoseconds: Unix time nanoseconds. Defaults to None.
```

setValue()

```
lispparse.DataHubPoint.setValue ( self, value)
```

```
Sets the value.

Arguments:
    value: The value to set.
```

setValueFromString()

```
lispparse.DataHubPoint.setValueFromString ( self, value, type)
```

```
Sets the value from a string based on the type.

Arguments:
    value: The value as a string.
    type: The type of the value.
```

unix_time_to_windows_time()

```
lispparse.DataHubPoint.unix_time_to_windows_time ( self, seconds,
nanoseconds)
```

```
Converts Unix time to Windows time.

Arguments:
    seconds: Unix time seconds.
    nanoseconds: Unix time nanoseconds.

Returns:
    float: Windows time.
```

unqualifyName()

```
str lispparse.DataHubPoint.unqualifyName (str pointname)
```

```
Removes the domain prefix from a point name if it exists.

Arguments:
    pointname: The qualified point name.

Returns:
    str: The unqualified point name.
```

unqualifyNameWithDomain()

```
tuple lispparse.DataHubPoint.unqualifyNameWithDomain (str pointname)
```

```
Splits a qualified point name into its domain and unqualified name.

Arguments:
    pointname: The qualified point name.
Returns:
    tuple: A tuple containing the unqualified point name
    and the domain name.
```

Member Data Documentation

CanonicalType

```
lispparse.DataHubPoint.CanonicalType = None
```

ChangeFlags

```
lispparse.DataHubPoint.ChangeFlags = None
```

confidence

```
lispparse.DataHubPoint.confidence = None
```

DomainName

```
lispparse.DataHubPoint.DomainName = None
```

flags

```
int lispparse.DataHubPoint.flags = flags
```

name

```
lispparse.DataHubPoint.name = name
```

OnPointChangeMethod

```
list lispparse.DataHubPoint.OnPointChangeMethod = []
```

quality

```
int lispparse.DataHubPoint.quality = quality
```

timestamp

```
int lispparse.DataHubPoint.timestamp = timestamp
```

value

```
lispparse.DataHubPoint.value = value
```

The documentation for this class was generated from the following file:

lispparse.py

DataHubConnection.DataHubStatus Class Reference

Static Public Attributes

- int OK = 0
- int ERROR = 1
- int NO_TASK = 2
- int NO_MSG = 3
- int WOULDBLOCK = 4
- int INTR = 5
- int FULL = 6
- int LOCKED = 7
- int SECURITY = 8
- int NO_POINT = 9
- int INSIG = 10
- int UNKNOWN = 11
- int NO_QUEUE = 12
- int CMD_SYNTAX_ERROR = 13
- int REPLIED = 14
- int WRONG_TYPE = 15
- int TOO_LARGE = 16
- int NO_MEMORY = 17
- int OLD_DATA = 18
- int TIMEOUT = 19
- int POINT_EXISTS = 20
- int POINT_READONLY = 21
- int IS_CONFIG = 22

- int NOT_ALLOWED = 23
- int NO_LICENSE = 24
- int NOT_AVAILABLE = 25
- int NOT_IMPLEMENTED = 26
- int NO_DOMAIN = 27
- int POINT_COMPUTED = 28

Detailed Description

```
IntEnum representing various DataHub statuses.
```

Member Data Documentation

CMD_SYNTAX_ERROR

```
int DataHubConnection.DataHubStatus.CMD_SYNTAX_ERROR = 13[static]
```

ERROR

```
int DataHubConnection.DataHubStatus.ERROR = 1[static]
```

FULL

```
int DataHubConnection.DataHubStatus.FULL = 6[static]
```

INSIG

```
int DataHubConnection.DataHubStatus.INSIG = 10[static]
```

INTR

```
int DataHubConnection.DataHubStatus.INTR = 5[static]
```

IS_CONFIG

```
int DataHubConnection.DataHubStatus.IS_CONFIG = 22[static]
```

LOCKED

```
int DataHubConnection.DataHubStatus.LOCKED = 7[static]
```

NO_DOMAIN

```
int DataHubConnection.DataHubStatus.NO_DOMAIN = 27[static]
```

NO_LICENSE

```
int DataHubConnection.DataHubStatus.NO_LICENSE = 24[static]
```

NO_MEMORY

```
int DataHubConnection.DataHubStatus.NO_MEMORY = 17[static]
```

NO_MSG

```
int DataHubConnection.DataHubStatus.NO_MSG = 3[static]
```

NO_POINT

```
int DataHubConnection.DataHubStatus.NO_POINT = 9[static]
```

NO_QUEUE

```
int DataHubConnection.DataHubStatus.NO_QUEUE = 12[static]
```

NO_TASK

```
int DataHubConnection.DataHubStatus.NO_TASK = 2[static]
```

NOT_ALLOWED

```
int DataHubConnection.DataHubStatus.NOT_ALLOWED = 23[static]
```

NOT_AVAILABLE

```
int DataHubConnection.DataHubStatus.NOT_AVAILABLE = 25[static]
```

NOT_IMPLEMENTED

```
int DataHubConnection.DataHubStatus.NOT_IMPLEMENTED = 26[static]
```

OK

```
int DataHubConnection.DataHubStatus.OK = 0[static]
```

OLD_DATA

```
int DataHubConnection.DataHubStatus.OLD_DATA = 18[static]
```

POINT_COMPUTED

```
int DataHubConnection.DataHubStatus.POINT_COMPUTED = 28[static]
```

POINT_EXISTS

```
int DataHubConnection.DataHubStatus.POINT_EXISTS = 20[static]
```

POINT_READONLY

```
int DataHubConnection.DataHubStatus.POINT_READONLY = 21[static]
```

REPLIED

```
int DataHubConnection.DataHubStatus.REPLIED = 14[static]
```

SECURITY

```
int DataHubConnection.DataHubStatus.SECURITY = 8[static]
```

TIMEOUT

```
int DataHubConnection.DataHubStatus.TIMEOUT = 19[static]
```

TOO_LARGE

```
int DataHubConnection.DataHubStatus.TOO_LARGE = 16[static]
```

UNKNOWN

```
int DataHubConnection.DataHubStatus.UNKNOWN = 11[static]
```

WOULDBLOCK

```
int DataHubConnection.DataHubStatus.WOULDBLOCK = 4[static]
```

WRONG_TYPE

```
int DataHubConnection.DataHubStatus.WRONG_TYPE = 15[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.DomainFlags Class Reference

Static Public Attributes

- int ALL = 0x01
- int FUTURE = 0x02
- int QUALIFY = 0x04
- int ONCEONLY = 0x08
- int MODEL = 0x10
- int SYNC = 0x20
- int UNREGISTER = 0x40
- int METAINFO = 0x80
- int NOEVENT = 0x0100
- int ECHO = 0x0200

Detailed Description

```
IntFlag representing various domain flags.
```

Member Data Documentation

ALL

```
int DataHubConnection.DomainFlags.ALL = 0x01[static]
```

ECHO

```
int DataHubConnection.DomainFlags.ECHO = 0x0200[static]
```

FUTURE

```
int DataHubConnection.DomainFlags.FUTURE = 0x02[static]
```

METAINFO

```
int DataHubConnection.DomainFlags.METAINFO = 0x80[static]
```

MODEL

```
int DataHubConnection.DomainFlags.MODEL = 0x10[static]
```

NOEVENT

```
int DataHubConnection.DomainFlags.NOEVENT = 0x0100[static]
```

ONCEONLY

```
int DataHubConnection.DomainFlags.ONCEONLY = 0x08[static]
```

QUALIFY

```
int DataHubConnection.DomainFlags.QUALIFY = 0x04[static]
```

SYNC

```
int DataHubConnection.DomainFlags.SYNC = 0x20[static]
```

UNREGISTER

```
int DataHubConnection.DomainFlags.UNREGISTER = 0x40[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.LogSeverity Class Reference

Static Public Attributes

- int ERROR = 0x01
- int WARNING = 0x02
- int INFO = 0x04
- int DEBUG = 0x08

Detailed Description

```
IntFlag representing various Log Severity flags.
```

Member Data Documentation

DEBUG

```
int DataHubConnection.LogSeverity.DEBUG = 0x08[static]
```

ERROR

```
int DataHubConnection.LogSeverity.ERROR = 0x01[static]
```

INFO

```
int DataHubConnection.LogSeverity.INFO = 0x04[static]
```

WARNING

```
int DataHubConnection.LogSeverity.WARNING = 0x02[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.MetadataFlags Class Reference

Static Public Attributes

- int NONE = 0x0000
- int EU = 0x0001
- int DESCRIPTION = 0x0002
- int EU_LOW = 0x0004
- int EU_HIGH = 0x0008
- int INSTR_LOW = 0x0010
- int INSTR_HIGH = 0x0020
- int OPEN = 0x0040
- int CLOSE = 0x0080
- int ORIGIN_NAME = 0x0100
- int ORIGIN_DESCRIPTION = 0x0200
- int ORIGIN_USER = 0x0400
- int ORIGIN_HOST = 0x0800
- int ORIGIN_TYPE = 0x1000

Detailed Description

```
Dataclass representing various metadata flags.
```

Member Data Documentation

CLOSE

```
int DataHubConnection.MetadataFlags.CLOSE = 0x0080[static]
```

DESCRIPTION

```
int DataHubConnection.MetadataFlags.DESCRIPTION = 0x0002[static]
```

EU

```
int DataHubConnection.MetadataFlags.EU = 0x0001[static]
```

EU_HIGH

```
int DataHubConnection.MetadataFlags.EU_HIGH = 0x0008[static]
```

EU_LOW

```
int DataHubConnection.MetadataFlags.EU_LOW = 0x0004[static]
```

INSTR_HIGH

```
int DataHubConnection.MetadataFlags.INSTR_HIGH = 0x0020[static]
```

INSTR_LOW

```
int DataHubConnection.MetadataFlags.INSTR_LOW = 0x0010[static]
```

NONE

```
int DataHubConnection.MetadataFlags.NONE = 0x0000[static]
```

OPEN

```
int DataHubConnection.MetadataFlags.OPEN = 0x0040[static]
```

ORIGIN_DESCRIPTION

```
int DataHubConnection.MetadataFlags.ORIGIN_DESCRIPTION =
0x0200[static]
```

ORIGIN_HOST

```
int DataHubConnection.MetadataFlags.ORIGIN_HOST = 0x0800[static]
```

ORIGIN_NAME

```
int DataHubConnection.MetadataFlags.ORIGIN_NAME = 0x0100[static]
```

ORIGIN_TYPE

```
int DataHubConnection.MetadataFlags.ORIGIN_TYPE = 0x1000[static]
```

ORIGIN_USER

```
int DataHubConnection.MetadataFlags.ORIGIN_USER = 0x0400[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.ModelDomain Class Reference

Public Member Functions

- __init__ (self, name)
- add_instruction (self, command)
- sort_instructions (self)

Public Attributes

- name = name
- list instructions = []
- dict instruction_hash = {}

Detailed Description

```
Class to handle domain-specific instructions.
```

Constructor & Destructor Documentation

__init__()

```
DataHubConnection.ModelDomain.__init__ ( self, name)
```

```
Initialize the ModelDomain object.

Arguments:
    name: The name of the domain.
```

Member Function Documentation

add_instruction()

```
DataHubConnection.ModelDomain.add_instruction ( self, command)
```

```
Add an instruction to the domain.

Arguments:
    command: The command to add.
```

sort_instructions()

```
DataHubConnection.ModelDomain.sort_instructions ( self)
```

```
Sort instructions in the order of create, assembly, subassembly,
private_attribute, instance.
```

Member Data Documentation

instruction_hash

```
DataHubConnection.ModelDomain.instruction_hash = {}
```

instructions

```
list DataHubConnection.ModelDomain.instructions = []
```

name

```
DataHubConnection.ModelDomain.name = name
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.ModelEmitter Class Reference

Public Member Functions

- __init__ (self, conn)
- add_domain (self, name)
- emit (self)
- map_point (self, pointname, delimiters=".", type="R8", access="rw", depth=0)

Public Attributes

- list domains = []
- verbose = None

- conn = conn
- str domains = f"(domain {domain.name})"

Detailed Description

```
Class to handle model emission for a connection.
```

Constructor & Destructor Documentation

__init__()

DataHubConnection.ModelEmitter.__init__ (self, conn)

```
Initialize the ModelEmitter object.

Arguments:
    conn: Connection object to send commands.
```

Member Function Documentation

add_domain()

DataHubConnection.ModelEmitter.add_domain (self, name)

```
Add a domain if it doesn't already exist.

Arguments:
    name: The name of the domain.

Returns:
    The domain object.
```

emit()

DataHubConnection.ModelEmitter.emit (self)

```
Emit commands to the connection, sorted by domain.
```

map_point()

DataHubConnection.ModelEmitter.map_point (self, pointname, delimiters = "." , type = "R8" , access = "rw" , depth = 0)

```
Map a pointname to its domain and generate the necessary instructions.

Arguments:
    pointname: The point name.
```

```
    delimiters: Delimiters for splitting the point name.
    type: The type of the point.
    access: Access type of the point.
    depth: Depth for splitting the point name.
```

Member Data Documentation

conn

```
DataHubConnection.ModelEmitter.conn = conn
```

domains[1/2]

```
list DataHubConnection.ModelEmitter.domains = []
```

domains[2/2]

```
str DataHubConnection.ModelEmitter.domains = f"(domain {domain.name})"
```

verbose

```
DataHubConnection.ModelEmitter.verbose = None
```

The documentation for this class was generated from the following file:

DataHubConnection.py

PID.MyConnection Class Reference

Public Member Functions

- __init__ (self, loop)

Public Member Functions inherited from DataHubConnection.DataHubConnection

- performConnect (self)
- connect (self)
- defaultOnPointChange (self, point)
- runAllPointChangeMethods (self)
- log (self, severity, message)
- runPointChangeMethod (self, point)
- runCallback (self, callback)
- getCnxState (self)
- getCnxStateString (self)
- MarkAllPointsAsNotConnected (self)

- read_messages (self)
- message_writer (self)
- startDomainListTimer (self)
- cancelDomainListTimer (self)
- DomainListEventHandler (self)
- sendAlive (self)
- timeoutCheck (self)
- sendLogin (self)
- sendWantSuccess (self)
- appendPointValueMetaData (self, list sb, MetadataFlags valid_flags, Union[str, float, None] value, MetadataFlags flag)
- Optional[Exception] writeMetadata (self, str point_name, Optional[PointMetaInfo] metadata)
- Exception setDefaultDomain (self, str domain)
- sendHeartbeatTimes (self)
- startHeartbeatTimers (self)
- activeHeartbeatTimers (self)
- cancelHeartbeatTimers (self)
- setHeartbeatTimes (self, heartbeat_ms, timeout_ms)
- getPort (self)
- getHostName (self)
- getReconnectionDelay (self)
- getHeartbeat (self)
- getTimeout (self)
- setConnState (self, newstate)
- startReconnectionTimer (self)
- RetryEventHandler (self)
- setReconnectionDelay (self, recon_ms)
- cancelReconnectionTimer (self)
- setUsername (self, username, password)
- setSsl (self, isSSL, acceptInvalidCertificates, clientCertificate)
- setProxyParms (self, proxyHostname, proxyPort, proxyUsername, proxyPassword)
- setWebparms (self, httpPort, isHttps)
- setConnectionParms (self, hostname, port, username=None, password=None, parent_session_id=None)

- getPointCache (self)
- registerDomain (self, domainname, flags)
- registerPoint (self, point_or_name, create=False)
- unregisterPoint (self, point)
- LookupOrCreatePoint (self, point)
- lookupPoint (self, point)
- createPoint (self, point)
- sendCommand (self, message)
- preciseTimer (self, loop, delay, interval, callback, *args, **kwargs)
- Timer (self, loop, delay, interval, callback, *args, **kwargs)
- writePoint (self, pointname, value, type=None, seconds=None, nanoseconds=None, quality=None, create=None, force=None)
- performWritePoint (self, pointname, point_type, strval, seconds, nanoseconds, quality, create, force)
- initializePointCache (self, model=None)
- getDefaultDomain (self)
- shutdown (self)
- changeType (self, valueType, stringValue)
- mathPointValue (self, operation, pointname, value, sec, nsec)
- dividePointValue (self, point, value)
- multiplyPointValue (self, point, value)
- addPointValue (self, point, value)
- appendPointValue (self, point, value)
- setPointTimeStamp (point, datetime_obj)
- sendConnectionCommands (self)
- Connection_ConnectFailed (self, host, port)
- Connection_ConnectSucceeded (self, host, port)
- Connection_Connecting (self, host, port)
- closeConnection (self)

Public Attributes

- model = DataHubConnection.ModelEmitter(self)

Public Attributes inherited from DataHubConnection.DataHubConnection

- onConnected = None
- onDisconnected = None

- onPointChange = lambda x : self.defaultOnPointChange(x)
- onCommand = None
- onEcho = None
- onAsyncMessage = None
- onAlive = None
- onSuccess = None
- onError = None
- onLog = None
- onConnectionSuccess = None
- onConnectionFailure = None
- onConnecting = None
- onStatusChange = None
- data = bytearray()
- m_connstate = DataHubConnectionStatus.Idle
- ConnectionStatus = self.m_connstate
- m_aliveTimer = None
- m_retrytimer = None
- m_domainlisttimer = None
- Options = ConnectionOptions()
- loop = loop
- writer = None
- reader = None
- name = None
- m_datamodel = dict()
- message_queue = asyncio.Queue()
- m_timeoutTimer = None
- bool dataWasRead = False

Detailed Description

```
Custom connection class inheriting from DataHubConnection.

Arguments:
    model: An instance of ModelEmitter associated with this
    connection.
```

Constructor & Destructor Documentation

__init__()

```
PID.MyConnection.__init__ ( self, loop)
```

```
Initialize the MyConnection object.
```

Reimplemented from DataHubConnection.DataHubConnection.

Member Data Documentation

model

```
PID.MyConnection.model = DataHubConnection.ModelEmitter(self)
```

The documentation for this class was generated from the following file:

PID.py

TrendChart.MyConnection Class Reference

Public Member Functions

- __init__ (self, loop)

Public Member Functions inherited from DataHubConnection.DataHubConnection

- performConnect (self)
- connect (self)
- defaultOnPointChange (self, point)
- runAllPointChangeMethods (self)
- log (self, severity, message)
- runPointChangeMethod (self, point)
- runCallback (self, callback)
- getCnxState (self)
- getCnxStateString (self)
- MarkAllPointsAsNotConnected (self)
- read_messages (self)
- message_writer (self)
- startDomainListTimer (self)
- cancelDomainListTimer (self)
- DomainListEventHandler (self)
- sendAlive (self)
- timeoutCheck (self)

- sendLogin (self)
- sendWantSuccess (self)
- appendPointValueMetaData (self, list sb, MetadataFlags valid_flags, Union[str, float, None] value, MetadataFlags flag)
- Optional[Exception] writeMetadata (self, str point_name, Optional[PointMetaInfo] metadata)
- Exception setDefaultDomain (self, str domain)
- sendHeartbeatTimes (self)
- startHeartbeatTimers (self)
- activeHeartbeatTimers (self)
- cancelHeartbeatTimers (self)
- setHeartbeatTimes (self, heartbeat_ms, timeout_ms)
- getPort (self)
- getHostName (self)
- getReconnectionDelay (self)
- getHeartbeat (self)
- getTimeout (self)
- setConnState (self, newstate)
- startReconnectionTimer (self)
- RetryEventHandler (self)
- setReconnectionDelay (self, recon_ms)
- cancelReconnectionTimer (self)
- setUsername (self, username, password)
- setSsl (self, isSSL, acceptInvalidCertificates, clientCertificate)
- setProxyParms (self, proxyHostname, proxyPort, proxyUsername, proxyPassword)
- setWebparms (self, httpPort, isHttps)
- setConnectionParms (self, hostname, port, username=None, password=None, parent_session_id=None)
- getPointCache (self)
- registerDomain (self, domainname, flags)
- registerPoint (self, point_or_name, create=False)
- unregisterPoint (self, point)
- LookupOrCreatePoint (self, point)
- lookupPoint (self, point)
- createPoint (self, point)

- sendCommand (self, message)
- preciseTimer (self, loop, delay, interval, callback, *args, **kwargs)
- Timer (self, loop, delay, interval, callback, *args, **kwargs)
- writePoint (self, pointname, value, type=None, seconds=None, nanoseconds=None, quality=None, create=None, force=None)
- performWritePoint (self, pointname, point_type, strval, seconds, nanoseconds, quality, create, force)
- initializePointCache (self, model=None)
- getDefaultDomain (self)
- shutdown (self)
- changeType (self, valueType, stringValue)
- mathPointValue (self, operation, pointname, value, sec, nsec)
- dividePointValue (self, point, value)
- multiplyPointValue (self, point, value)
- addPointValue (self, point, value)
- appendPointValue (self, point, value)
- setPointTimeStamp (point, datetime_obj)
- sendConnectionCommands (self)
- Connection_ConnectFailed (self, host, port)
- Connection_ConnectSucceeded (self, host, port)
- Connection_Connecting (self, host, port)
- closeConnection (self)

Public Attributes

- model = DataHubConnection.ModelEmitter(self)
- points = dict()
- latest_timestamp = datetime.now()

Public Attributes inherited from DataHubConnection.DataHubConnection

- onConnected = None
- onDisconnected = None
- onPointChange = lambda x : self.defaultOnPointChange(x)
- onCommand = None
- onEcho = None
- onAsyncMessage = None
- onAlive = None

- onSuccess = None
- onError = None
- onLog = None
- onConnectionSuccess = None
- onConnectionFailure = None
- onConnecting = None
- onStatusChange = None
- data = bytearray()
- m_connstate = DataHubConnectionStatus.Idle
- ConnectionStatus = self.m_connstate
- m_aliveTimer = None
- m_retrytimer = None
- m_domainlisttimer = None
- Options = ConnectionOptions()
- loop = loop
- writer = None
- reader = None
- name = None
- m_datamodel = dict()
- message_queue = asyncio.Queue()
- m_timeoutTimer = None
- bool dataWasRead = False

Detailed Description

```
Custom connection class inheriting from DataHubConnection.

Arguments:
    model: An instance of ModelEmitter associated with this connection.
```

Constructor & Destructor Documentation

__init__()

```
TrendChart.MyConnection.__init__ ( self, loop)
```

```
Initialize the MyConnection object.

Arguments:
    loop: The event loop.
```

Reimplemented from DataHubConnection.DataHubConnection.

Member Data Documentation

latest_timestamp

```
TrendChart.MyConnection.latest_timestamp = datetime.now()
```

model

```
TrendChart.MyConnection.model = DataHubConnection.ModelEmitter(self)
```

points

```
TrendChart.MyConnection.points = dict()
```

The documentation for this class was generated from the following file:

TrendChart.py

PID.PID Class Reference

Public Member Functions

- __init__ (self, domain, basename, conn)

Public Attributes

- name = basename
- domain = domain
- conn = conn
- int sp = 50
- str spTag = f"{basename}.Sp"
- int mv = 0
- str mvTag = f"{basename}.Mv"
- int pv = 0
- str pvTag = f"{basename}.Pv"
- float ckd = 0.01
- str ckdTag = f"{basename}.Controller.Kd"
- float cki = 0.5
- str ckiTag = f"{basename}.Controller.Ki"
- float ckp = 0.25

- str ckpTag = f"{basename}.Controller.Kp"
- float pki = 0.5
- str pkiTag = f"{basename}.Plant.Ki"
- int pkp = 2
- str pkpTag = f"{basename}.Plant.Kp"
- int amplitude = 100
- str amplitudeTag = f"{basename}.Range.Amplitude"
- int offset = 50
- str offsetTag = f"{basename}.Range.Offset"
- int automode = 1
- str automodeTag = f"{basename}.Setpoint.AutoMode"
- int autotime = 5
- int autotimeMs = 5000
- str autotimeTag = f"{basename}.Setpoint.AutoTime"
- int updatefrequency = 10
- str updatefrequencyTag = f"{basename}.UpdateFrequency"
- int errorInt = 0
- int errorPrev = 0
- int errorDrv = 0
- setpointTimer = None
- mvPvTimer = None
- int dt = 0
- float next_call = 0.01
- me = None

Detailed Description

```
Represents a PID controller.

Attributes:
    domain (str): The domain name.
    name (str): The base name of the PID controller.
    conn: The connection associated with the PID controller.
    sp (float): Setpoint value.
    mv (float): Manipulated variable.
    pv (float): Process variable.
    ckd (float): Controller Kd value.
    cki (float): Controller Ki value.
```

```
    ckp (float): Controller Kp value.
    pki (float): Plant Ki value.
    pkp (float): Plant Kp value.
    amplitude (float): Amplitude value.
    offset (float): Offset value.
    automode (int): Auto mode flag.
    autotime (int): Auto time value.
    autotimeMs (int): Auto time in milliseconds.
    updatefrequency (int): Update frequency value.
    errorInt (float): Integral error.
    errorPrev (float): Previous error.
    errorDrv (float): Derivative error.
    setpointTimer: Timer for setpoint updates.
    mvPvTimer: Timer for MV and PV updates.
    dt (float): Time delta.
    next_call (float): Next call time.
    me: Model emitter.
```

Constructor & Destructor Documentation

__init__()

```
PID.PID.__init__ ( self, domain, basename, conn)
```

```
Initialize the PID object.

Arguments:
    domain: The domain name.
    basename: The base name of the PID controller.
    conn: The connection associated with the PID controller.
```

Member Data Documentation

amplitude

```
int PID.PID.amplitude = 100
```

amplitudeTag

```
str PID.PID.amplitudeTag = f"{basename}.Range.Amplitude"
```

automode

```
int PID.PID.automode = 1
```

automodeTag

```
str PID.PID.automodeTag = f"{basename}.Setpoint.AutoMode"
```

autotime

```
int PID.PID.autotime = 5
```

autotimeMs

```
int PID.PID.autotimeMs = 5000
```

autotimeTag

```
str PID.PID.autotimeTag = f"{basename}.Setpoint.AutoTime"
```

ckd

```
float PID.PID.ckd = 0.01
```

ckdTag

```
str PID.PID.ckdTag = f"{basename}.Controller.Kd"
```

cki

```
float PID.PID.cki = 0.5
```

ckiTag

```
str PID.PID.ckiTag = f"{basename}.Controller.Ki"
```

ckp

```
float PID.PID.ckp = 0.25
```

ckpTag

```
str PID.PID.ckpTag = f"{basename}.Controller.Kp"
```

conn

```
PID.PID.conn = conn
```

domain

```
PID.PID.domain = domain
```

dt

```
int PID.PID.dt = 0
```

errorDrv

```
int PID.PID.errorDrv = 0
```

errorInt

```
int PID.PID.errorInt = 0
```

errorPrev

```
int PID.PID.errorPrev = 0
```

me

```
PID.PID.me = None
```

mv

```
int PID.PID.mv = 0
```

mvPvTimer

```
PID.PID.mvPvTimer = None
```

mvTag

```
str PID.PID.mvTag = f"{basename}.Mv"
```

name

```
PID.PID.name = basename
```

next_call

```
float PID.PID.next_call = 0.01
```

offset

```
int PID.PID.offset = 50
```

offsetTag

```
str PID.PID.offsetTag = f"{basename}.Range.Offset"
```

pki

```
float PID.PID.pki = 0.5
```

pkiTag

```
str PID.PID.pkiTag = f"{basename}.Plant.Ki"
```

pkp

```
int PID.PID.pkp = 2
```

pkpTag

```
str PID.PID.pkpTag = f"{basename}.Plant.Kp"
```

pv

```
int PID.PID.pv = 0
```

pvTag

```
str PID.PID.pvTag = f"{basename}.Pv"
```

setpointTimer

```
PID.PID.setpointTimer = None
```

sp

```
int PID.PID.sp = 50
```

spTag

```
str PID.PID.spTag = f"{basename}.Sp"
```

updatefrequency

```
int PID.PID.updatefrequency = 10
```

updatefrequencyTag

```
str PID.PID.updatefrequencyTag = f"{basename}.UpdateFrequency"
```

The documentation for this class was generated from the following file:

PID.py

DataHubConnection.PointFlags Class Reference

Static Public Attributes

- int DH_ITEM_READABLE = 0x000001
- int DH_ITEM_WRITABLE = 0x000002
- int DH_ITEM_LOCKED = 0x000004
- int DH_ITEM_PROPERTY = 0x000008
- int DH_ITEM_SUBASSEMBLY = 0x000010
- int DH_ITEM_ASSEMBLY = 0x000020
- int DH_ITEM_ATTRIBUTE = 0x000040
- int DH_ITEM_TYPE = 0x000080
- int DH_ITEM_ACTIVE = 0x000100
- int DH_ITEM_PRIVATE_ATTRIBUTE = 0x000200
- int DH_ITEM_PROCESSED = 0x000400
- int DH_ITEM_HIDDEN = 0x000800
- int DH_ITEM_AUTO_ID = 0x001000
- int DH_ITEM_NO_MASTER_WRITE = 0x002000
- int DH_ITEM_NO_SLAVE_WRITE = 0x004000
- int DH_ITEM_FORCE_WRITE = 0x008000
- int DH_ITEM_FORCE_INSIG = 0x010000
- int DH_ITEM_MIRROR_ONLY = 0x020000
- int DH_ITEM_TEMP_VALUE = 0x040000
- int DH_ITEM_FORCE_WRITE_RO = 0x100000

- int DH_ITEM_UNINITIALIZED = 0x200000
- int DH_ITEM_FIRST_VALUE = 0x400000
- int DH_ITEM_IMMUTABLE = 0x800000
- int DH_ITEM_PUBLISH_MODEL = 0x01000000
- int DH_ITEM_ZIP_MODEL = 0x02000000
- int DH_ITEM_DELETED = 0x04000000
- int DH_ITEM_CHILD = DH_ITEM_PROPERTY | DH_ITEM_SUBASSEMBLY | DH_ITEM_ATTRIBUTE
- int DH_ITEM_ACCESS_MASK = DH_ITEM_WRITABLE | DH_ITEM_READABLE
- int DH_ITEM_MODEL_BRANCH = DH_ITEM_SUBASSEMBLY | DH_ITEM_ASSEMBLY | DH_ITEM_TYPE
- int DH_POINT_FLAGS_MIRRORED = DH_ITEM_HIDDEN | DH_ITEM_UNINITIALIZED | DH_ITEM_DELETED

Detailed Description

```
IntFlag representing various point flags.
```

Member Data Documentation

DH_ITEM_ACCESS_MASK

```
int DataHubConnection.PointFlags.DH_ITEM_ACCESS_MASK =
DH_ITEM_WRITABLE | DH_ITEM_READABLE[static]
```

DH_ITEM_ACTIVE

```
int DataHubConnection.PointFlags.DH_ITEM_ACTIVE = 0x000100[static]
```

DH_ITEM_ASSEMBLY

```
int DataHubConnection.PointFlags.DH_ITEM_ASSEMBLY = 0x000020[static]
```

DH_ITEM_ATTRIBUTE

```
int DataHubConnection.PointFlags.DH_ITEM_ATTRIBUTE = 0x000040[static]
```

DH_ITEM_AUTO_ID

```
int DataHubConnection.PointFlags.DH_ITEM_AUTO_ID = 0x001000[static]
```

DH_ITEM_CHILD

```
int DataHubConnection.PointFlags.DH_ITEM_CHILD = DH_ITEM_PROPERTY |
DH_ITEM_SUBASSEMBLY | DH_ITEM_ATTRIBUTE[static]
```

DH_ITEM_DELETED

```
int DataHubConnection.PointFlags.DH_ITEM_DELETED = 0x04000000[static]
```

DH_ITEM_FIRST_VALUE

```
int DataHubConnection.PointFlags.DH_ITEM_FIRST_VALUE =
0x400000[static]
```

DH_ITEM_FORCE_INSIG

```
int DataHubConnection.PointFlags.DH_ITEM_FORCE_INSIG =
0x010000[static]
```

DH_ITEM_FORCE_WRITE

```
int DataHubConnection.PointFlags.DH_ITEM_FORCE_WRITE =
0x008000[static]
```

DH_ITEM_FORCE_WRITE_RO

```
int DataHubConnection.PointFlags.DH_ITEM_FORCE_WRITE_RO =
0x100000[static]
```

DH_ITEM_HIDDEN

```
int DataHubConnection.PointFlags.DH_ITEM_HIDDEN = 0x000800[static]
```

DH_ITEM_IMMUTABLE

```
int DataHubConnection.PointFlags.DH_ITEM_IMMUTABLE = 0x800000[static]
```

DH_ITEM_LOCKED

```
int DataHubConnection.PointFlags.DH_ITEM_LOCKED = 0x000004[static]
```

DH_ITEM_MIRROR_ONLY

```
int DataHubConnection.PointFlags.DH_ITEM_MIRROR_ONLY =
0x020000[static]
```

DH_ITEM_MODEL_BRANCH

```
int DataHubConnection.PointFlags.DH_ITEM_MODEL_BRANCH =
DH_ITEM_SUBASSEMBLY | DH_ITEM_ASSEMBLY | DH_ITEM_TYPE[static]
```

DH_ITEM_NO_MASTER_WRITE

```
int DataHubConnection.PointFlags.DH_ITEM_NO_MASTER_WRITE =
0x002000[static]
```

DH_ITEM_NO_SLAVE_WRITE

```
int DataHubConnection.PointFlags.DH_ITEM_NO_SLAVE_WRITE =
0x004000[static]
```

DH_ITEM_PRIVATE_ATTRIBUTE

```
int DataHubConnection.PointFlags.DH_ITEM_PRIVATE_ATTRIBUTE =
0x000200[static]
```

DH_ITEM_PROCESSED

```
int DataHubConnection.PointFlags.DH_ITEM_PROCESSED = 0x000400[static]
```

DH_ITEM_PROPERTY

```
int DataHubConnection.PointFlags.DH_ITEM_PROPERTY = 0x000008[static]
```

DH_ITEM_PUBLISH_MODEL

```
int DataHubConnection.PointFlags.DH_ITEM_PUBLISH_MODEL =
0x01000000[static]
```

DH_ITEM_READABLE

```
int DataHubConnection.PointFlags.DH_ITEM_READABLE = 0x000001[static]
```

DH_ITEM_SUBASSEMBLY

```
int DataHubConnection.PointFlags.DH_ITEM_SUBASSEMBLY =
0x000010[static]
```

DH_ITEM_TEMP_VALUE

```
int DataHubConnection.PointFlags.DH_ITEM_TEMP_VALUE = 0x040000[static]
```

DH_ITEM_TYPE

```
int DataHubConnection.PointFlags.DH_ITEM_TYPE = 0x000080[static]
```

DH_ITEM_UNINITIALIZED

```
int DataHubConnection.PointFlags.DH_ITEM_UNINITIALIZED =
0x200000[static]
```

DH_ITEM_WRITABLE

```
int DataHubConnection.PointFlags.DH_ITEM_WRITABLE = 0x000002[static]
```

DH_ITEM_ZIP_MODEL

```
int DataHubConnection.PointFlags.DH_ITEM_ZIP_MODEL =
0x02000000[static]
```

DH_POINT_FLAGS_MIRRORED

```
int DataHubConnection.PointFlags.DH_POINT_FLAGS_MIRRORED =
DH_ITEM_HIDDEN | DH_ITEM_UNINITIALIZED | DH_ITEM_DELETED[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.PointMetaInfo Class Reference

Public Member Functions

- __eq__ (self, other)
- __hash__ (self)
- __str__ (self)
- str escaped (self, str s)
- copy_from (self, other)
- clear (self)
- set_metadata (self, MetadataFlags valid_flags, str eu="", str description="", float eu_high=0, float eu_low=0, float instrument_high=0, float instrument_low=0, str contact_close_label="", str contact_open_label="")

Public Attributes

- int EuHigh
- int EuLow
- int InstrumentHigh
- int InstrumentLow

Static Public Attributes

- MetadataFlags ValidFlags = MetadataFlags.NONE
- Optional Eu = None
- Optional Description = None
- float EuHigh = 0.0
- float EuLow = 0.0
- float InstrumentHigh = 0.0
- float InstrumentLow = 0.0
- Optional ContactCloseLabel = None
- Optional ContactOpenLabel = None
- int RefCount = 0

Detailed Description

```
Dataclass representing metadata information for a point.
```

Member Function Documentation

__eq__()

```
DataHubConnection.PointMetaInfo.__eq__ ( self, other)
```

```
Check if two PointMetaInfo objects are equal.

Arguments:
    other: The other PointMetaInfo object.
Returns:
    bool: True if equal, False otherwise.
```

__hash__()

```
DataHubConnection.PointMetaInfo.__hash__ ( self)
```

```
Get the hash value of the PointMetaInfo object.

Returns:
```

```
    int: The hash value.
```

__str__()

DataHubConnection.PointMetaInfo.__str__ (self)

```
Get the string representation of the PointMetaInfo object.

Returns:
    str: The string representation.
```

clear()

DataHubConnection.PointMetaInfo.clear (self)

```
Clear the metadata.
```

copy_from()

DataHubConnection.PointMetaInfo.copy_from (self, other)

```
Copy metadata from another PointMetaInfo object.

Arguments:
    other: The other PointMetaInfo object.
```

escaped()

str DataHubConnection.PointMetaInfo.escaped (self, str s)

```
Escape special characters in a string.

Arguments:
    s: The string to escape.
Returns:
    str: The escaped string.
```

set_metadata()

DataHubConnection.PointMetaInfo.set_metadata (self, MetadataFlags valid_flags, str eu = "" , str description = "" , float eu_high = 0 , float eu_low = 0 , float instrument_high = 0 , float instrument_low = 0 , str contact_close_label = "" , str contact_open_label = "")

```
Set the metadata.
```

```
Arguments:
    valid_flags: The valid flags.
    eu: The engineering units.
    description: The description.
    eu_high: The high engineering unit.
    eu_low: The low engineering unit.
    instrument_high: The high instrument value.
    instrument_low: The low instrument value.
    contact_close_label: The contact close label.
    contact_open_label: The contact open label.
```

Member Data Documentation

ContactCloseLabel

`DataHubConnection.PointMetaInfo.ContactCloseLabel = None[static]`

ContactOpenLabel

`DataHubConnection.PointMetaInfo.ContactOpenLabel = None[static]`

Description

`DataHubConnection.PointMetaInfo.Description = None[static]`

Eu

`DataHubConnection.PointMetaInfo.Eu = None[static]`

EuHigh[1/2]

`float DataHubConnection.PointMetaInfo.EuHigh = 0.0[static]`

EuHigh[2/2]

`int DataHubConnection.PointMetaInfo.EuHigh`

EuLow[1/2]

`float DataHubConnection.PointMetaInfo.EuLow = 0.0[static]`

EuLow[2/2]

`int DataHubConnection.PointMetaInfo.EuLow`

InstrumentHigh[1/2]

`float DataHubConnection.PointMetaInfo.InstrumentHigh = 0.0[static]`

InstrumentHigh[2/2]

`int DataHubConnection.PointMetaInfo.InstrumentHigh`

InstrumentLow[1/2]

`DataHubConnection.PointMetaInfo.InstrumentLow = 0.0[static]`

InstrumentLow[2/2]

`int DataHubConnection.PointMetaInfo.InstrumentLow`

RefCount

`int DataHubConnection.PointMetaInfo.RefCount = 0[static]`

ValidFlags

`MetadataFlags DataHubConnection.PointMetaInfo.ValidFlags = MetadataFlags.NONE[static]`

The documentation for this class was generated from the following file:

DataHubConnection.py

lispparse.PointQuality Class Reference

Static Public Attributes

- int QUALITY_MASK = 0xC0
- int STATUS_MASK = 0xFC
- int LIMIT_MASK = 0x03
- int BAD = 0x00
- int UNCERTAIN = 0x40
- int GOOD = 0xC0
- int CONFIG_ERROR = 0x04
- int NOT_CONNECTED = 0x08
- int DEVICE_FAILURE = 0x0c

- int SENSOR_FAILURE = 0x10
- int LAST_KNOWN = 0x14
- int COMM_FAILURE = 0x18
- int OUT_OF_SERVICE = 0x1C
- int LAST_USABLE = 0x44
- int SENSOR_CAL = 0x50
- int EGU_EXCEEDED = 0x54
- int SUB_NORMAL = 0x58
- int LOCAL_OVERRIDE = 0xD8
- int INITIALIZING = 0x20

Detailed Description

```
Enum representing various point quality states.
```

Member Data Documentation

BAD

```
int lispparse.PointQuality.BAD = 0x00[static]
```

COMM_FAILURE

```
int lispparse.PointQuality.COMM_FAILURE = 0x18[static]
```

CONFIG_ERROR

```
int lispparse.PointQuality.CONFIG_ERROR = 0x04[static]
```

DEVICE_FAILURE

```
int lispparse.PointQuality.DEVICE_FAILURE = 0x0c[static]
```

EGU_EXCEEDED

```
int lispparse.PointQuality.EGU_EXCEEDED = 0x54[static]
```

GOOD

```
int lispparse.PointQuality.GOOD = 0xC0[static]
```

INITIALIZING

```
int lispparse.PointQuality.INITIALIZING = 0x20[static]
```

LAST_KNOWN

```
int lispparse.PointQuality.LAST_KNOWN = 0x14[static]
```

LAST_USABLE

```
int lispparse.PointQuality.LAST_USABLE = 0x44[static]
```

LIMIT_MASK

```
int lispparse.PointQuality.LIMIT_MASK = 0x03[static]
```

LOCAL_OVERRIDE

```
int lispparse.PointQuality.LOCAL_OVERRIDE = 0xD8[static]
```

NOT_CONNECTED

```
int lispparse.PointQuality.NOT_CONNECTED = 0x08[static]
```

OUT_OF_SERVICE

```
int lispparse.PointQuality.OUT_OF_SERVICE = 0x1C[static]
```

QUALITY_MASK

```
int lispparse.PointQuality.QUALITY_MASK = 0xC0[static]
```

SENSOR_CAL

```
int lispparse.PointQuality.SENSOR_CAL = 0x50[static]
```

SENSOR_FAILURE

```
int lispparse.PointQuality.SENSOR_FAILURE = 0x10[static]
```

STATUS_MASK

```
int lispparse.PointQuality.STATUS_MASK = 0xFC[static]
```

SUB_NORMAL

```
int lispparse.PointQuality.SUB_NORMAL = 0x58[static]
```

UNCERTAIN

```
int lispparse.PointQuality.UNCERTAIN = 0x40[static]
```

The documentation for this class was generated from the following file:

lispparse.py

DataHubConnection.PointRegister Class Reference

Static Public Attributes

- int QUALIFY = 0x04
- int ONCEONLY = 0x08
- int SYNC = 0x20
- int UNREGISTER = 0x40

Detailed Description

```
IntFlag representing various point register flags.
```

Member Data Documentation

ONCEONLY

```
int DataHubConnection.PointRegister.ONCEONLY = 0x08[static]
```

QUALIFY

```
int DataHubConnection.PointRegister.QUALIFY = 0x04[static]
```

SYNC

```
int DataHubConnection.PointRegister.SYNC = 0x20[static]
```

UNREGISTER

```
int DataHubConnection.PointRegister.UNREGISTER = 0x40[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

lispparse.PointType Class Reference

Static Public Attributes

- int STRING = 0
- int REAL = 1
- int INT64 = 2
- int VOID = 3

Detailed Description

```
Enum representing various point types.
```

Member Data Documentation

INT64

```
int lispparse.PointType.INT64 = 2[static]
```

REAL

```
int lispparse.PointType.REAL = 1[static]
```

STRING

```
int lispparse.PointType.STRING = 0[static]
```

VOID

```
int lispparse.PointType.VOID = 3[static]
```

The documentation for this class was generated from the following file:

lispparse.py

DataHubConnection.PreciseTimer Class Reference

Public Member Functions

- __init__ (self, loop, initial_wait_ms, repeat_interval_ms, callback, *args, **kwargs)
- start (self)
- cancel (self)

Public Attributes

- loop = loop
- int initial_wait = initial_wait_ms/1000
- int repeat_interval = repeat_interval_ms/1000

- callback = callback
- args = args
- kwargs = kwargs

Protected Member Functions

- _run (self)

Protected Attributes

- bool _running = False

Detailed Description

```
A precise timer that triggers a callback at regular intervals.
```

Constructor & Destructor Documentation

__init__()

```
DataHubConnection.PreciseTimer.__init__ ( self, loop, initial_wait_ms,
repeat_interval_ms, callback, * args, ** kwargs)
```

```
Initialize the PreciseTimer object.

Arguments:
    loop: The event loop.
    initial_wait_ms: The initial wait period in milliseconds.
    repeat_interval_ms: The repeat interval period in milliseconds.
    callback: The callback function to trigger.
    args: Additional arguments for the callback.
    kwargs: Additional keyword arguments for the callback.
```

Member Function Documentation

_run()

```
DataHubConnection.PreciseTimer._run ( self)[protected]
```

```
Run the timer.
```

cancel()

```
DataHubConnection.PreciseTimer.cancel ( self)
```

```
Stop the timer.
```

start()

```
DataHubConnection.PreciseTimer.start ( self)
```

```
Start the timer.
```

Member Data Documentation

_running

```
bool DataHubConnection.PreciseTimer._running = False[protected]
```

args

```
DataHubConnection.PreciseTimer.args = args
```

callback

```
DataHubConnection.PreciseTimer.callback = callback
```

initial_wait

```
DataHubConnection.PreciseTimer.initial_wait = initial_wait_ms/1000
```

kwargs

```
DataHubConnection.PreciseTimer.kwargs = kwargs
```

loop

```
DataHubConnection.PreciseTimer.loop = loop
```

repeat_interval

```
int DataHubConnection.PreciseTimer.repeat_interval =
repeat_interval_ms/1000
```

The documentation for this class was generated from the following file:

DataHubConnection.py

DataHubConnection.Timer Class Reference

Public Member Functions

- __init__ (self, loop, initial_wait, interval, callback, *args, **kwargs)
- start (self)

- stop (self)

Public Attributes

- loop = loop
- int initial_wait = initial_wait/1000
- int interval = interval/1000
- callback = callback
- args = args
- kwargs = kwargs

Protected Member Functions

- _run_and_repeat (self)
- _stop_timer (self)

Protected Attributes

- bool _running = False
- _run_and_repeat
- _stop_timer

Detailed Description

```
A custom timer that triggers a callback after an initial wait period,
then repeats at the specified interval.
```

Constructor & Destructor Documentation

__init__()

```
DataHubConnection.Timer.__init__ ( self, loop, initial_wait, interval,
callback, * args, ** kwargs)
```

```
Initialize the Timer object.

Arguments:
    loop: The event loop.
    initial_wait: The initial wait period in milliseconds.
    interval: The interval period in milliseconds.
    callback: The callback function to trigger.
    args: Additional arguments for the callback.
    kwargs: Additional keyword arguments for the callback.
```

Member Function Documentation

_run_and_repeat()

```
DataHubConnection.Timer._run_and_repeat ( self)[protected]
```

```
Run the callback and schedule the next callback after the interval.
```

_stop_timer()

```
DataHubConnection.Timer._stop_timer ( self)[protected]
```

```
Stop the timer by canceling the scheduled callback.
```

start()

```
DataHubConnection.Timer.start ( self)
```

```
Start the timer by waiting for the initial delay, then repeat.
```

stop()

```
DataHubConnection.Timer.stop ( self)
```

```
Stop the timer.
```

Member Data Documentation

_run_and_repeat

```
DataHubConnection.Timer._run_and_repeat[protected]
```

_running

```
bool DataHubConnection.Timer._running = False[protected]
```

_stop_timer

```
DataHubConnection.Timer._stop_timer[protected]
```

args

```
DataHubConnection.Timer.args = args
```

callback

```
DataHubConnection.Timer.callback = callback
```

initial_wait

```
DataHubConnection.Timer.initial_wait = initial_wait/1000
```

interval

```
DataHubConnection.Timer.interval = interval/1000
```

kwargs

```
DataHubConnection.Timer.kwargs = kwargs
```

loop

```
DataHubConnection.Timer.loop = loop
```

The documentation for this class was generated from the following file:

DataHubConnection.py

TrendChart.Trace Class Reference

Public Member Functions

- __init__ (self, name, square=False, extend=False)

Public Attributes

- name = name
- list x = []
- list y = []
- square = square
- extend = extend

Detailed Description

```
Class representing a trace for plotting.

Attributes:
    name: The name of the trace.
    x: The x data points.
    y: The y data points.
    square: Whether the trace should be a square wave.
    extend: Whether the trace should extend the last value.
```

Constructor & Destructor Documentation

__init__()

```
TrendChart.Trace.__init__ ( self, name, square = False , extend =
False )
```

```
Initialize the Trace object.

Arguments:
    name: The name of the trace.
    square: Whether the trace should be a square wave.
    extend: Whether the trace should extend the last value.
```

Member Data Documentation

extend

```
TrendChart.Trace.extend = extend
```

name

```
TrendChart.Trace.name = name
```

square

```
TrendChart.Trace.square = square
```

x

```
list TrendChart.Trace.x = []
```

y

```
list TrendChart.Trace.y = []
```

The documentation for this class was generated from the following file:

TrendChart.py

DataHubConnection.VariantType Class Reference

Static Public Attributes

- int EMPTY = 0
- int NULL = 1
- int I2 = 2
- int I4 = 3
- int R4 = 4

- int R8 = 5
- int CY = 6
- int DATE = 7
- int BSTR = 8
- int STRING = 8
- int DISPATCH = 9
- int ERROR = 10
- int BOOL = 11
- int VARIANT = 12
- int UNKNOWN = 13
- int DECIMAL = 14
- int I1 = 16
- int UI1 = 17
- int UI2 = 18
- int UI4 = 19
- int I8 = 20
- int UI8 = 21
- int INT = 22
- int UINT = 23
- int VOID = 24
- int HRESULT = 25
- int PTR = 26
- int SAFEARRAY = 27
- int CARRAY = 28
- int USERDEFINED = 29
- int LPSTR = 30
- int LPWSTR = 31
- int RECORD = 36
- int INT_PTR = 37
- int UINT_PTR = 38
- int ARRAY = 8192

Detailed Description

```
IntEnum representing various variant types.
```

Member Data Documentation

ARRAY

```
int DataHubConnection.VariantType.ARRAY = 8192[static]
```

BOOL

```
int DataHubConnection.VariantType.BOOL = 11[static]
```

BSTR

```
int DataHubConnection.VariantType.BSTR = 8[static]
```

CARRAY

```
int DataHubConnection.VariantType.CARRAY = 28[static]
```

CY

```
int DataHubConnection.VariantType.CY = 6[static]
```

DATE

```
int DataHubConnection.VariantType.DATE = 7[static]
```

DECIMAL

```
int DataHubConnection.VariantType.DECIMAL = 14[static]
```

DISPATCH

```
int DataHubConnection.VariantType.DISPATCH = 9[static]
```

EMPTY

```
int DataHubConnection.VariantType.EMPTY = 0[static]
```

ERROR

```
int DataHubConnection.VariantType.ERROR = 10[static]
```

HRESULT

```
int DataHubConnection.VariantType.HRESULT = 25[static]
```

I1

```
int DataHubConnection.VariantType.I1 = 16[static]
```

I2

```
int DataHubConnection.VariantType.I2 = 2[static]
```

I4

```
int DataHubConnection.VariantType.I4 = 3[static]
```

I8

```
int DataHubConnection.VariantType.I8 = 20[static]
```

INT

```
int DataHubConnection.VariantType.INT = 22[static]
```

INT_PTR

```
int DataHubConnection.VariantType.INT_PTR = 37[static]
```

LPSTR

```
int DataHubConnection.VariantType.LPSTR = 30[static]
```

LPWSTR

```
int DataHubConnection.VariantType.LPWSTR = 31[static]
```

NULL

```
int DataHubConnection.VariantType.NULL = 1[static]
```

PTR

```
int DataHubConnection.VariantType.PTR = 26[static]
```

R4

```
int DataHubConnection.VariantType.R4 = 4[static]
```

R8

```
int DataHubConnection.VariantType.R8 = 5[static]
```

RECORD

```
int DataHubConnection.VariantType.RECORD = 36[static]
```

SAFEARRAY

```
int DataHubConnection.VariantType.SAFEARRAY = 27[static]
```

STRING

```
int DataHubConnection.VariantType.STRING = 8[static]
```

UI1

```
int DataHubConnection.VariantType.UI1 = 17[static]
```

UI2

```
int DataHubConnection.VariantType.UI2 = 18[static]
```

UI4

```
int DataHubConnection.VariantType.UI4 = 19[static]
```

UI8

```
int DataHubConnection.VariantType.UI8 = 21[static]
```

UINT

```
int DataHubConnection.VariantType.UINT = 23[static]
```

UINT_PTR

```
int DataHubConnection.VariantType.UINT_PTR = 38[static]
```

UNKNOWN

```
int DataHubConnection.VariantType.UNKNOWN = 13[static]
```

USERDEFINED

```
int DataHubConnection.VariantType.USERDEFINED = 29[static]
```

VARIANT

```
int DataHubConnection.VariantType.VARIANT = 12[static]
```

VOID

```
int DataHubConnection.VariantType.VOID = 24[static]
```

The documentation for this class was generated from the following file:

DataHubConnection.py

File Documentation

DataHubConnection.py File Reference

Classes

- class DataHubConnection.ModelEmitter
- class DataHubConnection.ModelDomain
- class DataHubConnection.ConnectionOptions
- class DataHubConnection.DataHubConnectionType
- class DataHubConnection.DataHubConnectionStatus
- class DataHubConnection.ChangeFlags
- class DataHubConnection.PointFlags
- class DataHubConnection.DomainFlags
- class DataHubConnection.LogSeverity
- class DataHubConnection.PointRegister
- class DataHubConnection.DataHubStatus
- class DataHubConnection.VariantType
- class DataHubConnection.MetadataFlags
- class DataHubConnection.PointMetaInfo
- class DataHubConnection.Timer
- class DataHubConnection.PreciseTimer
- class DataHubConnection.DataHubConnection

Namespaces

- namespace DataHubConnection

introduction.md File Reference

lispparse.py File Reference

Classes

- class lispparse.PointQuality
- class lispparse.PointType
- class lispparse.DataHubPoint

Namespaces

- namespace lispparse

Functions

- lispparse.SlEscapeChar (inbuf, offset, outbuf, outoffset)
- lispparse.SlSkipTo (inbuf, offset, stops, maxbuf)
- lispparse.SlSkipFast (inbuf, offset, stop, maxbuf)
- lispparse.SlSkipToClosing (buffer, offset, maxbuf, opening, closing)
- lispparse.SlSkipWhite (buffer, offset, maxbuf)
- lispparse.addArg (arglist, inbuf, offset, length)
- lispparse.UT_LispParseSafe (buffer, offset, buflen, flags)
- lispparse.parse (buffer)
- lispparse.initialize_terminators ()
- lispparse.escaped_string (string, quoted, terminators)
- lispparse.escaped_string2 (string, quoted, terminators)
- lispparse.escaped_string_with_options (string, quoted, special_only)
- lispparse.escaped_string_auto (string, quoted)
- lispparse.escaped_symbol (string)

Variables

- int lispparse.UT_ParseFlagExpressions = 1
- lispparse.NormalTerminators = set(['\\', ' ', '\t', '\n', '\f', '\r', '\'', '\"', '(', ')', '[', ']', '#', ';', '`', ',', '{', '}', chr(0), chr(0x1b)])
- lispparse.SpecialTerminators = set(['\t', '\n', '\f', '\r', chr(0), chr(0x1b), '\\', '\"'])
- list lispparse.BNormalTerminators = [False] * 128
- list lispparse.BSpecialTerminators = [False] * 128
- list lispparse.BSymbolTerminators = [False] * 128
- bool lispparse.TerminatorsConfigured = False
- lispparse.terminators_lock = threading.Lock()

PID.py File Reference

Classes

- class PID.MyConnection
- class PID.PID

Namespaces

- namespace PID

Functions

- PID.qualify (client, pointname)
- str PID.unqualifyName (str pointname)
- PID.updateOnPointChange (point, name, pid, dhclient)
- PID.pid_create_points (client, pid)
- PID.output_point (pid, name, value)
- PID.pid_calculate (pid)
- PID.pid_calculate_procvar (pid)
- PID.update_setpoint (pid)
- PID.update_pids (pid)
- PID.recalculate_dt (pid)
- PID.change_controller (pid)
- PID.change_procvar (pid)
- PID.have_connection (client, allpids)
- PID.lost_connection (client, allpids)
- PID.register_pid (client, pid, is_register)
- PID.reset_timer (loop, client, pid, timeoutSecs)
- PID.delete_timer (timer)
- PID.start_client (loop, host, port, domain, name, allpids)
- PID.RegisterPointChangeCallback (pid, sym, dhclient)
- PID.outputControlPoints (client, pid)
- PID.main (loop)

Variables

- PID.loop = asyncio.new_event_loop()

TrendChart.py File Reference

Classes

- class TrendChart.MyConnection
- class TrendChart.Trace

Namespaces

- namespace TrendChart

Functions

- TrendChart.start_client (loop, host, port, name)

- TrendChart.lost_connection (client)
- TrendChart.have_connection (client)
- TrendChart.registerPoint (client, point_name, square=False, extend=False)
- TrendChart.on_point_changed (client, point)
- TrendChart.update_plot (client)
- TrendChart.main ()

Variables

- TrendChart.traceDictionary = dict()
- TrendChart.fig
- TrendChart.ax
- int TrendChart.window_size = 60
- TrendChart.current_time = datetime.now()
- TrendChart.start_time = current_time - timedelta(minutes=1)

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Gamma scripting language

Version 11.0

A high-level programming language optimized for building applications that utilize real-time data.

Table of Contents

Introduction

What is Gamma?

The Gamma language is an interpreter, a high-level programming language that has been designed and optimized to reduce the time required for building applications. It has extensions that support HTTP and MySQL.

With a Gamma program a user can quickly implement algorithms that are far harder to express in other languages such as C. The Gamma language lets the developer take advantage of many time-saving features such as memory management and improved GUI support. These features, coupled with the ability to fully interact with and debug programs as they run, mean that developers can build, test and refine applications in a shorter time frame than when using other development platforms.

The Gamma language is an improved and expanded version of our previous Slang Programming Language for QNX and Photon. The Gamma language was originally available on QNX 4, QNX 6 and Linux, and is now only used with Cogent DataHub software in Microsoft Windows.

The implementation of the Gamma language is based on a powerful SCADALisp engine. SCADALisp is a dialect of the Lisp programming language which has been optimized for performance and memory usage, and enhanced with a number of internal functions. All references in this manual to Lisp are in fact to the SCADALisp dialect of Lisp.

You could say the Gamma object language is Lisp, just like Assembler is the object language for C. Knowing Lisp is not a requirement for using the Gamma language, but it can be helpful. All necessary information on Lisp and how it relates to the Gamma language is in the Input and Output chapter of this guide.

The syntax of a Gamma program is very similar to C, so programmers familiar with C can start programming in the Gamma language almost immediately. Knowledge of pointers and memory allocation is not necessary for writing Gamma scripts or programs.

Getting Started

Interactive Mode

You can invoke the Gamma engine by typing

```
[sh]$  gamma
```

at the shell prompt.

It will return the following Gamma prompt:

```
Gamma>
```

Now you can start writing instructions to the Gamma engine and get an immediate response. If you define a variable a without assigning it a value, the Gamma engine will respond with the message that the symbol is undefined and suggest debugging:

```
Gamma> a;
Symbol is undefined: a
debug 1>
```

Type **Ctrl - D** to return to the Gamma prompt and assign a a value:

```
Gamma> a = 5;
5
Gamma>
```

This time the Gamma engine responds with the value assigned to the variable. In a Gamma program a variable must be assigned a value. The library function `undefined_p` can be used to test if a variable is defined:

```
Gamma> undefined_p (b);
t
Gamma> b = 1;
1
Gamma> undefined_p (b);
nil
Gamma>
```

This function returns `t` for true and `nil` for false. The objects *t* and *nil* are discussed in more detail in the Logical Types section of the Basic Data Types and Mechanisms chapter.

A function is defined in the Gamma language using a *function* statement:

```
Gamma> function MyFunc (a) { a *= 10;}
(defun MyFunc (a) (*= a 10))
Gamma>
```

The Gamma engine returns the function definition in Lisp syntax. It reflects the fact that a Gamma program is using the Lisp engine internally. Basically, Lisp displays functions as lists, surrounded by parentheses. The first word in every Gamma function definition is `defun` because that is the Lisp function for defining functions. After that, the function name is listed, followed by its arguments and code, which is also in Lisp format.

The `MyFunc` function called with 12 as its argument will return the value 120, as follows:

```
Gamma> MyFunc (12);
120
Gamma>
```

Notice that no type specification is used. An important feature of the Gamma language is that it is an abstractly typed language, making it unnecessary to specify the type of a data object in order to be able to use it. This does not mean that objects do not have types, but rather the system does not require that the type of an object be known until the code actually executes. This allows a function to return entirely different types, depending on what the calculation produces.

For example, a `MIN` function could be defined as:

```
function min (x, y) { if (x < y) x; else y; }
```

This function will return an integer or floating point number depending on the types of the arguments. The arguments do not need to be the same type. The Gamma engine automatically type-casts them, favoring the smallest possible memory allocation. However, the less-than comparison will fail if both arguments are not numeric types.

Finally, `return` statements are not necessary in a Gamma program. Looking at the function MyFunc, we see it returns 120, the result of multiplying a by 10. Any Gamma function that executes successfully always returns a value, which is the result of evaluating the last expression in the function. This return value determines the value and type of the function.

This topic is discussed in greater detail in Function Definitions in the Functions and Program Structure chapter.

Executable Programs

There is currently no facility for embedding Gamma source code into a stand-alone Gamma executable. However, it is possible to create a Gamma program which appears to be a stand-alone executable to the user. This is done by using the shell's **#!** directive at the top of the Gamma file. Simply include the line indicating the full path for your Gamma program, for example:

```
#!/usr/cogent/bin/gamma
```

Then change the permissions on the Gamma file to be executable. The Gamma file can now be run directly as if it were a stand-alone executable. The directive must appear as the first line of the program, and it must reference the actual Gamma executable, not a link.

The following example program will print the famous "Hello world" message to the screen:

```
#!/usr/cogent/bin/gamma

princ ("Hello world\n");
```

There is no requirement for a function named `main`. If a function with the name `main` is defined, then the Gamma engine automatically starts to execute that function. Thus, the result of the following program:

```
#!/usr/cogent/bin/gamma

function MyPrint()
{
    princ ("Hello world\n");
}

function main()
{
    MyPrint();
}

MyPrint();
```

is that the function `MyPrint` will be executed twice.

Command line arguments can be passed to the Gamma program using the list variable `argv`. For more details see Tutorial I.

Symbols and Values

A *symbol* is a fundamental notion in the Gamma language. It is a unique word or name within the program. In this sense all symbols are global in a Gamma program (although they can have local scope), and all references to a particular symbol will be the exact same Gamma object.

A symbol can contain: lowercase letters, uppercase letters, digits, and underscores. Using a symbol character operator, other characters can be used. A '\' character escapes the next character. A '$' escapes any and all of the characters in the symbol.

Symbols can have values so they can be used as variables. For the time being it is probably easier to think of a symbol as a variable. (For other uses of symbols see the Advanced Types and Mechanisms chapter of this guide). The same symbol can have different values depending on the part of the program in which the reference to the symbol is made.

For example:

```
Gamma> i = 5;
5
Gamma> function MyLocal (n) { local i; for (i = 1; i < n; i++)
                       princ("i = ", i, "\n");}
(defun ...)
Gamma> MyLocal (3);
i = 1
i = 2
2
Gamma> i;
5
```

In this example the symbol `i` is created and the value of `5` is assigned to it. Then in the definition of function `MyLocal` the value of `i` is declared to be *local* to the function (or to have *local scope*). The function prints the local values of `i` and returns the result of the last calculation. After `MyLocal` returns, the value of the symbol `i` remains `5`, as defined at the beginning.

Unlike many procedural languages such as C and Pascal, the Gamma language uses *dynamic scoping*. That means that if a function defines a local variable, then that variable becomes global to any functions it calls. In the example above, suppose we define `MyScope` in the higher call, or at the global level:

```
Gamma>  function MyScope (s) {........}
```

Then we modify the function `MyLocal` such that now it calls `MyScope`:

```
Gamma>  function MyLocalNew (n)
{
  local i;
  for (i = 1; i < n; i++)
    {
      princ("i = ", i, "\n");
      MyScope(i);
    }
```

```
}
```

The value of `i` used as an argument for `MyScope` will be the value of the local variable most recently declared in the calling sequence: `MyScope (1)`, `MyScope (2)`, etc. The scope of the variable is thus determined at run time by the order in which functions are called.

Dynamic scoping in a Gamma program is very different from the convention in C known as lexical scoping, where the scope of a variable is determined according to the syntactic position in a program where it is declared.

Basic Data Types and Mechanisms

Numeric Types

A number in the Gamma language is any integer, real, or fixed-point value.

Integer

An integer is any 32-bit integer number. Integers can be read and written in the following representations:

1. decimal

   Example: 45, 129000

2. hexadecimal (start with 0x)

   Example: 0xf12

3. octal (start with 0o)

   Example: 0o777

4. binary (start with 0b)

   Example: 0b101001

5. character (enclosed by ' ')

   Example: 's'

Real

A real number is a 64-bit double precision floating point number. It can contain a decimal point and it may end with the letter e followed by a signed exponent.

Examples: 0.1, 235.02013576, 5e-2, 3.74e-7

Fixed-point Real

A fixed-point real number is one that is represented by an integer, where the high 16 bits represent an integer value, and the low 16 bits represent a mantissa. There are very few reasons to work with fixed-point numbers unless floating-point error in numeric comparison is intolerable. Fixed-point numbers are created by any numeric function so long as the value of the symbol `_fixed_point_` is non-`nil`. The default value of `_fixed_point_` is `nil`, so that floating point numbers of type real are created by default.

Number Operators

The following operators can be used with numeric data:

- arithmetic (+, -, *, /, %, div)

Example:

```
Gamma> 2 + 3;
5
```

- logical (!, &&, ||)

  Example:

```
Gamma> !2.75;
nil
```

- comparison (!=, ==, <, <=, >, >=)

  Example:

```
Gamma> 2 != 3;
t
```

- bitwise (<<, >>, ~, &, |, ^)

  Example:

```
Gamma> bin(25);
0b00011001
Gamma> bin(25 << 1);
0b00110010
```

Logical Types

In the Gamma language, there are two objects of logical type: *t* and *nil*. `t` is a logically true value, and `nil` is the ONLY logically false value in the Gamma language. All other objects are considered to be logically true, including the number zero. This is different from the C language where the number zero is treated as logically false.

The operators `!`, &&, and `||` can be used with `t` and `nil`.

Example:

```
Gamma> !nil;
t
Gamma> !t;
nil
Gamma> !0;
nil
Gamma> 2 || nil;
```

```
2
Gamma> 2 && nil;
nil
```

Strings

A string is a sequence of characters (whose values range from 0x01 to 0xff), stored in consecutive bytes of memory, terminated by the null character \0. Unlike symbols, strings are not unique within the system. Strings are denoted by enclosing them in double quotation marks (for example: `"A string."`). A string is created by any of the string functions (particularly `string`), or by reading a string constant in the form **`"A string."`**.

The following types of operators can be used with strings:

- comparison (!=, ==)

  Example:

  ```
  Gamma> "cat" != "dog";
  t
  Gamma> "cat" == "dog";
  nil
  ```

- logical (!, &&, ||). Strings have the logical value of true in the Gamma language.

  Example:

  ```
  Gamma> "cat" && "dog" && nil;
  nil
  Gamma> "cat" || "dog" || nil;
  "cat"
  ```

However, strings are normally manipulated in the Gamma language using the string functions (see Strings and Buffers in the Reference Manual.)

Lists and Arrays

An *array* is an ordered collection of elements, each of which can be of a different type. Each element is associated with a fixed numeric index into the array, and can be set or read using the functions `aset` and `aref`, or through the use of square brackets `[]`. If an attempt is made to set an array at an index beyond the end of the array, the array will increase in size to the given index, filling any undefined intermediate values with `nil`. If an attempt is made to read an element from an array beyond the size of the array, then `aref` will return `nil`, and no error will be reported.

An array is created by a call to `array`, or by reading a Lisp expression of the form `[ element element ...]`. A side effect of creating an array using the `[...]` syntax is that the array will be effectively static, in the sense that if the array is defined within a function, then it will not be re-created during each call to the function. It would appear to exist within the code space of the function.

A *list* is a linked group of consecutive elements called cons cells. A cons cell consists of a reference to the list element and a forward pointer to the next cons cell. This organization necessarily means that a list is single-directional, and also means that any cons cell within the list is the head of another list, consisting of that cons cell and all cells after it in the list. The last cons cell in a list normally has a forward pointer of `nil`.

It is possible to create a list whose last cons cell points to a non-`nil` object. For example, a single cons cell could have a data value of `1`, and a forward pointer to number `2`. This would create a *dotted* list, written as `(1 . 2)` (note the spaces around the dot). Only the last element in a list can be a dotted cons cell. Thus, it is not possible to create a list `(1 . 2 3)` or `(1 . (2 3))`. A dotted cons cell is created by a call to `cons`, or by reading a Lisp expression of the form `(x . y)`. The form `(x . nil)` is equivalent to `(x)`.

There are two very important functions used to access the members of a list: `car(list)` and `cdr(list)`. The `car` function returns the first element of a list. For example, `car(list(3,2,1))` returns 3. The `cdr` function returns the "tail" of the list, that is, the list without the first element. For example, `cdr(list(3,2,1))` returns (2 1). The combinations of these two functions allow access to any element(s) of a list. For example, `car(cdr(list(3,2,1)))` returns 2, the second element of the list. Normally a shortcut `cadr(list)` is used for `car(cdr(list))`.

For more information see `car, cdr` in the Reference Manual.

A list is created by a call to `cons` or `list`, or by reading a Lisp expression of the form `(x ...)`, or by evaluating a Lisp expression of the form `'(x ...)` or `` `(x ...) ``.

Both lists and arrays can be traversed using the `with` statement. For example:

```
Gamma> sum = 0;
0
Gamma> with i in list(1,2,3) do {sum += i;}
nil
Gamma> sum;
6
Gamma>
```

For more information on the `with` statement, see `with` in the Reference Manual.

Constants

A constant is any symbol that has been defined as such with the assignment operator `::=`. Note that since the check is made at run-time, the constant is protected, even if the symbol name is evaluated at run-time.

Example:

```
Gamma> CON ::= 5.4545454;
5.4545454999999997663
Gamma> CON = 7;
Script error during command CON = 7; Assignment to constant symbol: CON
Gamma>
```

There are four pre-defined constants in Gamma:

`PI`	The value of pi, approximately `3.14159`.
`E`	The base of the natural logarithm, approximately `2.71828`.
`INF`	Floating point positive infinity.
`NAN`	Floating point not-a-number.

Please refer to Literals for more information on `INF` and `NAN`.

Operators and Expressions

The Gamma language provides operators for the basic arithmetic calculations: addition, subtraction, multiplication, division and taking the modulus. There is also a group of assignment, bitwise, comparison, increment and decrement, logical, and quote operators. For information on operator precedence and associativity see Operators in the Reference Manual.

Operators are used with one, two, or three values to create *expressions*. For instance, `4 + 2` is an expression whose value is `6. In` the Gamma language, every expression has a value.

Not all expressions contain operators, though. The number `5`, for example, is also an expression. Generally speaking, an expression in the Gamma language is anything that can be evaluated. This includes numbers, symbols that have been assigned values, strings, `t`, `nil`, constants, lists, arrays, and so on.

These are also known as *symbolic* expressions, a term that has been abbreviated to *s_exp*. Since expressions are often used as arguments for functions, you will come across the parameter *s_exp* in function definitions in the Reference Manual.

An expression can become a *statement* by adding a semicolon. Thus, `4 + 2;` is a statement. For more information on statements, see the Statements section in the Control Flow chapter.

Comments

There are two ways insert comments into Gamma code. To comment out a line, you can use a double slash (`//`) like this:

```
a = 5;
```

```
b = 7;

// This assigns the value of c.

c = a + b;
```

To comment out a block of text, you can put the symbol `/*` at the beginning, and `*/ at the end, like this:`

```
a = 5;
b = 7;

/* This assigns the value of c,
   which is very important to the
   future of our project.*/

c = a + b;
```

It is not permitted to put an unmatched double quote mark (`"`) into the second type of comment. This is a feature that allows you to comment out a string, to include a comment mark in a string, and even to comment out a string that includes comment characters, like this:

```
/*
princ ("/* this is what a comment looks like\n");
princ ("   when extended to multiple lines\n");
princ ("*/\n");
*/
```

Reserved Words

In the Gamma language, certain words are predefined and reserved for system use. No symbols can be defined by the user that are identical to these reserved words.

The reserved words are:

`class, collect, do, else, for, function, if, local, method, tcollect, while, with.`

For more details see Reserved Words entry in the Reference Manual.

Memory Management

The programmer generally does not need to consider the memory management aspects of Gamma programming in because the Gamma engine handles all memory management requirements of a task internally through a mechanism known as *garbage collection*. This greatly simplifies programming and eliminates errors associated with dangling pointers, freeing unallocated memory, and array overruns so common in languages such as C.

Nevertheless, the Gamma language provides some functions for examining and invoking the garbage collector. These may be used to determine run-time memory requirements or to ensure that the garbage is collected at pre-determined times.

For more information on garbage collections and the related functions see gc in the Reference Manual.

Tutorial I

This tutorial contains examples of the basic types and mechanisms of Gamma programs. The first example shows you how to manipulate lists. A list is a very important data type in the Gamma language. The understanding of list manipulation is a key notion to many Gamma constructions. The second example walks you through the famous "Hello world" program.

Lists

The examples below demonstrate some of the basics of list manipulation. Since the Gamma language uses the Lisp engine, it inherits the rich set of list functions for which Lisp is known.

```
/* The program starts with the line containing the shell's
directive #!. It makes a Gamma program appear to be a
stand_alone executable to the user. The directive must appear
as the first line and must reference the actual Gamma
executable, not a link.  */

#!/usr/cogent/bin/gamma

/*
 * Lisp defines the functions 'car', 'cdr', and 'cons' as the basic
 * list manipulation functions.  The origins of these names have no
 * meaning on today's computers:
 * CAR - Contents of the Address Register
 * CDR - Contents of the Decrement Register
 * CONS - Construct (OK, this makes sense)
 *
 * We can define alternate names for car and cdr here:
 */

head := car;
tail := cdr;

/*
 * Create some lists.
 */

a = list ("My", "dog", "has", "fleas");
b = list (1, 2, 3, 4, 5, 6);

/* The pound sign "#" in front of a symbol prevents the Gamma
engine from evaluating the symbol so the symbol is taken
literally. Thus, if x = 5, then the function call
```

```
list (#x, 1) will create the list (x 1) rather than (5 1).
 */

c = list (#a, #b, #c, #d, #e, #f);
d = list (#d, #h, #b, #i, #g, #e, #c);

/*
 * Take the first component of a list.
 */

e = head (a);
princ ("The first component of ", a, " is ", e, "\n");

/*
 * Take the tail of a list.
 */

e = tail (a);
princ ("\nThe tail of ", a, " is ", e, "\n");

/*
 * Concatenate two lists.  Notice that list elements do not need to
 * be the same type.
 */

e = append (a, b);
princ ("\nappending ", b, " to ", a, " gives:\n ", e, "\n");

/*
 * Walk a list and print each element
 */

princ ("\nThe elements of 'a' are:\n");
with i in a do
{
    princ (" ", i, "\n");
}

/*
 * Add an element to the beginning of a list
 */

princ ("\nAdding a zero to ", b, "\n");
b = cons (0, b);
princ ("    Gives: ", b, "\n");
```

```
/*
 * Take the first element of the tail of the list (the second element)
 * We can use combinations of car and cdr to do this.  However, the
 * Gamma engine predefines a number of car and cdr combinations to
 * make this easier, by inserting multiple 'a's and 'd's between the
 * 'c' and the 'r' in the words car and cdr.
 * For example,   caddr(x)    is the same as    car(cdr(cdr(x)))
 *
 * The Gamma language defines all one-, two-, and three-letter
 * combinations of car and cdr.
 */

princ ("\na is ", a, "\n");
x = car (cdr (a));
princ ("    car(cdr(a)) is: ", x, "\n");
x = cadr (a);
princ ("    cadr(a) is: ", x, "\n");

/*
 * Some other interesting list functions...
 */

princ ("\n");
princ ("Union of        ", c, " and ", d, " is ",
       union (c, d), "\n");
princ ("Intersection of ", c, " and ", d, " is ",
       intersection (c, d), "\n");
princ ("Difference of   ", c, " and ", d, " is ",
       difference (c, d), "\n");
princ ("Difference of   ", d, " and ", c, " is ",
       difference (d, c), "\n");
```

"Hello world" program

This example program prints a personalized "Hello" message a given number of times. It demonstrates variable naming, function definitions and basic control structures, as well as command line arguments.

The program also shows the basic similarities between the Gamma language and the C language, and some important differences which highlight the power of the Gamma language.

```
#!/usr/cogent/bin/gamma

/* This function iterates, saying hello to the given name.
In the Gamma language, all functions return a value, which
```

```
is the result of the last evaluated expression in the
function. In this case, we return the string "ok".
*/

function say_hello (name, n)
{
    local i;

    for (i = 0; i < n; i++)
        princ ("Hello ", name, "\n");
        "ok";
}

/* A program may optionally have a function main()
declared, in which case the Gamma engine will execute the
main() function after all of the program file has been
read in. If no main() declared, the programmer must
explicitly call a function or enter an event loop at
some point while reading the file. Any code which is not a
function definition will be automatically run AS THE FILE
IS READ. This is useful for providing feedback to the user
while loading.  */

function main ()
{
    /* Define some locally scoped variables. Notice that
    the Gamma engine implements abstract data typing, so
    it is not necessary to declare the variable type.
    */

    local repeat = 1, my_name = "world";

    /* Access the command line arguments. argv is a list of the
    command line arguments, as strings, where the first argument
    is the program name.  */

    /* The second argument (cadr(argv)) is my_name,
    if present.
    */

    if (cadr(argv))
        my_name = cadr (argv);

    /* The third argument (caddr(argv)) is the number
    of iterations, if present.
    */
```

```
    if (caddr(argv))
        repeat = number (caddr(argv));

    /_now print the message */

    result = say_hello (my_name, repeat);
    princ (result, "\n");
}
```

Control Flow

The Gamma language provides a variety of mechanisms for control flow. These generally fall into the categories of statements, function calls, event handlers and error handlers. Many of these are dealt with in more detail in other sections of this document. All functions have a detailed entry in the Reference Manual.

Statements

A *statement* in the Gamma language is any syntactically complete piece of code that can be independently evaluated, written in statement syntax. There are two kinds of statement syntax, as follows:

; A semi-colon at the end of an expression is used to denote a single, one-line statement.

{ } Curly brackets surrounding zero or more expressions or statements create a single statement from them. Multiple statements within the curly brackets can be grouped in any combination, and nested in any number of levels. This statement syntax is also referred to as a *compound statement* or *code block*. Each expression or statement is evaluated in order, and the result is the result of the last statement or expression. A Gamma code block does not create a local scope.

The Gamma language has a number of built-in statements, several of which are explained below. For a complete list of built-in Gamma statements, see Statements in the Reference Manual.

Conditionals

The Gamma language contains a single conditional statement: `if`. The `if` function evaluates its condition, and if the condition is non-`nil`, then the first statement after the `if` is performed. If the condition is `nil`, the `else` clause of the statement is executed. It is not mandatory that an `if` statement have an `else` clause. In the case of nested `if` statements, an `else` clause will always bind with the nearest `if` statement.

For example:

```
...
if (var == 1)
    count1 ++;
else if (var == 2)
    count2 ++;
else if (var == 3)
    count3 ++;
...
```

The `if` statement accepts only a single statement for its true and false clauses. Using the code block statement syntax, it is possible to perform more than one action inside an `if`.

Example:

```
...
if (var == "string")
{
     count++;
     princ("The number is ", count, "\n");
}
...
```

Loops

The Gamma language supports three looping statements: `for`, `while` and `with`. The `for` loop looks exactly like a `for` loop in C:

```
...
local i;
for (i = 1; i < N; i++)
 {
   body_statements
 }
...
```

A `while` loop is also exactly like the C `while` loop, though the do/while variant available in C is not supported in Gamma programs.

The Gamma language adds the `with` loop, which walks a list or an array and executes a body statement once for each element in the list or array. The `with` loop may be instructed to collect the results of the body statement for each iteration, and return the accumulated results as a new list or array. The iteration variable in a `with` loop is defined only within the body of the loop. For an example, see the Lists and Arrays section in the Basic Data Types and Mechanisms chapter.

Goto, Break, Continue, Return

A Gamma program does not contain facilities for non-linear local jumps. Many languages provide one or more wrappers on the `goto` function, such as `break` (go to the end of the expression), `continue` (go to the beginning of the expression) and `return` (go to the end of the function). These facilities can be used on occasion for clarity, but can commonly act to confuse both the programmer and the reader.

In a Gamma program, such a facility would be very confusing, as it is not always clear which expression constitutes the scope of a break, continue or return. In addition, the execution speed penalty associated with supporting local jumps in a functional language generally outweighs the benefit in the few cases where a local jump would be convenient. Further, because the Gamma language is dynamically scoped, a local jump would be defined as a jump that does not cross a scope boundary rather than the more common

C definition of a jump that does not cross a function boundary. This distinction greatly reduces the value of, and the need for, a local jump capability.

The most common local jump instruction in procedural languages is `return`. This instruction moves the execution to the bottom of the function and supplies a return value for the function. In a Gamma program, all functions implicitly return a value which is the result of the last expression to be evaluated within the function body. If no expression is evaluated, then the function returns `nil`. If the programmer wishes to return the value of a symbol, he or she can simply write that symbol, followed by a semicolon, as the last statement to be evaluated in the function.

Function Calls

Any Gamma expression which makes a call to a function, such as `tan(3.14159)`, causes a change of program flow, entering a new scope and causing execution to be temporarily diverted into the function being called. In most cases, the function simply returns and flow continues at the expression containing the function call.

If an error occurs during a function call, the function will not return, and execution will continue from the most recent `protect/unwind` or `try/catch` construct (see the Error Handling section of this chapter).

Event Handling

An *event* is a change to which the system responds. Events include interprocess communication (message exchanging between processes) events, signals, timer events (execution of a block of code at specified time), Graphical User Interface events (clicking on the screen buttons), and DataHub exceptions (a change in value of a DataHub point).

The Gamma language provides a generalized event handling capability which processes all these events. A Gamma function that responds to an event is called an *event handler*, or a *callback*. A pair of functions, `next_event` and `next_event_nb`, invoke the event handler, that is, any callback function(s) that have been attached to the event. For example, the simple construct:

```
while ( t)
{
    next_event ( );
}
```

placed at the end of the file, together with the set of callback functions defined in the application to handle all the required events, creates a purely event-driven Gamma program. However, unlike typical event-driven systems applications (such as many GUI-based applications), the user has here the opportunity to further process the events, providing a conditional which is more complex than an infinite loop, or even choosing not to receive events. The events will not be processed (or callbacks invoked) until one of the `next_event` calls are made.

The result of `next_event` is the result of executing the callbacks, or `nil` if no event handler has been defined (that is, no callbacks have been attached). The result of `next_event_nb` (nb stands for non-blocking) is the same except that `nil` is also returned if no event was available.

Attaching callbacks and receiving events depends on the type of event. For example, in Photon the function `PtAttachCallback` is used to attach actions to clicking on buttons. Normally one does not wait for an explicit event type, that is, the `next_event` call will process ANY event defined within the system. The following sections describe how some common event types are handled.

Interprocess Communication Message Events

The Gamma language uses a *send/receive/reply* (SRR) mechanism to provide interprocess communication via *messages*. In this context, a message is any valid Gamma or Lisp expression passed synchronously from one process to another, using the `send` function. The engine treats the message as a null-terminated character string in Lisp syntax (the Gamma internal representation), which it parses and evaluates. Any expression may be transmitted in this way, including function definitions, function calls, variable names and complex blocks of code. The reply returned is the result of the evaluation.

This process is transparent to the application. The Gamma engine evaluates the incoming message inside an implicit `try/catch` block to ensure that externally originated expressions cannot accidentally affect the running program. Any errors that occur while the message is being evaluated will be indicated in the return value for the message, but the overall running status of the engine will not be otherwise affected.

For more information see the Interprocess Communication section in the Special Topics chapter.

Timers

A *timer* is a Gamma expression that is submitted for evaluation at specified time in the future. Timer related events are set up through the `every` and `after` functions which provide a relative time delay, and the `at` function which accepts an absolute time. These functions accept timing parameters and a block of code that will be evaluated when the timer expires. The code can be simply a function name, or can be an entire expression to be evaluated.

A timer will only be handled during a call to `next_event`, `next_event_nb` or `flush_events`. If a timer expires while another operation is being performed, the engine will evaluate the timer code at the next event handling instruction.

In the Gamma language, by default, timers are internally handled by using *proxies*. A proxy is non-blocking system message that does not require a reply. The Gamma engine can act on a proxy immediately, or delay a little while in order to finish what it is currently doing. It is this 'little while' that becomes the limit of the accuracy of the timers in a Gamma program when they are driven from proxies. You see, most Gamma programs are run through an event loop. The maximum time a proxy-based timer can be delayed is the execution time of the longest path of code attached to an event. Since this quantity is totally dependent on how your code is written and the speed of your CPU, it is difficult to put an exact number on the practical accuracy of Gamma proxy-based timers. The maximum resolution of the timers is equal to the OS tick size setting.

Setting a timer

A timer is created when any of the following functions are called:

The `after` timer is used to evaluate a piece of code after a given amount of time. It is a one-shot timer that "goes away" after being fired.

The `every` timer is used to evaluate a piece of code at a specified interval.

The `at` timer evaluates the associated code when the current time matches the profile created by six arguments to the function.

For syntax and examples see the Reference Manual.

Canceling a Timer

All timer functions return a timer_id that can be used to cancel the timer. To do so, the `cancel` function is called, using the timer-id for its argument.

The TIMERS variable:

On startup of a Gamma program a variable called `TIMERS` is initialized. This variable is an array of all the timers currently in the system. Initially, its value is `[ ]` (an empty array) but as timers are added to the system this array grows.

```
Gamma> TIMERS;
[]
Gamma> a = every(3,#princ("Hello\n"));
1
Gamma> >TIMERS;
[[860700531 176809668 3 ((princ "Hello\n")) 1]]
```

The `TIMERS` variable was initially an empty array. Once the first timer was added the `TIMERS` variable contained information on the first timer. The contents of each element can be summarized as:

```
second nanosecond repeat function timer_id
```

The second is the number of seconds since Jan. 1, 1970 which is compatible with the `clock` and `date` functions. The nanosecond is the fraction of the second. Combining these two times gives an accurate time that identifies the next time the timer will fire. The repeat is `nil` if the timer is a once-only "`after`" timer or an "`at`" timer. Otherwise, this is the period of an "every" timer. The next item is the code that is evaluated when the timer fires. The last item in this sub-array is the timer-id.

This array grows as timers are added to the system:

```
Gamma> b = every(5, #princ("Test\n"));
2
Gamma> _timers_;
[[860700531 176809668 3 ((princ "Hello\n")) 1]
[860700563 494732737 5 ((princ "Test\n")) 2]]
Gamma>
```

An important point to remember is that the `TIMERS` variable is an array, and therefore can be referenced as such. To reference the first element in the `TIMERS` array, use `TIMERS` [0] just like a regular array reference. Altering the `TIMERS` array can cause unpredictable behavior, and should be avoided.

Blocking timers from firing

Sometimes a segment of code is written which must be executed non-stop, without an interruption from timers. To accomplish this, the code is wrapped between `block_timers` and `unblock_timers` functions. In this way the code will be safe from interruption from timers. This blocking is not necessary unless timers have been bound to signals rather than proxies.

`timer_is_proxy` function

This function controls how timers are fundamentally handled within a Gamma program. By default, timers are handled by the processing of proxies. This allows the Gamma engine to delay the timer, if necessary, when a critical system process is occurring.

Calling the `timer_is_proxy` function with `nil` makes all timers operate by using signals. In the QNX 4 operating system, for example, SIGALRM is used, and the attached code is run as a handled signal. Running timers via signals has some very dramatic consequences. First and foremost, when running in this mode *all timer code must be signal safe*. This status must be analyzed with caution, as most code is *not* signal safe. This mode should be avoided except in very rare circumstances.

Symbol Value Events (Active Values)

The Gamma language has the capability to generate an event when a variable is modified in any way. A variable that can trigger an event is called an *active value*. The code that is executed when the variable changes is called the *set expression* that is effectively a callback.

The `add_set_function` permits attaching an expression to any defined variable. (It is an error to attach a set expression to a constant symbol.) When the value of a symbol changes, either by being declared within a sub-scope or by being explicitly changed using

=, :=, --, or ++, the Gamma engine checks the symbol for the existence of an associated set expression. If a set expression exists, then it is executed directly after the value of the symbol is changed. This set expression can be any valid Gamma code, and is evaluated within its own sub-scope. The symbols `value`, `previous` and `this` are defined within this sub-scope to be the current value of the symbol, the previous value of the symbol, and the symbol itself respectively. If an active value causes another active value to change, then that new active value's set expression is also evaluated. This provides a very simple and powerful means by which forward chaining algorithms such as those in expert systems can be implemented.

Active values provide a very powerful way of constructing an event-driven application with a high degree of cohesiveness. Often, there is some functionality that is related to a derived variable, not an event itself. The function can be attached to that internal variable, decoupling it from the event, and generating clearer and more concise code. In the following example, we wish to attach an action to an alarm condition, which in turn is generated by a change in a measured variable (e.g., the temperature). The **#** sign protects an expression from evaluation, causing it to be treated as a literal. (We discuss Deferring Expression Evaluation in more details later, in the chapter on Advanced Types and Mechanisms).

```
Gamma> temp = 35;
35
Gamma> hi_limit = 40;
40
Gamma> function check_temp (tp)
     {if (tp > hi_limit) alarm_hi_on = t;
      else alarm_hi_on = nil;}
(defun check_temp (tp)
  (if (> tp hi_limit)
    (setq alarm_hi_on t)
    (setq alarm_hi_on nil)))
Gamma> function print_alarm ()
     {if (alarm_hi_on == t) princ("Alarm is on: Temp is over ",
                                  hi_limit, ".\n");
      if (alarm_hi_on == nil) princ("Alarm is off.\n");}
(defun print_alarm ()
  (progn (if (equal alarm_hi_on t)
            (princ "Alarm is on: Temp is over " hi_limit ".\n"))
         (if (equal alarm_hi_on nil)
            (princ "Alarm is off.\n"))))
Gamma> add_set_function(#temp,#check_temp(temp));
(check_temp temp)
Gamma> add_set_function(#alarm_hi_on, #print_alarm());
(print_alarm)
Gamma> temp = 38;
Alarm is off.
38
```

```
Gamma> temp = 39;
39
Gamma> temp = 42;
Alarm is on: Temp is over 40.
42
Gamma>
```

Cogent DataHub instance Point Events (Exception Handlers)

The Cogent DataHub program is a data collection and distribution center designed for easy integration with the Gamma language. A point is a name for data in a DataHub instance. An exception handler is a Gamma expression that is attached to a point. The DataHub instance can asynchronously transmit any number of point values to a Gamma program, which will then automatically update the value of a symbol named the same as the DataHub point.

The `add_exception_function` and `add_echo_function` functions permit an application to bind an expression to a DataHub point exception in a similar way to `add_set_function` above. If an application can both write a point and receive exceptions from that point, then the DataHub instance will "echo" the exception originated by the application. The two functions make it possible to distinguish between these two situations. Only the originating task will see a point exception as an echo, while all other tasks will see a normal exception.

In addition, the programmer may attach any number of expressions to the symbol, to be evaluated when the DataHub point changes. The expressions are evaluated within a sub-scope, with the special symbols: `value`, `previous` and `this` defined to be: the current value of the point, the previous value of the point and the point name itself as a symbol. An exception handler is only triggered during a call to `next_event`, `next_event_nb` or `flush_events`.

Windowing System Events

Gamma's GUI support offers `PtAttachCallback` for Photon and `AttachCallback` for X Windows that permit attaching callbacks to any GUI event. Like the other event handling functions, the user can in fact bind any Gamma expression for execution when the event occurs.

GUI Event Handlers (Callbacks)

A GUI event handler, also known as a *callback*, is an arbitrary expression attached to a particular callback of a widget. A callback may occur whenever a call is made to `next_event`, `next_event_nb`, and `flush_events`. If the appropriate GUI event has occurred, then the Gamma engine automatically evaluates any callback handlers that deal with the event attached to the particular widget. This results in essentially asynchronous program flow, where the callback may occur, from the user's perspective, at any time during the program execution. In reality, the GUI event is only handled if the system has been instructed to deal with one or more incoming events.

Signals

Signals are the traditional method of asynchronous communication between tasks, in which no data is transferred. A *signal handler* is an expression attached to an operating system signal, which is delivered asynchronously to the running program. A signal handler is attached by a call to the `signal` function.

A signal pre-empts any activity except garbage collection, and causes control flow to enter the signal handler. The signal handler should not call non-reentrant functions. It is safe for a signal handler to make a call to the `error` function, which will throw flow control to the nearest error handler.

Gamma supports the following signals:

```
SIGABRT, SIGBUS, SIGCHLD, SIGCONT, SIGDEV,
SIGEMT, SIGFPE, SIGHUP, SIGILL, SIGINT,
SIGIO, SIGIOT, SIGKILL, SIGNAL_HANDLERS,
SIGPIPE, SIGPOLL, SIGPWR, SIGQUIT, SIGSEGV,
SIGSTOP, SIGSYS, SIGTERM, SIGTRAP, SIGTSTP,
SIGTTIN, SIGTTOU, SIGURG, SIGUSR1, SIGUSR2,
SIGWINCH
```

For the description of signal values see the `signal` entry in the Reference Manual.

`block_signal` & `unblock_signal`

There are times when certain portions of code must not be interrupted by certain or all signals. Use the `block_signal` and `unblock_signal` functions to protect a process.

Error Handling

An error handler is a function that responds to an error. In general, when a program executes, the flow of control moves from one expression to the next, possibly passing into and out of function calls, and following branches and loops as necessary. If an error occurs, however, the flow of control will not move to the next expression, but will jump immediately to the most recently declared error handler, either through the `protect/unwind` or the `try/catch` constructs. These constructs are the two pairs of functions available in Gamma which allow for trapping and handling errors. See Tutorial II for more details.

The combination of signal handlers and error handlers can cause a program to jump to a predefined point at any time during its execution. An error can be explicitly caused by a call to the `error` function.

Situations that might cause Gamma to crash

Gamma is a very robust language, particularly in comparison to programming in C. However, the power and ease of use can sometimes lead a programmer to create situations that could crash the Gamma engine. Generally these are errors that would certainly have crashed a C program, and would be considered part of the debug cycle. The following list highlights some situations where care must be taken:

1. A call to `init_ipc` inside a timer or signal handling routine. You should call (`init_ipc`) once at the beginning of your program if at all.
2. Abuse of Photon widget resources. While care has been taken to minimize the risk of a crash by abusing the Photon widgets, the bottom line is that widgets are raw C structures with fairly complex manipulation functions. If you write a bad value into a C structure, your program will crash. If you fail to call `PtInit`, your program will crash. If you create a non-window widget with no parent, your program will crash. These are just facts of life.
3. Gamma provides a 'wrapper' for most of the standard C library functions that makes the corresponding C function call after extracting the Gamma arguments. If the arguments passed cause the C function to crash, then your program and the Gamma engine will crash as well.

Having said these things, we are always interested in hearing about new ways that we can make Gamma more robust. Please don't hesitate to let us know if you find a weak spot.

Tutorial II

This tutorial includes examples related to control flow in Gamma: namely, error handling and dynamic scoping.

Error Handling - `try/catch`, `protect/unwind`

This example demonstrates the error handling mechanisms available in Gamma. There are two basic means of trapping and handling errors.

1. Execute a protected block of code, and specify an error handler which is only executed if an error occurs within the protected code. If an error occurs, the error handling code is executed, and the error condition is cleared. This is the `try/catch` mechanism.
2. Execute a protected block of code, and specify a second block of code which must be executed even if an error occurs in the first block. Normally when an error occurs, the execution stack is unwound to the nearest error handler, aborting any intervening execution immediately. If a block of code must be run, even when an error occurs, we want to unwind protect that code. After the error is dealt with, it is passed on up the stack rather than being cleared. This is the `protect/unwind` mechanism.

The code for the example is shown below.

```
#!/usr/cogent/bin/gamma

/*
 * Create a function which has an error in it.
 * The symbol zero is not defined.
 */

function sign (x)
{
    if (x < zero)
        princ ("Negative\n");
    else
        princ ("Positive\n");
}

/*
 * Create a function which checks the sign of a number,
 * but ensures that an error will not terminate the program.
 */

function checkit (x)
{
    princ ("\nEntering a TRY, CATCH block...\n");
    try
    {
```

```
        sign (x);
    }
    catch
    {
        princ ("Oops: ", _last_error_, "\n");
    }
}

/*
 * Create a function which checks the sign of a number,
 * and which will print a status message whether or not an error
 * occurs, before passing a possible error condition up the stack.
 * The 'princ' statement in this case will always be run, even if
 * an error occurs.
 */

function unwindit (x)
{
    princ ("\nEntering a PROTECT, UNWIND block...\n");
    protect
    {
        sign (x);
    }
    unwind
    {
        princ ("Finished checking the sign\n");
    }
}

/*
 * Attempt to call this function, but if we get an error,
 * simply print the error message and continue.
 */

checkit (-5);

/*
 * Run the same code, but with zero defined
 */

zero = 0;
checkit (-5);

/*
 * Run the unwind protected function.  This should print its unwind
 * message.
```

```
 */

unwindit (-5);

/*
 * Make 'zero' undefined again so that the error will occur.  Now we
 * run a function which is unwind protected.  This function will not
 * return since it passes the error up to the global error handler,
 * which causes the program to exit.
 */

zero = _undefined_;
unwindit (-5);

princ ("This message should never be printed\n");
```

Dynamic Scoping

This example uses the error handling mechanisms from the previous Error Handling section to demonstrate dynamic scoping. Most compiled languages use lexical scoping, which means that a variable is defined only where it is visibly declared, either as an external global, file global, or local variable. Gamma uses dynamic scoping, meaning that a variable is defined in any function which defines it, and in any function which the defining function subsequently calls. This powerful mechanism allows the programmer to override global variables by defining them in a higher scope, and then calling a function which believes itself to be using a global variable.

One useful side-effect of dynamic scoping is that functions and variables do not have to be declared before they are used in other functions. The function or variable only has to be declared when the other function is actually run.

The code for the example is shown below.

```
#!/usr/cogent/bin/gamma

/*
 * Create a function which has an error in it.
 * The symbol zero is not defined.
 */

function sign (x)
{
    if (x < zero)
        princ ("Negative\n");
    else
        princ ("Positive\n");
}
```

```
/*
 * Create a function which checks the sign of a number,
 * but ensures that an error will not terminate the program.
 */

function checkit (x)
{
    try
    {
        sign (x);
    }
    catch
    {
        princ ("Oops: ", _last_error_, "\n");
    }
}

/*
 * Create a function which locally declares the variable 'zero', and
 * then calls the checkit function.  Since 'zero' is a local variable,
 * the local value will override the current global definition, which
 * is undefined.
 */

function zero_check (x)
{
    local zero = 0;
    checkit (x);
}

/*
 * Create a function which sets zero to -10, and calls the checkit
 * function.
 */

function minus_ten_check (x)
{
    local zero = -10;
    checkit (x);
}

/*
 * Attempt to call the checkit function with zero not defined.
 */
```

```
princ ("With 'zero' undefined...\n");
checkit (-5);

/*
 * Now let zero be defined and try again.
 */

princ ("\nWith 'zero' locally defined to 0...\n");
zero_check (-5);

/*
 * Now run with zero defined as -10
 */

princ ("\nWith 'zero' locally defined to -10...\n");
minus_ten_check (-5);

/*
 * Finally, try running checkit again from the global scope.  Note that
 * zero is undefined once again.
 */

princ ("\nOnce again from the global scope...\n");
checkit (-5);
```

Error Handling - interactive session

The code below provides an example of starting an interactive session in case of an error. In this example a window with two buttons is created. Pressing the button labeled **good button** will print a message to stdout. Pressing the button labeled **error button** will cause the UNDEFINED symbol g to be evaluated. This causes an error and starts the interactive session from the catch block. The function that runs the interactive session is designed to be recursive and relies on the dynamic scoping of variables in Gamma. Notice that Lisp grammar is being used in this interactive session. You can query the value of any variable simply by typing the variable name in. For example:

```
win
but1
but2
(@ win title)
```

or use some functions like:

```
(stack)
(* 8 3)
```

Before terminating the interactive session, try to resize the window. Notice that it does not work because the event loop is temporarily suspended. Now exit the interactive session by typing **Ctrl** - D and notice that the window can now be resized. Also notice that once the event loop is re-started, the contents of the window are not updated but the callbacks are still active. This happens because Photon was interrupted in the middle of a function call and an error condition now exists between Gamma and the Photon library.

```
#!/usr/cogent/bin/gamma

require_lisp("PhotonWidgets");

PtInit(nil);
win = new(PtWindow);
win.SetArea(100,100,100,100);

but1 = new(PtButton);
but1.text_string = "good button";
PtAttachCallback(but1,Pt_CB_ACTIVATE,#princ("good button\n"));
but1.SetPos(10,10);

but2 = new(PtButton);
but2.text_string = "error button";
PtAttachCallback(but2,Pt_CB_ACTIVATE,#g);
but2.SetPos(10,40);

PtRealizeWidget(win);

function interactive_mode ( level )
{
 local expr;

    princ("internal error: ", _last_error_,"\n");
    writec(stdout,"\ndebug", level,">");
    while ( (expr = read(stdin)) != _eof_)
 {
        try
        {
            writec(stdout,eval(expr));
            writec(stdout,"\ndebug", level,">");
        }
        catch
        {
            interactive_mode(level + 1);
            writec(stdout,"\ndebug", level,">");
        }
```

```
    }
}

while (t)
{
    try
    {
        next_event();
    }
    catch
    {
        princ("starting temporary interactive mode using Lisp grammar\n");
        princ("use ^D to exit this mode and return to event loop\n");
        interactive_mode(1);
        princ("\nleaving temporary interactive mode\n");
    }
}
```

Functions and Program Structure

Function Definition

A function is defined in Gamma using a `function` statement:

```
Gamma>  function thing (a) { random() * a;}
(defun thing (a) (* (random) a))
Gamma>  thing (5);
2.3869852581992745399
```

```
function pow (v, exp)
{
    local result = 1;

    while (exp ## > 0)
    {
    result *= v;
    }

    result;
}
```

No type specification is used since the type returned will be determined by the expressions within the function when it executes:

```
Gamma> pow (2,3);
8
Gamma> pow (2.1, 3.25);
19.4481
```

C programmers should note that this typeless function definition bears no similarity to a void function type, which does not exist in Gamma.

The value and type of a function is the return value of the last expression evaluated within the function. To return the value of a specific variable that only exists within the scope of the user function, that variable name is placed by itself on the last line of the function. This effectively causes that symbol to be evaluated, returning its value.

Functions do not need to be defined before they are referenced in a file, but they must exist before they are called. In other words, it is the run-time order, not the loading (reading) order that is important.

Function Arguments

When a function is called, the arguments in the call are mapped to the arguments specified in the function definition on a one-to-one basis. The Gamma engine evaluates the arguments and maps the results of those evaluations to each function argument name. Since Gamma is abstractly typed, there is no need to specify a data type in the function definition. If a particular data type is required within the function, then the function body can check for the type using the type predicate, `type-p`.

Variable number of arguments

It is possible to create a function that takes a variable number of arguments. The last argument in a function's argument list may be made to act as a "catch-all" or *vararg* argument which collects all remaining arguments provided in the function call as a list. For example,

```
function f (x, y...)
```

creates a function with 2 mandatory arguments, the second of which can have one or more values. If this function is called as `f (1,2)`, then *x* will have the value `1`, and *y* will have the value `(2)`, that is, a list containing one element whose value is `2`. If this function is called as `f (1,2,3,4,5)`, then *x* will be `1`, and *y* will be `(2 3 4 5)`, a list of four elements. If this function is called as `f(1)`, then an error would occur because y is not optional.

Optional arguments

Gamma allows optional arguments at the end of an argument list. An optional argument is specified by appending a question mark (`?`) to an argument in the function's argument list. All arguments after the first optional argument are implicitly optional as well. If the caller wants to provide a value to an optional argument, then the caller must also provide values for all preceding optional arguments. If an optional argument is not provided during the call, then the argument will take on the value `UNDEFINED`, which must be dealt with within the body of the function. A default value for an optional argument can also be provided in the function definition. For example,

```
function f (x, y?, z=5)
```

creates a function with 1 mandatory argument and two optional arguments. The argument *y* has no default value, and *z* has a default value of `5`. This function could be called as `f(1)`, `f(1,2)` or `f(1,2,3)`.

Protection from evaluation

Any function argument can be protected from evaluation by an exclamation mark (`!`) before the argument name in the function's argument list. For example,

```
function f (x, !y)
```

creates a function with two mandatory arguments , the second of which will not be evaluated when it is called. If this function were called as `f (2+2, 3+3)` then *x* would have the value of 4, and *y* would have as its value the expression 3+3. *y* could be evaluated using `eval(y)` to produce the value 6.

Variable, optional, unevaluated arguments

A variable argument can also be made optional. If so, and if it is not evaluated, then all the arguments which are collected into its list will not be evaluated either. For example,

```
function f (!y...? = 17)
```

creates a function with one optional argument named *y*. The argument *y* is not evaluated, and may take any number of values, passed as a list. If no argument is specified to the function, then *y* will have the value of `17`. If, instead of `17` the default is set to `nil`, no default will be assigned. This syntax effectively gives a way to pass a list of arguments of any length to a funtion.

Examples

The following program shows example functions with argument lists similar to those described above.

```
#!/usr/cogent/bin/gamma

function variable_args (x, y...)
{
  princ("---- Output from variable_args(x, y...) ---- \n");
  princ("The first arg: ", x, "\n");
  with a in y do
    {
      princ("One of the variable args: ", a, "\n");
    }
  princ("\n");
}

function optional_args (x, y?, z=5)
{
  princ("---- Output from optional_args(x, y?, z=5) ---- \n");
  if (undefined_p(y))
    y = "This value has not been defined.";
  princ("The first arg: ", x, "\n");
  princ("The second arg: ", y, "\n");
  princ("The third arg: ", z, "\n");
  princ("\n");
}
```

```
function no_eval(x, !y)
{
  princ("---- Output from no_eval(x, !y) ---- \n");
  princ("This argument was evaluated: ", x, "\n");
  princ("This argument was not evaluated: ", y, "\n");
  princ("\n");
}

function many_args (fixed_arg, !y?... = nil)
{
  princ("-- Output from many_args(fixed_arg, !y?... = nil) ---- \n");
  princ("fixed_arg: ", fixed_arg, "\n");
  princ("y: ", y, "\n");
  princ("The first y arg: ", car(y), "\n");
  with a in cdr(y) do
    {
      princ("The next y arg: ", a, "\n");
    }
  princ("\n");
}

variable_args("hello", 9, "world", 4 + 7, #x);
optional_args(1);
optional_args(1, 2);
optional_args(1, 2, 3);
no_eval(2+2, 3+3);
many_args("Fixed", "hello", 9, "world", 4 + 7, #x);
```

The output of this program is as follows:

```
---- Output from variable_args(x, y...) ----
The first arg: hello
One of the variable args: 9
One of the variable args: world
One of the variable args: 11
One of the variable args: x

---- Output from optional_args(x, y?, z=5) ----
The first arg: 1
The second arg: This value has not been defined.
The third arg: 5

---- Output from optional_args(x, y?, z=5) ----
The first arg: 1
```

```
The second arg: 2
The third arg: 5

---- Output from optional_args(x, y?, z=5) ----
The first arg: 1
The second arg: 2
The third arg: 3

---- Output from no_eval(x, !y) ----
This argument was evaluated: 4
This argument was not evaluated: (+ 3 3)

---- Output from many_args(!y?... = nil) ----
One of the args: hello
One of the args: 9
One of the args: world
One of the args: (+ 4 7)
One of the args: 'x
```

Function Renaming

When a function is defined, Gamma automatically assigns the function definition to the symbol that was provided as the function name, in the global scope. This does not mean that the symbol and the function definition are permanently related.

(A function definition is an independent data object which can be passed as an argument to a function or assigned to a symbol in any scope. For a C programmer this makes a Gamma function definition operate in much the same way as a function pointer in C. However, Gamma function definitions are much more versatile.)

It is possible to re-map a function definition at run-time to modify its behavior. For example, we may like to modify the function pow defined in the Function Definition section. We would like the improved pow to check the argument type and accept a string as its argument as well as a number. In Gamma, there are functions like `int_p`, `real_p`, and `string_p` that are used to determine the data type of a variable. (For the complete list of `-p` functions see Data Types and Predicates in the Reference Manual).

Thus, we rename the pow function defined in the section Function Definition to __pow and write the new version as follows:

```
...
__pow = pow;
function pow (v, exp)
{
    local result;
    if (string_p (v))
    {
```

```
        result = "";
        while (exp ## > 0)
            result = string(result, v);
    }
    else
        result = __pow(v, exp);
    result;
}
```

Then the function call `pow("hello", 3)` will produce:

```
"hellohellohello"
```

Loading files

Files are loaded from the disk to memory using the `load` and `require` functions. The `load` function loads a Gamma file every time it is called. The `require` function checks to see if a Gamma file has been loaded, and if not, it loads it. The `load_lisp` and `require_lisp` functions do the same thing for files written in Lisp grammar. All of these functions take the name of the file, as a string, for their argument.

As a file is loaded by the Gamma engine, the `require` mechanism is used to access additional files. This is similar to the `#include` directive used in C programs, and likewise permits modularization of the application code. Note however that since Gamma is a run-time language, there is no equivalent to object modules of compiled languages. The `require` function therefore provides the sole mechanism for bringing together modules that define an application.

The pre-defined global variable `_require_path_` contains a list of the paths to be searched to find the specified filename. This variable usually references the current directory, and the location for libraries. The list of paths can be augmented with:

```
_require_path_ = cons ("my_directory_name", _require_path_);
```

The pre-defined global variable `_load_extensions_` contains a list of default extensions that are used by the `require` functions. Filenames with these extensions do not have to specify the full filename in the `require` argument. The variable is initialized to (`".slg" ".lsp" ""`), and can be augmented in the same way as `_require_path_`.

The `main` Function

In Gamma there is no requirement for a function named `main` as there is in C. As a program file is loaded, a call to a function at the outermost scope will in fact cause that function to be run at that point. In the same way, variable definitions and assignments at the outermost scope level are executed, effectively becoming globals. In most cases, the application is initiated by calling the user's "top level mainline" function at the end of the file, or by entering a loop, such as an infinite event loop.

If a function is defined with the name `main`, then Gamma will automatically start to execute that function after the load is complete. This is equivalent to placing `main` as the last statement in the file. Note that `main`'s function definition must contain the keyword `function` , just like any other function definition. Since `argv` is available as a global variable, `main` does not require any arguments.

Executable Programs

Since the Gamma language is based on Lisp (ie. SCADALisp), programs can be written and executed using either Gamma or Lisp grammar. How to execute a Gamma program is discussed in Stand_Alone Executable Programs in the Getting Started chapter of this Guide, as well as in the next two sections of this chapter.

Writing Lisp programs is beyond the scope of normal Gamma programming, but it may be useful from time to time to invoke a Lisp executable. This is done in a similar way to Gamma. Stand-alone programs will invoke the Lisp engine by using the following shell directive as the first line of the file:

```
#!/usr/cogent/bin/lisp
```

The Photon dialect is available through:

```
#!/usr/cogent/bin/phlisp
```

Running a Gamma Program

Gamma programs can be run in two ways: as a stand-alone executable, or by invoking Gamma from the command line.

1. For stand-alone executable program, the user simply types the name of the executable, possibly with command line arguments. The program invokes the Gamma engine through the shell `!#` directive (as explained in Executable Programs in the Getting Started chapter of this Guide.
2. In the case where there is no Gamma engine "embedded" into the program, the command **gamma** is available to run the executable. This command has several options, a few of which we mention here, and the rest of which are given in the **gamma** entry in the Reference.

`-h` gives a help message displaying all the options for this command.

`-C` declares all Gamma constants at startup. These constants can be viewed using the `apropos` function.

`-d` saves debugging information: the file name and line number.

-F declares all Gamma functions at startup. As with the `-C` option, these functions can be viewed using the `apropos` function.

The next section discusses command line arguments for a program, and how to access them within the program.

Command Line Arguments

Gamma provides a mechanism for accessing command line arguments. The symbol `argv` contains a list of the parsed command line arguments. Thus, if you have an application named **my_app** which takes two arguments `arg1` and `arg2`, then the executable invoked with:

```
my_app arg1 arg2
```

will receive the following `argv`:

```
(my_app arg1 arg2)
```

Like any list, the length of `argv` is simply `length (argv);` The command line arguments can be accessed like any list, using any of the following sample approaches:

```
for ( i=0; i < length(argv); i++)
{
    arg = car (nth_cdr (argv, i));
    ... process arg ...
}
```

or similarly, but more efficient:

```
while (length (argv) > 0)
{
    arg = car (argv);
    ... process arg ...
    argv = cdr (argv);
}
```

which can also be expressed, still more efficiently, and without modifying the original `argv`, with:

```
for (i=argv; i; i = cdr(i))
{
    arg = car (i);
    ... process arg ...
```

```
}
```

Object Oriented Programming

Classes are a powerful feature that helps users to organize a program as a collection of objects. Users that are familiar with C++ will find some syntax similar.

Classes and Instances

A class is a collection of variables and functions that, together, embody the definition of data type that is distinct and significant for the user's problem. Class functions are called *methods*. Class variables can be of the two kinds: *attributes* and *class variables*. Attributes are more common and do not require any special identifiers. Class variables are defined with the identifier static. We'll discuss class variables later in this chapter. Every class has a name. Here we define a class named `Polygon`, and give it four attributes:

```
class Polygon
{
    sides;
    angles;
    dimensions = 2;
    color = nil;
}
```

Here is another example, `Catalog`, with one attribute, defined in interactive mode:

```
Gamma> class Catalog { data;}
(defclass Catalog nil [][data])
```

When you define a class in interactive mode Gamma returns an internal representation of its *class definition* in Lisp syntax. This definition is a list with the following elements: the `defclass` function, the class name, the parent class name (`nil` in this case), the class methods and class variables in one array (none in this example), and the class attributes in a second array.

Default values can be assigned to the attributes. For example, the `Polygon` class (above) has 2 dimensions and no color by default. The `Catalog` class has no default data values.

Instances

A class is an abstract data type. A class is used by constructing new *instances* of it. This is done using the function new:

```
Gamma> pentagon = new(Polygon);
{Polygon (angles) (color) (dimensions . 2) (sides)}

Gamma> autoparts = new(Catalog);
{Catalog (data)}
```

In this example, the class is `Polygon` and the newly-created instance of the class is `pentagon`. Or, the class is `Catalog` and the instance is `autoparts`.

The variables of the instances of a class are called *instance variables*. They correspond to the attributes in the class definition. In the `Polygon` class, for example, the instance variables are: `sides`, `angles`, `dimensions`, and `color`. Note that the function `new` returns the written representation of an instance, which consists of the class name and a list of instance variables. An instance variable with a default value is represented as a dotted list, such as `(dimensions . 2)` in our example.

In Gamma, to set or query the instance variable of an instance, the dot notation is used. Thus, each of the instance variables associated with the pentagon instance can now be set as follows:

```
Gamma> pentagon.angles = 108;
108
Gamma> pentagon.sides = 5;
5
Gamma> pentagon.color = "blue";
"blue"
Gamma> pentagon;
{Polygon (angles . 108) (color . "blue") (dimensions . 2) (sides . 5)}
Gamma>
```

Notice that internally Gamma holds a class instance and its instance variables together in curly braces. This is called *literal instance syntax*.

Methods

Methods are functions that are directly associated with a class.

We will create a `Lookup` method for the `Catalog` class. This method lets you look up an entry in the catalog by a key associated with the entry. In this example we implement our data as an association list, that is, a list whose elements are also lists, each of which contains exactly two elements : key and value. The library function `assoc_equal` returns the remainder of the association list starting at the element whose key coincides with the key in the argument of the method `Lookup`. Thus, `Lookup` returns the list associated with the key. The special keyword `self` is used when the instance refers to itself within the function:

```
method Catalog.Lookup (key)
{
    car(assoc_equal(key, self.data));
}
```

Note that the keyword `self` can be omitted and the call would look as follows:

```
    car(assoc_equal(key, .data));
```

The calls to class methods are made by instances, using the dot notation. For example, the instance `autoparts` created above can call the `Lookup` method as follows:

```
Gamma> autoparts.Lookup ("muffler");
nil
```

Since the data attribute did not have a default value, the first time call to `Lookup` returns `nil`. In order to put data in the data list, we must create another method:

```
method Catalog.Add (key, value)
{
    local i;

    if (i = .Lookup (key))
    {
        princ("The entry ", key, " already exists\n");
        nil;
    }
    else
    {
        .data = cons(list(key, value), .data);
    }
}
```

Notice that the `Add` method is using `Lookup` to determine whether or not the entry already exists in the association list. If so, it returns `nil`. Otherwise the new entry is added to the data list using the library function `cons`. The return value of a method is the return value of the last function executed within the body of the method.

Now we can add some data. For example, we can add an entry with the keyword "muffler" and the value 1, which is, for example, the number of mufflers in the stock:

```
Gamma> autoparts.Add ("muffler", 1);
(("muffler" 1))
Gamma> autoparts.Add ("starter", 5);
(("starter" 5) ("muffler" 1))
```

Now we can look up the entry for a muffler by the keyword:

```
Gamma> autoparts.Lookup("muffler");
("muffler" 1)
```

Note that the `autoparts` instance variables can be queried using the dot notation as follows:

```
Gamma> autoparts.data;
(("starter" 5) ("muffler" 1))
```

Inheritance

Let us consider the following example where a new class is created:

```
class Book Catalog
{
    size =  0;
}
```

The Book class is called a *derived* class and the `Catalog` class is called a *base*, or *parent* class for the Book class. In addition to having its own attributes, methods, and class variables, a derived class *inherits* all these things from the base class as well. For example, the Book class inherits the `data` attribute from the `Catalog` class:

```
(defclass Book Catalog [][data (size . 0)])
```

The relation between the base classes and the derived classes can be described as an "is-a" relation: a derived class "is-a" base class, with its own additional features. Due to inheritance, an instance of a derived class in Gamma can call any method of the base class just like it was an instance of the base class itself:

```
Gamma> math = new(Book);
{Book (data) (size . 0)}
Gamma> math.Lookup("Calculus");
nil
```

In this case it returns `nil` because no entry "Calculus" was added to the list of data. Now we can create an Add method for the Book class. This method adds an author and a publisher to the association list of data. If the Add operation is successful, the size of the list is incremented by 1. This Add method internally calls the Add method of the base `Catalog` class using the `call` function. We say that the derived class inherits implementation from the base class. If we were to change the way the Add method is implemented in the base class, the implementation would propagate to the derived class.

```
method Book.Add (title, author, publisher)
{
    local pair = list(author, publisher);
```

```
    local result = call(self, Catalog, Add, title, pair);

    if (result)
        {
            .size+= 1;
        }
}
```

The method Add can be evaluated as follows:

```
Gamma> math.Add ("Calculus", "Thompson", "Wiley");
1
```

It returns the size of the math catalog as the result of the last evaluated expression within the method. Now if we would like to search for the entry "Calculus", the method `Lookup` is evaluated as follows:

```
Gamma>  math.Lookup ("Calculus");
(Calculus (Thompson Wiley))
```

Classes can be related by "is-a" relations, since one class is a derived class of the other. There can also be "has-a" relations between classes. Let us consider the following example:

```
class Figure
{
    color;
    height;
    width;
}

class Book_1
{
    size;
    figure = new(Figure);
}
```

Class Book_1 "has" an instance of class Figure as an attribute. In other words, class Book_1 *contains* one instance of the class Figure. Let us consider the connections between the methods of the two classes with the "has-a" relations. Suppose the following methods are defined:

```
method Figure.Show()
{
```

```
...

}

method Book_1.Show()
{
    .figure.Show();
}
```

The method Show of the Book_1 class internally calls the method Show of the Figure ("contained") class. We say that the Book_1 class *delegates* its method to the Figure class. Thus, the effect of the delegation is implementation inheritance. It's true that to inherit implementation, the Figure class could be simply derived from the Book_1 class and the "is-a" relations would be in effect. But then it would be impossible for an instance of the Book_1 class to have several instances of the Figure class.

Note that in the definition of the Book_1 class, the Figure class is instantiated, which makes the attribute figure an *instance* of the class Figure. Thus, if an instance of the Book_1 class is created it can evaluate its Show method right away:

```
...
mystery = new(Book_1);
mystery.Show();
...
```

However, if an instance of figure is not actually created in a Book class definition,

```
class Book_2
{
    size;
    figure;
}
method Book_2.Show()
{
    .figure.Show();
}
```

then it has to be instantiated for each new instance of Book_2 before any "delegation" will occur:

```
...
mystery = new(Book_2);
mystery.figure = new(Figure);
mystery.Show();
...
```

Instance Variables

We recall that instance variables (*ivars*), are non-method items that make up an instance of a class. In the example below, the ivars of the instance `math` are `data` and `size`. To set or query the value of an ivar use the class instance and ivar in dot notation:

```
Gamma> math.size;
1
```

Gamma has the ability to add ivars to a class at any time, using the function `class_add_ivar`. As an example consider the `Catalog` class used in the above examples. Suppose we would like to have a variable which holds the date when a catalog is started:

```
Gamma> class_add_ivar(Catalog,#start_date);
nil
Gamma> Catalog;
(defclass Catalog nil [...][data  start_date])
```

Once an instance variable has been added to a class, all new instances of that class created *after* the variable was added will receive the new ivar.

```
Gamma> math;
{Book (data) (size . 0)}
Gamma> cooking = new(Book);
{Book (data) (size . 0) (start_date)}
```

Class Variables

Class variables (*cvars*), are non-method items that permanently belong to the class in which they are defined. One can think of a class variable as named data associated with the class. There is only ever one copy of the variable. All instances of that class share that copy. All derived classes and all the instances of the derived classes share that one copy. It is like a global variable.

Gamma has the ability to add cvars to a class at any time, using the function `class_add_cvar`. Once a class variable has been added to a class it becomes available to all new instances of that class and the derived classes. However they do not get a private copy of that variable but share one and the same variable that belongs to the class. As an example consider the `Catalog` class and its derived class, `Book`, once more.

```
Gamma> class_add_cvar(Catalog,#capacity, 200);
200
```

```
Gamma> Catalog;
(defclass Catalog nil [ ... (capacity . 200)][data start_date])
Gamma> Book;
(defclass Book Catalog [...][data (size . 0) start_date]
Gamma> history = new(Book);
{Book (data) (size . 0) (start_date)}
```

We can see that the derived class `Book` does not have a private copy of the class variable `capacity`. However this variable is *available* for the derived class as well as for the instances of that class:

```
Gamma> Book.capacity;
200
Gamma> history.capacity;
200
```

To set or query the value of a cvar use the class name (or the instance name) and the cvar in dot notation. Remember, though, a change to the cvar in any class or instance of `Catalog` will change it for all classes and instances of `Catalog`.

```
Gamma> Book.capacity = 300;
300
Gamma> history.capacity;
300
Gamma> history.capacity = 400;
400
Gamma> Book.capacity;
400
Gamma> Catalog.capacity;
400
Gamma>
```

Constructors and Destructors

A *constructor* is a method that is automatically run when a new instance of a class is made. A *destructor* is a method that is automatically run when the instance is destroyed. Constructors are called for all parent (base) classes of an instance starting with the root of the instance's class hierarchy. Destructors are called for all parent (base) classes of an instance starting with the class of the instance and proceeding toward the root of the instance's class hierarchy.

In Gamma these two methods take the special names `constructor` and `destructor`.

```
method Book.constructor ()
{
```

```
    total_books++;
}

method Book.destructor ()
{
    total_books ##;
}
```

We'll now set the example variable `total_books` to 2 (since two have already been created: math and history):

```
Gamma> total_books = 2;
2
```

A new `Catalog` object can now be created, and the effect of the constructor and destructor observed:

```
Gamma> biology = new(Book);
{Book (data) (size . 0) (start_date)}
Gamma> total_books;
3
Gamma> biology = nil;
nil;
Gamma> total_books;
3
Gamma> gc();
166
Gamma> total_books;
2
```

The constructor worked as expected, but the destructor appears to have failed. Only after the `gc` function was called did the destructor get called. The gc function forces the garbage collector to run. When `biology` was set to `nil` the memory containing the previous definition for `biology` was left unlinked. Once this unlinked memory was recovered by the garbage collector, the destructor was called.

The frequency of the garbage collector running will depend on the program written in Gamma. The garbage collector can be forced to run by using the gc function. Occasionally, system activity may prevent it from running immediately, but the requirement to run is noted and it will do so at the next opportunity.

Classes are often used to keep track of real-world objects, and as such, it is important to keep statistics on these objects. One of the most common methods of doing this is by using constructors and destructors to increment and decrement a counter of the number of objects created or currently available.

Polymorphism

The concept of *polymorphism* has its roots in programming language design and implementation. A language is called polymorphic if functions, procedures and operands are allowed to be of more than one type. In comparison with polymorphic languages, there are languages called monomorphic, such as FORTRAN and C. Being monomorphic means that it is not possible, for example, to define two subroutines in FORTRAN with the same name but different number of parameters.

Overloading is a specific kind of polymorphism which Gamma supports.

Operator Overloading

Operator overloading allows the programmer to define new actions for operators (+,-,*,/, etc.) normally associated only with numbers. For example, the plus operator (+) normally adds only numeric variables. Operator overloading allows the user to define an alternate action to adopt when non-numeric variables are used in conjunction with an operator. The plus operator is often overridden so that strings may be concatenated using the syntax:

```
result = "hello" + " " + "there";
```

When overloading an operator in Gamma the developer must exercise extreme caution since operator overloading is achieved by redefining the operator itself. The typeless quality of variables in Gamma does not allow the interpreter to select an appropriate operator based on the types of the arguments.

Consider the following program fragment:

```
// Assign plus to a function called 'real_plus'.
real_plus = \+;

// Re_define plus to check for strings, and call
// string() or real_plus() depending on arg types.
function \+ (arg1, arg2)
{
    if (string_p(arg1) || string_p(arg2))
        string(arg1,arg2);
    else
        real_plus(arg1,arg2);
}
```

The first step in this example is to re-assign the functionality of the + operator to a function called `real_plus`. Notice that the backslash character is used to pass the + character explicitly. Without the backslash Gamma would interpret the plus character in the function definition statement as a mistake in syntax.

Once this assignment and definition are entered into Gamma the plus operator can be used with strings as well as with numbers:

```
Gamma> 5 + 4;
9
Gamma> "hello" + " " + "there";
"hello there"
```

While it is convenient to set up overloaded functions in Gamma, remember that user functions are generally slower than Gamma's built-in functions.

Binary Classes and User Classes

Binary classes are classes that are built into the specific version of Gamma that you are using. User classes are those classes defined by the programmer in the process of developing an application.

To test the number of built-in classes in the version of Gamma you are using, start a fresh instance and use the `apropos` function interactively to find all available classes:

```
andrew:/home/andrew > gamma
Gamma;(TM) Advanced Programming Language
Copyright (C) Cogent Real-Time Systems Inc., 1996.  All rights
reserved.
Version 2.4 Build 139 at Jul 6 1999 10:48:51
Gamma> apropos("*",class_p);
(Osinfo)
```

As we can see, **gamma** does not have built-in binary classes. Now let us try to run **phgamma**:

```
andrew:/home/andrew > phgamma
Gamma(TM) Advanced Programming Language
Copyright (C) Cogent Real-Time Systems Inc., 1996.  All rights
reserved.
Version 2.4 Build 139 at July 6 1999 14:21:45
Gamma> apropos("*",class_p);
(Osinfo PhArea PhBlitEvent PhBoundaryEvent PhDim PhDragEvent
PhDrawEvent PhEvent PhEventRegion PhExtent PhImage PhKeyEvent
PhLpoint PhPoint PhPointerEvent PhPrect PhRect PhRegion PhRgb
PhWindowEvent PtArc PtBarGraph PtBasic PtBasicCallback PtBezier
PtBitmap PtBkgd PtButton PtCallbackInfo PtComboBox
PtComboBoxListCallback PtComboBoxTextCallback PtContainer
PtDivider PtEllipse PtEventData PtFontSel PtGauge PtGenList
PtGenTree PtGraphic PtGrid PtGroup PtHtml PtIcon PtLabel PtLine
PtList PtListCallback PtMenu PtMenuBar PtMenuButton PtMenuLabel
```

```
PtMessage PtMeter PtMultiText PtOnOffButton PtPane PtPixel
PtPolygon PtRaw PtRect PtRegion PtScrollArea PtScrollbar
PtScrollbarCallback PtSeparator PtSlider PtTerminal PtText
PtTextCallback PtToggleButton PtTree PtTrend PtTty PtWidget
PtWindow RtTrend)
```

There is a significant difference in supported classes between the **gamma** and **phgamma** executables. The reason is that Photon widgets are mapped into **phgamma** as classes. The standard Gamma executable does not have support for Photon graphics and does not have these built-in binary classes.

User classes are found in the same manner. After user classes are defined they will match the `class_p` predicate in the `apropos` function and be added to the list:

```
andrew:/home/andrew> gamma
Gamma(TM) Advanced Programming Language
Copyright (C) Cogent Real-Time Systems Inc., 1996.  All rights
reserved.
Version 2.4 Build 139 at Jul 6 1999 10:48:51
Gamma> class test
{
    a;
    b;
    c;
}
(defclass test nil [][a b c])
Gamma> apropos("*",class_p);
(Osinfo test)
```

Tutorial III

Classes and OOP

Gamma implements object-oriented programming (OOP) features which provide a single-inheritance class mechanism with instance variables and methods. Since Gamma is an interpreter, the object definitions are truly dynamic, allowing for run-time extensibility. This example provides the simplest of starting points to this key software methodology.

```
#!/usr/cogent/bin/gamma

/*
 *  Demonstrates:
 *  class definitions: attributes and methods.
 *  constructors and destructors
 *  method overloading
 */

/*
 * Define a class of animal, with no default type and a default
 * of 4 legs
 */
class animal
{
    type = "animal";
    num_legs = 4;       // By default, animals have 4 legs
}

/*
 * The constructor for an animal is called when any instance of
 * animal or a subclass of animal is created using a call to 'new'.
 * Constructors have no arguments.
 */
method animal.constructor()
{
    princ ("A ", class_name(class_of(self)), " is born\n");
}

/*
 * The destructor for an animal is called when any instance of animal
 * or a subclass of animal is deleted by the garbage collector.
 * There is no explicit deletion mechanism in Gamma.  Destructors
 * have no arguments.
 */
method animal.destructor ()
```

```
{
    princ ("A ", class_name(class_of(self)), " dies\n");
}

/*
 * All methods except constructor and destructor are overloaded,
 * meaning that only the method for the nearest class in the
 * ancestry of the instance will be called for any given method name.
 */
method animal.describe ()
{
    princ ("The ", self.type, " has ", self.num_legs, " legs.\n");
}

/*
 * Create a subclass of animal of a particular type.
 */

class cat animal
{
    type = "feline";
}

/*
 * Create another subclass of animal which is itself a parent class
 */

class insect animal
{
    num_wings = 2;
    num_legs = 6;
}

/*
 * Overload the description method for insects so we hear about
 * wings and legs when we ask about insects.
 */

method insect.describe ()
{
    /*
     * We can explicitly call a method of a parent class using the
     * 'call' function and naming a parent class.
     */
    call (self, #animal, #describe);
    princ (" (oh, and ", self.num_wings, " wings)\n");
```

```
}

/*
 * Create a destructor for an insect.  This will be run before the
 * animal destructor.
 */

method insect.destructor ()
{
    princ ("Crunch. ");
}

/*
 * Create a subclass of an insect which is a particular type.
 */

class beetle insect
{
    type = "rhinoceros beetle";
    num_wings = 4;
}

function main ()
{
    local  pet = new (cat);
    local  bug = new (beetle);

    /*
     * cat gets its describe method from the animal class
     */
    pet.describe();

    /*
     * beetle gets its describe method from the insect class
     */
    bug.describe();

    /*
     * Since the destructor will be implicitly called by the garbage
     * collector, we can cause the destructor to occur by removing
     * all references to the instances (set the variables referencing
     * the instances to nil), and then explicitly invoke the garbage
     * collector.  Typically this is not necessary, as the garbage
     * collector will run when necessary.
     */
    pet = nil;
```

```
    bug = nil;

    gc();
}
```

Interactive Development and Debugging

Interactive Mode Implementation

The implementation of Gamma's interactive mode provides an interesting example of the how to use the concise power of the language. Interactive mode is implemented with the following few lines of Gamma:

```
princ("Gamma> ");
flush(stdout);
while ((x = read( stdin)) != _eof_)
{
    princ( eval( x));
    terpri();
    princ("Gamma> ");
    flush(stdout);
}
```

An application can easily provide its own customized "interactive mode" by executing a Gamma script file with a variation of this code that is entered when the file is loaded.

Getting On-Line Help for Functions

Gamma can display function definitions and parameters. To do this, start Gamma interactively and type the name of the function followed by a semicolon and return. For example,

```
andrewt@1:~ >  Gamma
Gamma (TM) Advanced Programming Language
Copyright (C) Cogent Real-Time Systems Inc., 1996. All rights
reserved.
Version 2.4 Build 142 at Aug 25, 1999 21:39:51
Gamma> init_ipc;
(defun init_ipc (my_name &optional my_queue_name domain) ...)
Gamma> new;
(defun new (class) ...)
Gamma> array;
(defun array (&optional &rest contents) ...)
Gamma> insert;
(defun insert (array position_or_function value) ...)
```

Note that the function definitions are described in the internal Lisp representation, as a list. The function is always displayed with the word `defun` first, followed by the name of the function, and then its syntax. The function arguments are enclosed in parentheses, but not separated by commas as they are in Gamma syntax. The Gamma

function modifiers (`!`, `?`, and `...`) are represented by: `&noeval`, `&optional`, and `&rest` respectively. For details on these modifiers, see `function` in the Reference section.
To give you a general idea, here is how the above functions definitions appear, first in Gamma syntax and then Lisp syntax:

```
init_ipc (my_name, my_queue_name?, domain?)
(defun init_ipc (my_name &optional my_queue_name domain) ...)
```

```
new (class)
(defun new (class) ...)
```

```
array (s_exp?...)
(defun array (&optional &rest contents) ...)
```

```
insert (array, position|compare_function, value)
(defun insert (array position_or_function value) ...)
```

Examining Variables in a Class or Instance

Classes and instances can be examined in two ways. For a class, you can simply type the name at the prompt. Instances of classes bound to C structures can be viewed using the `instance_vars` function. To examine an instance of a class, simply type an expression which evaluates to that instance (see, for example, `elephant` as an instance of the `animal` class in the Instances section of the Class chapter).

You can examine not only user-defined classes, but also the classes which are implemented in Gamma. For example,

```
Gamma> PhImage;
# < Binary Class: PhImage >
Gamma> instance_vars (PhImage);
[bpl colors flags format image image_tag palette palette_tag size \
     type xscale yscale]
Gamma> x = new (PhImage);
{PhImage (bpl . 0) (colors . 0) (flags . 0) (format . 0) \
     (image . #{}) (image_tag . 0) (palette . []) (palette_tag . 0) \
     (size . {PhDim (h . 0) (w . 0)}) (type . 0) (xscale . 0) \
     (yscale . 0)}
Gamma> x;
{PhImage (bpl . 0) (colors . 0) (flags . 0) (format . 0) \
     (image . #{})(image_tag . 0) (palette . []) (palette_tag . 0) \
     (size . {PhDim (h . 0) (w . 0)}) (type . 0) (xscale . 0) \
     (yscale . 0)}
Gamma> instance_vars (x);
[(bpl . 0) (colors . 0) (flags . 0) (format . 0) (image . #{}) \
     (image_tag . 0) (palette . []) (palette_tag . 0) (size . \
{PhDim (h . 0) (w . 0)}) (type . 0) (xscale . 0) (yscale . 0)]
Gamma> pretty_princ (x, "\n");
```

```
{PhImage (bpl . 0) (colors . 0) (flags . 0) (format . 0) (image . #{} ))
      (image_tag . 0) (palette . []) (palette_tag . 0) \
      (size . {PhDim (h . 0) (w . 0)}) (type . 0) (xscale . 0) \
      (yscale . 0)}
t
```

Using the Debug Prompt

The debug> prompt appears when an error occurs in interactive mode. Gamma halts execution of the program and produces the prompt. You can perform any action at the debug> prompt that you can perform at the top level, including modifying program source and setting variable values. The value of any variable can be queried by simply typing its name. The calling stack can be queried by using the `stack` function.

The `stack` function displays the execution stack, providing a list with the names of the nested functions executing when the error occurred. The outermost, or top level, function appears first (after `progn`). The function causing the error appears last on the list.

Once the debug> prompt appears, the program cannot be continued and must be re-started. If an error occurs again as a result of code executed within the debug level, another nested level of debug will appear. Each level adds to the current point on the execution stack. You can move up debug levels and return to the Gamma> prompt by pressing **Ctrl - D** at the debug> prompt.

Debugging a program

The use of an interpreter engine enables some unique approaches to the process of debugging and testing software. This section describes some of the tools and techniques for debugging an application.

Interacting with an Active Program

Gamma can provide an active *view-port* into the running application. Another task (or shell) can, at any time, interact with a running Gamma program, without halting it or otherwise disturbing its real-time response. This provides an approach to debugging that is much more powerful than adding debug print statements.

For example, suppose that we started a process with the name "my_task" interactively:

```
Gamma> init_ipc ("my_task");
t
```

The **gsend** (for Gamma) or **lsend** (for Lisp) utility is used to interact with a running application from a shell:

```
[sh]$ gsend my_task
```

```
my_task>
```

The **lsend** utility accepts Lisp input as the default and **gsend** accepts Gamma input as its default.

Once connected to a running Gamma program using **gsend**/**lsend**, the developer can:

- query/set variables/objects/instance_vars in the global scope
- call functions/methods
- re-define function definitions
- run any Gamma command interactively

The syntax for starting the `gsend` utility is as follows:

`gsend` [-l] [-g] [*program*] [*pid*]

-l

Accept Lisp input from the keyboard.

-g

Accept Gamma input from the keyboard.

program

a Gamma program name, attached by `name_attach`, `init_ipc`, or `qnx_name_attach`

pid

(QNX 4 only) a task ID

gsend and **lsend** attach to a running Gamma program and allow the user to send commands without exiting the event loop of the attached process. Any statement may be issued, including changing the definitions of existing functions. In our simple example we can call the `princ` function for `my_task` to execute:

```
[sh]$ gsend my_task
my_task> princ ("Hello!\n");
t
```

Notice that event processing stops for the duration of the command. Now let's look at `my_task`. In order to respond to requests from **gsend**/**lsend**, **my_task** must be executing an event loop. We can start one using the `next_event` function in a `while` statement:

```
Gamma> init_ipc ("my_task");
t
Gamma> while(t) next_event();
Hello!
```

The `my_task` program continues to run as normal during this operation.

This presents an excellent opportunity for rapid development by programmers. Typically developers are used to the "code, compile, link, run, debug, code..." iterative approach to programming. Once a Gamma developer makes a program with a well written event loop, such as the one shown in the section below on trapping errors, programming and testing can become operations that happen in parallel.

Programmers will find that after a piece of code has been written, it can be uploaded to an already running Gamma process with **gsend**/**lsend** by using a simple "cut and paste". The code is automatically assimilated into Gamma and ready to run. Better yet, if there is a problem with the code, the programmer receives immediate feedback and can track the problem down through an interactive debugging prompt that can be built right into the event-loop.

Trapping and Reporting Errors

Gamma provides a pair of functions referred to as the `try/catch` mechanism, that is very important for debugging. Consider the following simple event loop:

```
while (t)
{
    next_event();
}
```

This will run until the program exits or an event triggers some code that produces an error condition. There is no protection against errors. Now consider the following setup:

```
while (t)
{
    try
    {
        next_event();
    }
    catch
    {
        princ("error occurred\n");
    }
}
```

This setup of `try/catch` will try to evaluate the block of code contained in the "try" portion and jumps to the "catch" portion when an error occurs. A more effective example of the `catch` code block is:

```
while (t)
{
    try
```

```
    {
        next_event();
    }
    catch
    {
        princ("internal error: ", _last_error_,
            " calling stack is: ",stack(),"\n");
    }
}
```

This setup provides the developer with information about the last error and the calling stack which led to the last error. Tutorial II provides an example which illustrates the `try/catch` and `protect/unwind` mechanisms to get reports on an error.

Another setup that the developer may find useful is to automatically start an interactive session in the case of an error. The example of such a setting can be found in Tutorial II.

Determining Error Location

The `stack` function will show the current function calling `stack`, expressed as a list of functions that the interpreter is currently evaluating. To trace the execution path of parts of a program it is useful to print out the code as it is evaluated. The `trace` and `notrace` functions act as delimiters to areas when tracing should occur. The tracing information is delivered to standard output.

The following table of predefined global variables provides additional information useful for debugging:

Table 1. Global Variables in Gamma

Global Variable	Description
`_error_stack_`	The stack at the time the last error occured.
`_unwind_stack_`	The stack at the time that an error was discovered.
`_last_error_`	A string containing the last error.

Filtering Object Query Output

Gamma permits the user to control the level of detail reported, and the format used, when an object is queried. This is done by defining a function named `_ivar_filter` with two arguments. For example, each class instance has a number of instance variables that are reported during interactive mode in the format:

```
Gamma> stats = qnx_osinfo(0);
{Osinfo (bootsrc . 72) (cpu . 586) (cpu_speed . 18883) (fpu . 587)
      (freememk . 16328) (machine . "PCI") (max_nodes . 7)
      (nodename . 2) (num_handlers . 64) (num_names . 100)
```

```
      (num_procs . 500) (num_sessions . 64) (num_timers . 125)
      (pidmask . 511) (release . 71) (reserve64k . 0)
      (sflags . 28675) (tick_size . 9999) (timesel . 177)
      (totmemk . 32384) (version . 423)}
```

The following example provides a function named `_ivar_filter` that controls the output format. Note that each instance variable consists of a name and a value. If we define the following:

```
function _ivar_filter (!instance,!value)
{
    princ(format("\n%-20s %-20s",
          string(car(value)), string(cdr(value))));
    nil;
}
```

then the output for Gamma in interactive mode now looks like:

```
Gamma> stats;
{Osinfo
      bootsrc         72
      cpu             586
      cpu_speed       18883
      fpu             587
      freememk        15544
      machine         PCI
      max_nodes       7
      nodename        2
      num_handlers    64
      num_names       100
      num_procs       500
      num_sessions    64
      num_timers      125
      pidmask         511
      release         71
      reserve64k      0
      sflags          28675
      tick_size       9999
      timesel         177
      totmemk         32384
      version         423
      }
```

Advanced Types and Mechanisms

Symbols

We introduced symbols in the Symbols and Values section at the beginning of this Guide. Recall that a symbol is a unique word or name within the system, and that references to a particular symbol will be to the exact same Gamma object, regardless of how that reference was obtained. Symbols can be used as variables, as they may have a value that can be queried through evaluation. The value of a symbol can change depending on the current execution scope.

A symbol may contain any character, though it is necessary to escape some characters using a backslash (`\`) when writing them. The normal character set for symbols consists of the following:

- The lowercase letters (a-z)
- The uppercase letters (A-Z)
- The digits (0-9)
- The underscore (_)

A symbol is created by a call to `symbol`, or by reading any legal string of characters which forms a symbol.

Undefined symbols

In Gamma a variable must be assigned a value. A variable does not exist until a value is assigned to it. Once defined, both the value and type of a variable can be changed, effectively re-defining the variable. A variable which is used but has never been assigned a value will cause an error:

```
Gamma> 3 + k;
Symbol is undefined: k
debug 1>
```

The `undefined_p` function can be used to test if a variable is defined, as follows:

```
Gamma> undefined_p (a);
t
Gamma> a = 5;
5
Gamma> undefined_p (a);
nil
```

Uniqueness of Symbols

The uniqueness of symbols in the system provides an interesting way to perform the equivalent of the C language enumerated type, in case you want a list of constant values representing different things. In Gamma, when two symbols are tested for equality, the comparison is first done on the symbol reference itself, not the value associated with the symbol. This is because the Gamma == operator is mapped to the Lisp `equal` function, which determines equality first with the eq function. The Lisp eq function tests for equality of the reference, and only if this has failed will the equal function perform an equality test on the value of the references. Also in Gamma, a symbol can be defined without assigning a value.

When the Gamma engine reads a literal symbol (see Literal Syntax and Evaluation in this chapter), as illustrated in the example below, it determines that the reference is in fact a symbol. If the symbol does not exist, Gamma creates the it with a value of `_undefined_`.

```
Gamma> x = #yes;
yes
Gamma> yes;
Symbol is undefined: yes
debug 1>
```

Therefore, it is valid in Gamma to make comparisons for equality between symbols whose values are not defined. Such comparisons between symbols are actually more efficient than comparing the values of two symbols. This leads to the following example. Here Gamma uses the equivalent of an enumerated type, but it is more efficient than assigning actual values to the constants, since the test is for the symbol reference only.

```
Gamma> function my_state (x)
{
if (x==#on)
    princ ("I am on.\n");
else if (x==#off)
    princ ("I am off.\n");
else if (x==#unstable)
    princ ("I am not stable.\n");
else
    princ ("I don't know.\n");
}
(defun .......)
Gamma> a = #on;
on
Gamma> my_state (a);
I am on.
t
Gamma> my_state (#off);
I am off.
t
```

Notice that the enumerated set (on, off, unstable) was not created as variables with assigned values (1, 2, 3,...) but used directly, leading to a more efficient and cleaner implementation.

Properties

Symbols can be assigned properties, using the `setprop` function. Each assigned property is a name/value pair, which is globally defined for the symbol, regardless of the current scope and value. These properties can be accessed using the `getprop` function.

Predefined Symbols

There are some symbols, such as `_undefined_` mentioned above, whose values are predefined in Gamma. For the complete listing of symbols that are predefined in Gamma see section Predefined Symbols in the Reference Manual.

Evaluation

Expressions in Gamma consist of a few basic types, which are submitted to an evaluator to produce a return value. Every evaluation returns a result. Any Gamma object may be submitted to the evaluator. The evaluator behaves differently according to the type of the evaluated object.

Table 2. Type Evaluation

Type of Object	Evaluation result
symbol	The value of the symbol in the current scope.
list	Function or method call.
all others	Itself.

Evaluation of a Symbol

If a symbol is being used as a variable, then its value will depend on the scope in which it is being evaluated. A new scope is entered whenever a user-defined function is executed, or when a `with` statement is executed. A symbol is defined within a scope when it appears in the argument list of a function, or when it appears in the variable list of a `local` statement. If a symbol is not defined within the current scope, then the value of the symbol in the next most local scope is used. This is called *dynamic* scoping, since the scope of a symbol used in a function may depend on the calling sequence that executed that function. The value of a symbol may be any Gamma object. See examples on dynamic scoping in Tutorial II.

Evaluation of a List

Since Gamma is built on top of Lisp, all Gamma statements and expressions are translated into lists, which represent the equivalent function call. For example, the expression `2 + 3;` is translated into the function call `(+ 2 3)` at read time, and evaluated as a list at run time. (Operators like + are functions in Lisp.) For more details on Lisp function syntax, see Getting On_Line Help for Functions.

When a list is submitted to the evaluator, it will be treated as either a function call or a method call. The first element in the list is evaluated, and the result examined. If the first element evaluates to a function definition, then the remainder of the list is treated as the arguments to this function, and the function is called. If the first element evaluates to an instance of a class, then the second element is evaluated.

If the second element evaluates to a class, then the third argument must be a symbol that names a method for that class. If the second element does not evaluate to a class, then it must be a symbol that names a method for the class of the instance, or a method of one of the instance's parent classes.

Once a method has been identified, the remaining elements of the list are treated as the arguments to the method, and the method is called on the instance. For example, here we call a function with the given arguments:

```
(function arg1 arg2...)
```

Here we call a method from an instance's own class.

```
(instance method_name arg1 arg2...)
```

And here we call a method from the instance's class hierarchy.

```
(instance class method_name arg1...)
```

If an explicit class is provided, it is normally a parent (base) class of the given instance. This is not enforced by the evaluator, so it is possible to call a method for an instance which is not a member of the class for which the method was defined. This is not normally a good idea, and can be highly confusing to anybody reading the code.

Evaluation to Itself

Most Gamma object types evaluate to themselves, meaning that the result of submitting the object to the evaluator is the object which was submitted, unmodified. Any object except a list or a symbol will simply return itself when evaluated. For example, the number 5, when evaluated, will return 5, which is itself.

Literal Syntax and Evaluation

One of the most powerful features of an interpreter-based language such as Gamma is the ability to evaluate symbols and expressions at run-time. Gamma uses the # operator to indicate a literal expression. For those familiar with Lisp, this is equivalent to the forward quote syntax. Gamma also supports evaluation of sub-expressions, using the ` and @ operators. For more details on their use, see Quote Operators and further explanation below.

Literal Expressions

A literal expression is the expression that specifies an actual value rather than a function for creating the value. For example, the number `3` is a literal, where the expression `(+ 1 2)` is not. Similarly, the string `"hello there"` is a literal, and the expression `string("hello ", "there")` is not, yet they produce equal values when evaluated.

Most object types in Gamma have Lisp and Gamma literal forms. You can create a valid object of some types (such as numbers, symbols, and strings) by reading a literal from a file or the command line. Other types (such as arrays, classes, and functions) are created by corresponding statements or functions.

See Literals in the Reference Manual for definitions, notations, and examples of literal expressions in Gamma.

Deferring Expression Evaluation

A Gamma expression preceded by the quote operator (#) will be taken literally, i.e., it will be protected from the evaluator. When the symbol containing this literal is evaluated, its contents are then interpreted. For example:

```
Gamma> x = #5 + 6;
(+ 5 6)
Gamma> #x;
x
Gamma> x;
(+ 5 6)
Gamma> eval (x);
11
```

In the first case, the quote operator (#) protects the entire expression from the evaluator. That is, it protects everything to its right, all the way to the end of the expression (usually a semicolon or closed parenthesis). In the second case it is used to "produce" the literal symbol x. Then x is evaluated, returning its literal contents. Finally, the `eval` function is used to force execution of the literal contents of x. The `eval` function forces the resolution of variable references, as in this example:

```
Gamma> a = 1;
1;
Gamma> x = a + 5;
6;
Gamma> x = #a + 5;
```

```
(+ a  5)
Gamma> a = 10;
10
Gamma> eval (x);
15
```

The literal is often used to delay the evaluation of an expression until an event is triggered. A good example is the `add_set_function`. This function takes two arguments. The first argument must be a symbol, so the # operator is used to prevent the required symbol from being evaluated. The second argument is simply any expression, most commonly a function. The `add_set_function` function sets the second argument to be evaluated when the first argument is changed:

```
Gamma> add_set_function (#a, #princ("My value = " ));
(princ "My value =")
Gamma> a = 21 / 3;
My value = 7
```

In the following variation of the above example, a symbol used as an argument has been assigned a literal symbol, so that its evaluation will result in the desired symbol:

```
Gamma> x = #b;
b
Gamma> add_set_function (x, #princ("My value = " ));
(princ "My value =")
Gamma> b = 21 / 3;
My value = 7
```

Literal Function Arguments

Some functions require arguments that are symbols. Normally, the arguments to a function are evaluated before the function is actually invoked. It is possible to cause a function's arguments not to be evaluated by using the *exclamation* modifier in the function declaration.

As an example, we can write our own version of the `add_set_function` function mentioned above:

```
Gamma> function my_add_set (!sym, !exp)
                {add_set_function(sym, exp);}
(defun my_add_set (&noeval sym &noeval exp) (add_set_function sym exp))
Gamma> my_add_set (c, princ("My value = "));
(princ "My value = ")
Gamma> c = 21 / 3;
My value = 7
```

For more details on function arguments see Function Arguments in the Functions and Program chapter of this Guide.

Partially Evaluated Literal

Gamma supports evaluation of sub-expressions, allowing you to write expressions whose elements may or may not be evaluated. In the following example, we want to create a literal expression which will calculate a to the power of b, where b is a specific power, evaluated at the time the literal is defined. The operator ` is used like # to prevent evaluation of the expression, but it allows for exceptions. These exceptions, which will be evaluated, are denoted using the @ operator.

```
Gamma> b = 3;
3
Gamma> my_cube = `(pow (a, @b));
(pow a 3)
Gamma> a = 10;
10
Gamma> eval(my_cube);
1000
```

In the following example, the timer event is used to demonstrate how the current value of a variable can be evaluated into a literal:

```
Gamma> a = "hello";
"hello"
Gamma> every (15, #princ(a,"\n"));
1
Gamma> next_event();
hello
nil
Gamma> a = "goodbye";
"goodbye"
Gamma> next_event();
goodbye
Gamma> cancel (1);
[866239787 836823463 15 ((princ a,"\n")) 1]
Gamma> every (15, list (#princ, a, "\n"));
2
Gamma> next_event();
goodbye
nil
Gamma> a = "no more";
"no more"
Gamma> next_event();
```

```
goodbye
nil
```

Constructing Variable Names at Run-time

Controlling when an expression is evaluated lets you generate the actual variable names at run-time. This can produce extremely concise code, particularly compared to the C language equivalent. In the following example, a set of simple objects each has a value. The object name and its value is entered. In a conventional language, we might search the array of objects to find the one with the given name, and then make the assignment. Gamma makes it possible to directly construct the variable reference using the `set` function, as follows:

```
Gamma> name = "fido";
"fido"
Gamma> value = "bites";
"bites"
Gamma> set(symbol(string(name)), value);
"bites"
Gamma> fido;
"bites"
```

Note that the syntax does not accept the = assignment operator, so the functional form of the assignment operator: `set` must be used. Note also that we would probably use `undefined_p` to verify that the variable actually existed to avoid halting the program due to an undefined variable error. Although the example is trivial, this technique is very useful for constructing function references based on run-time data.

Literal Array Syntax

An array is defined in Gamma with the `array` function, which creates the array and sets the elements to the specified values.

Gamma uses the familiar square brackets `[ ]` syntax to reference array elements. Although Gamma has the functions `aref` and `aset` for reading and writing specified elements of the array, the square bracket syntax is normally used. An array is automatically re-sized if an element beyond its current size is set. Arrays do not have a type, and array elements can be of different types. Array elements can be set to literals (including expressions protected from evaluation), as in the following example:

```
Gamma> x = array (3, "hi");
[3 "hi"]
Gamma> x[3] = #a + 5;
(+ a 5)
Gamma> x;
[3 "hi" nil (+ a 5)]
```

```
Gamma> a = 8;
8;
Gamma> eval(x[3]);
13
```

Generally, literal arrays should be avoided except for static variables. A literal array is embedded into your code. If it is changed, then the code is effectively changed!

Input and Output

Referencing Files

As in C, there are two ways to reference a file in Gamma, using a *descriptor* or a *pointer*.

A file descriptor is an integer that identifies an open file within a process. This is the lowest-level handle available for interacting with the open file. Disk files, pseudo-ttys, IP sockets, UNIX-domain sockets, pipes and other facilities all offer interaction through file descriptors.

A file pointer is an abstraction of the file that adds buffering on input and output. This would be of type FILE* in C. The reason this exists is that it is very inefficient to use a file descriptor, which does not perform any in-process buffering where many reads and writes are being performed. The file pointer stores many write requests until it has enough data to perform a more efficient write to disk, hopefully in multiples of the disk block size.

In Gamma, a file pointer is an opaque structure (the internals are not visible to the programmer) that is effectively a buffered file. (See the note in open.) It's abstracted a little further to also include strings as file pointers, when they are opened using `open_string`.

Some Gamma I/O functions work with file descriptors (generally those that start with `fd_`), others work with file pointers, and a few work with both.

Lisp and Gamma I/O mechanisms

Gamma provides sophisticated mechanisms for reading and writing expressions, which can greatly simplify most file manipulation functions. There are two fundamental facilities for manipulating file data in Gamma: the reader and the writer. Gamma is based on the SCADALisp engine, and acts as a read-time translator from Gamma syntax to SCADALisp internal form. Thus expressions can be read in either Gamma or Lisp (we abbreviate SCADALisp as simply Lisp) representation.

Since the internal representation of an expression is an optimized Lisp mapping, the writer will produce its output as Lisp. This makes the reader and the writer symmetrical in Lisp, but not symmetrical in Gamma. A purely symmetrical Gamma writer is not possible, since there is no way to express literals in Gamma for data types such as list, buffer, array, instance and class.

The Lisp writer is aware of the format that the Lisp reader requires, and is able to format any expression such that the reader can subsequently read it back in. This means that an arbitrarily complex expression, such as a list containing instances of a class whose instance variables include arrays and other instances, can be written using a single line of code, and read back in using a single line of code as well. Since a Gamma function is simply a data object, it can be written and read in exactly the same way.

Generally, the lack of symmetry between the Gamma reader and the Lisp writer is not a problem, since any data written by Gamma will still be readable simply by instructing the open function to recognize Lisp instead of Gamma syntax.

Writing

Print vs. Princ

It is not always appropriate to write a data item in a way that can be read by the Lisp reader. For example, the Lisp reader requires that all character strings are surrounded by double quotes to differentiate them from symbols and to deal with white space and special characters. In some cases, the programmer may wish to write a character string in "human-readable" form, with no quotes and escapes on special characters.

The Gamma writer will produce both kinds of output. The `print` function will always generate output which can be read by the Lisp reader, including escape characters, quotation marks and buffer and instance special forms. The `princ` function attempts to make the output as readable as possible to a human, but will not necessarily produce output that can be read by the Gamma reader. The name `princ` is historical, and can simply be thought of as an alternate form of `print`. Notice that neither `princ` nor `print` will automatically place a carriage return at the end of a line. The programmer must explicitly print a "\n" or make a call to `terpri`.

Write vs. Writec

Like `princ` and `print`, there are two forms of the `write` function. The `write` function operates identically to the `print` function, except that its first argument declares the file handle to which it will write its output. The result of a `write` function is machine readable, whereas the result of a `writec` function is intended to be human readable. Notice that neither `writec` nor `write` will automatically place a carriage return at the end of a line. The programmer must explicitly print a "\n" or make a call to terpri.

Terpri

The `terpri` function will produce a carriage return either to the standard output or to a given file handle. `terpri` is most commonly used to generate a carriage return in a file that is being written using the `write` function. If the programmer were to use (`write file "\n"`) then the file would actually contain the four characters "\n", rather than the intended carriage return. `terpri` will insert a carriage return into the file under any circumstances.

Pretty Printing

All of the printing functions have a further variant, known as the pretty printing functions. These variants attempt to format the output to an 80-column page, inserting line breaks and white space in order to make the output more readable. The pretty-printing indentation rules are intended to make data structure and program flow more easily understood, and closely follow the pattern used by GNU Emacs in its Lisp indentation mode.

Printing Circular References

It is common when programming with dynamic lists and arrays, or when constructing inter-related class definitions, to create a data structure which is self-referential, or which contains circular references. For example, it may be useful to have a child class contain a pointer to its parent, and the parent class contain a pointer to its child. In this circumstance, an attempt to print an instance of the child class would cause the Lisp writer to enter an infinite loop if it did not take precautions. In C programs, this circumstance is normally avoided by having a printing routine which understands the child/parent relationship and simply writes them in such a way that the infinite loop is never entered. This carries the problem that each data structure must have its own dedicated printing routine, which necessarily does not preserve a generalized data syntax, and which cannot perfectly represent the child/parent relationship in any but the simplest of cases.

Gamma solves the problems of self-reference and circularity by modifying the printed representation of an object to include embedded reference points in the data structure. Whenever a Gamma object is printed, all circular references and self-references are detected before the object is printed, and reference points are inserted into the printed representation. Subsequent attempts to print an object that was previously printed will merely produce a reference to the first printing of the object. This facility produces a result that is essentially impossible in languages such as C; it perfectly preserves multiple pointer references to data which are not known, a priori, to be multiple references.

A very simple example of self-reference may be a list that contains itself. This is normally achieved using destructive functions such as `nappend`, `rplaca` and `rplacd`. Consider the following dialogue:

```
Gamma> a = list(1, 2, 3);
(1 2 3)
Gamma> rplacd (cdr (a), a);
(1 2 (1 2 (1 2 (1 2 (1 2 (1 2 (1 2 (1 2 (1 2 ...)))))))))
```

In this case, by replacing the tail of the list with the list itself, it is possible to create a self-referential list which cannot be printed using normal means. Any attempt to print this list will cause an infinite loop. The Lisp writer in fact produces the following output:

```
Gamma> a = list(1, 2, 3);
(1 2 3)
Gamma> rplacd (cdr (a), a);
#0=(1 2 . #0#)
```

The first time that the self-referential list is printed, the Gamma writer determines that a self- reference will occur, and marks that point with a numbered place holder, using the syntax #n=, where n is a monotonically increasing number counting the number of circular references in the data object. Each subsequent reference to the marked object will cause the writer to produce a reference back to the original using the syntax #n#. For example, if we create another, similar list, and then put both lists together into another list, we will get the following:

```
Gamma> b = list(4, 5, 6);
(4 5 6)
Gamma> rplacd (cdr (b), b);
#0=(4 5 . #0#)
Gamma> d = list(a,b);
(#0=(1 2 . #0#) #1=(4 5 . #1#))
```

Using this method, arbitrarily complex objects can be written, with all circular and self-references maintained.

As a side effect of this printing mechanism, duplicate references to objects which are not circularly defined will also be caught and correctly reproduced. For example, suppose that a list contains a single string more than once. It would be wasteful to write that string many times, and would generate an incorrect result on reading if the multiple references to that string were not preserved. The Lisp writer will correctly handle this situation:

```
Gamma> x = "Hello";
"Hello"
Gamma> a = list (x, x, x);
(#0="Hello" #0# #0#)
Gamma> eq (car(a), cadr (a));
t
```

In the above example, if the Gamma writer did not preserve the multiple references to the string "Hello", then a would be printed as:

("Hello" "Hello" "Hello")

When this object is read by the Gamma reader, we would get a list which is visibly the same but for which the data references no longer match:

```
Gamma> a = list("Hello", "Hello", "Hello");
("Hello" "Hello" "Hello")
Gamma> eq (car(a),cadr(a));
nil
```

Reading

Reading Gamma Expressions

Any valid Gamma expression can be read by the Gamma reader using the function `read`. The `read` function will read from the current location in a file, skipping over comments, until it encounters a character which could be the beginning of a Gamma expression. The reader then constructs the shortest possible complete expression from the input and returns that. A complete Gamma expression may be as simple as a number, or as complex as a complete function definition or complex data object. The reader ignores white space, except as a token separator. It may be interesting to note that the entire Gamma mainline is essentially just a simple loop:

```
while ((exp = read (input_file)) != _eof_) eval (exp);
```

Reading Arbitrary ASCII Data

Gamma allows the programmer to read arbitrary ASCII data using the function `read_line`, which will read from the current file position to the first carriage return, regardless of the syntactic validity of the data on the line. If data fields are known to be separated by white space, then the `read` function using Lisp syntax may also be used to read a single field. Notice that the `read` function will treat an unquoted string of ASCII characters as a symbol, not as a string. It is more common when dealing with line-formatted data to use `read_line` followed by `string_split`.

Reading Binary Data

Gamma provides a number of functions for reading binary data. These functions all begin with the prefix `read_`, and they read according to the rules for C data types for the particular platform. For example, `read_char` will read a decimal representation of a string of length 1 containing a single character.

Special Topics

Modifying QNX Process Environment Variables

The QNX 4 environment variables can be read and modified by a Gamma program using the `getenv` and `setenv` function calls.

QNX 4 Interprocess Communication (IPC)

QNX 4 interprocess communication is a popular mechanism for 'talking' between software modules, based on the QNX 4 operating system. QNX 4's microkernel architecture implements message passing in such a way that only data locations are transferred between processes, making its IPC for small amounts of data as, or more, efficient than shared memory schemes. Gamma encapsulates most of the common QNX 4 IPC 'C' function calls.

Functions such as `qnx_receive` and `qnx_reply` may be redundant in a program that is using one of Gamma's built-in event-loop mechanisms. To review the built-in functionality of Gamma's event loops refer to the section on event loops.

The `qnx_name_attach` function attaches a 'name' to the current process. Names, rather than PIDs, are convenient ways to look for tasks since they are static while the PID of a program will not be.

Names are ASCII strings up to 32 character in length and can be either local or global. Local names must be unique to the node. Any attempt to register an existing local name will fail. Global names allow duplication and start with a slash '/' character. Global names are stored within a name program in QNX 4 called *nameloc*. When one process wants to look up another process's name, the `qnx_name_locate` function is called and the name to PID mapping is completed.

```
Gamma> myname = qnx_name_attach(0,"my_app");
20
```

The first argument to the `qnx_name_attach` function is the node on which to register the name. If the node number is zero the local node is assumed. `qnx_name_attach` returns a name id which is used with the `qnx_name_detach` function.

The `qnx_name_detach` function removes a local or global name from the local name list or the DataHub instance.

```
Gamma> qnx_name_detach(0,myname);
t
```

As with the `qnx_name_attach` function, the first argument to the `qnx_name_detach` function is the node number. The second argument must be the name id returned when attaching the name.

Once a name is registered then the `qnx_name_locate` function is useful for locating the task by name. The return value of this function is a dotted list of the format: `(pid . copies)` The pid is the process ID of the located task and copies is the number of processes that matched the name. Local names must be unique but there can be multiple instances of global names (those starting with '/').

An example of using the `qnx_name_locate` function follows:

```
Gamma> queue = qnx_name_locate(0,"qserve",0);
(91 . 1)
```

The PID of the `qserve` task is 91 and there was a single instance of that registered name found.It is important to assign the return value of the `qnx_name_locate` function to a variable since it is the first number in the list (PID) that is used as an argument to Gamma functions such as `qnx_send`, `qnx_receive`, `qnx_reply`, `qnx_vc_attach`, and `qnx_vc_detach`.

The `qnx_receive` function allows for the Gamma engine to remain receive-blocked on a specific PID, waiting for a message.

IMPORTANT: If Gamma is being run using a built-in event loop or using the `next_event` or `next_event_nb` functions then using the `qnx_receive` function MAY BE REDUNDANT. Event loops in Gamma have a built-in receive/reply mechanism.

The `qnx_send` function uses the QNX 4 `send` C/C++ function to send information between tasks. The `qnx_send` function is a synchronous IPC function, and as such, the sending task waits for the receiving task's reply before continuing.

The `qnx_send` function can be used to send Gamma expressions between Gamma modules. Gamma ships with a number of example programs, of which example 12 demonstrates the use of `qnx_send` to transmit and execute a function on another module. (Examples can be found in /usr/cogent/examples/ directory)

The important excerpts from this example are:

```
task = car (qnx_name_locate (0, "gui", 1000));
qnx_send (task, stringc (#Arc.fill_color = PgRGB(0xff, 0xff, 0)));
function TitleClock()
{
    win.title = date();
}
// Transmit new function
qnx_send (task, stringc (TitleClock));
// Execute new function once.
qnx_send (task, stringc (#TitleClock()));
```

The communications channel is opened by locating the task using the `qnx_name_locate` function and then using `qnx_send`. The first `qnx_send` sends a command for the receiving task to evaluate, in this case to change the fill color of an object named 'Arc'. The `stringc` function is used to produce an expression that is parse-able.

Next, a new function is defined, passed, and executed on the other task using two separate `qnx_send`'s.

If you are sending IPC messages to a non-Cogent IPC task the `send_string` and `send_string_async` functions should be used.

Cogent IPC

The Cogent IPC layer is a generalization of QNX 4's send/receive/reply IPC layer. Cogent IPC has many benefits that allow users to easily code what would be complex systems in C. Some of these services are:

- Network-wide name registration service
- DataHub exceptions and echos
- true asynchronous messages
- pseudo asynchronous messages
- synchronous messages
- QNX 4 IPC messages
- Task started notification
- Task death notification
- automatic handling of receive/reply for Cogent IPC messages
- remote procedure calls

Cogent IPC Service Modules

To use the Cogent IPC layer, two services optionally provided to the Gamma developer are required: **nserve** and **qserve**. These services are run as programs on the same CPU or network as Gamma.

The **nserve** command is the Cascade NameServer module. Although similar to the QNX 4 **nameloc** program in concept, this name database has some differences that make it worth using.

The **nserve** module is run on every node requiring name services. Every **nserve** module is updated on an event-basis, rather than on a timed basis as QNX 4's **nameloc** is, and therefore discrepancies between multiple nserve's on a network are rare.

The **qserve** program is the asynchronous queue manager for Cogent IPC;. Queues are used in Cogent IPC to implement asynchronous communication channels between two programs. The **qserve** module is run on every node requiring Cogent queue services.

Cogent IPC Advanced services

The Cogent IPC layer provides many advanced services that augment the basic send/receive/reply protocol. This section describes those services.

Cogent IPC Messages

The Cogent IPC layer provides a messaging protocol that is easier to use and different in format from raw QNX 4 send/receive/reply.

Messages between Cogent IPC-enabled tasks are very similar to function calls. A message is constructed and sent, and the task on the other end evaluates the message. The return value of the evaluation of the message is transmitted to the originating task in the reply.

Consider two Gamma modules using the following code:

Task A:

```
#!/usr/cogent/bin/gamma
init_ipc("task_a");

while (t)
{
    next_event();
}
```

The function `init_ipc` is called first to initialize Cogent interprocess communication. For more details, see IPC Initialization below.

Task B:

```
#!/usr/cogent/bin/gamma
init_ipc("task_b");

function ask_taska_date ()
{
    local result,tp;
    if (tp = locate_task("task_a",nil))
        result = send(tp,#date());
    else
        result = "could not locate task A";
}

every(1.0,#princ(ask_taska_date(),"\n"));

while (t)
{
```

```
    next_event();
}
```

Of specific note in this example is the format of the message in the send function. The first argument to the Cogent IPC function send is a task. The locate_task function, along with the nserve module provides the name lookup. The second argument is an expression for the receiver to evaluate. For simple send's an unevaluated Gamma expression (using #) will suffice. For more complex send's, such as when a partially evaluated list of arguments need to be passed, the format of the send command should be Lisp.

This code gives a good example of using the Cogent IPC layer as an RPC (Remote Procedure Call) mechanism.

To use the Cogent IPC layer for transferring data between tasks, use the Lisp expression for assignment: setq. An example is:

Task C:

```
#!/usr/cogent/bin/gamma
init_ipc("task_c");

add_set_function(#x,#princ("Task C reports x=",x,"\n"));

while (t)
{
    next_event();
}
```

Task D:

```
#!/usr/cogent/bin/gamma
init_ipc("task_d");

function inc_x ()
{
    local result,tp;
    x++;
    if (tp = locate_task("task_c",nil))
        result = send(tp,list(#setq, #x, x));
}

x = 0;
every(0.1,#inc_x());

while (t)
```

```
{
    next_event();
}
```

In this example task C sets up a `set_function` before starting its event loop. The set function will print out the value of x if it changes. Task D initializes x to 0 and then starts a timer to run every tenth of a second to increment x and send `setq` expressions to task C.

```
(setq x 1)
(setq x 2)
(setq x 3)
(setq x 4)
```

These expressions are in Lisp format because all messages between processes use the Lisp internal representation for efficiency.

The `setq` function is evaluated in task C. Any side effects of the function, for example the setting of the variable x, happens in task C. The return value of the function is the content of the reply message. The return value of the `send` function can be found by evaluating the 'result' variable in the `inc_x` function.

Consider the `inc_x` function re-written as:

```
function inc_x ()
{
    local result,tp;

    x++;

    if (tp = locate_task("task_c",nil))
    {
        result = send(tp,list(#setq, #x, x));
        princ("task D result of send: ",result,"\n");
    }
}
```

When this example is run the return value of the send is shown to be the result of the `setq` function. Obviously, task D must wait for task C to receive and evaluate the message before sending back the response.

Asynchronous Messages

Consider two tasks that wish to communicate: task E and task F. Task E is a time sensitive task that needs to deliver a package of data to task F. Task E cannot take the chance that task F will accept its data immediately and issue a reply so that it may continue with its own jobs. In short, a synchronous send compromises task E's job because it must wait for task F to respond before proceeding.

To send data asynchronously from task E to task F, a queue is used. Data is sent from task E to the queue. The queue responds immediately to task E, freeing it up to continue. Then a *proxy*, a special non-blocking message, is sent from the queue to task F. Upon receipt of the proxy, task F knows that the queue contains data for it. When task F is ready it asks the queue for the data.

With some small changes, the example from the previous section can be changed from synchronous messaging to asynchronous, as follows:

Task E:

```
#!/usr/cogent/bin/gamma
init_ipc("task_e","task_e_q");

add_set_function(#x,#princ("Task E reports x=",x,"\n"));

while (t)
{
    next_event();
}
```

Task F:

```
#!/usr/cogent/bin/gamma
init_ipc("task_f","task_f_q");

function inc_x ()
{
    local result,tp;

    x++;

    if (tp = locate_task("task_e",nil))
    {
        result = send_async(tp,list(#setq, #x, x));
        princ("task F result of send: ",result,"\n");
    }
}

x = 0;
every(0.1,#inc_x());

while (t)
{
```

```
    next_event();
}
```

The `init_ipc` function calls at the beginning of each module now open a queue name with **qserve**, and the `inc_x` function has been changed to use `send_async` instead of `send`.

When this example is run the results show that task `F` receives a `t` (true) that the message was delivered but does not have to wait for task `E` to generate the result of the expression.

Using asynchronous communication immediately solves the dead-lock problem that all developers of multi-module systems must eventually face. To the developer, the use of asynchronous communication in Gamma entails only the use of a slightly different function: `send_async` instead of `send`.

Pseudo-Asynchronous Messages

For situations where the **qserve** program is not running and an asynchronous non-blocking IPC call is required then Gamma pseudo-asynchronous IPC call can be used.

The `isend` function sends a message between two Cogent IPC enabled tasks. Immediately upon receipt of the message, the receiver replies that the message was received. The return value of the received message is not sent back.

Task Started & Death Notification

When a task registers a name with nserve it can thereafter receive information regarding any other nserve registered task that starts or stops.

This is done by defining two functions with specific names, each within their respective code, to handle this information. The functions are:

```
function taskstarted_hook (name, queue, domain, node, id);
```

and

```
function taskdied_hook (name, queue, domain, node, id);
```

The body of each of these functions is up to the programmer. Most "hook" functions check the name, queue, and possibly the domain of the started/stopped task and then take a specific action such as:

- restarting a task that has died;
- informing the user that a module has died;
- inform other modules that a new service is available;

- query the new module for information; and,
- DataHub instance start/stop.

Automatic Handling of QNX 4 receive and reply

The following Gamma functions automatically handle QNX 4 `receive/reply`:

- `PtMainLoop`
- `next_event`
- `next_event_nb`
- `flush_events`

IPC Initialization

Before any form of Cogent interprocess communication occurs there must be a call to the `init_ipc` function. This function opens the channels of communications between Gamma and other tasks powered by Gamma, Cascade Connect, or other Cogent products. With this function you determine your task's name and optionally its queue name and domain.

A program's name is the string registered with the nserve program. Gamma names and queue names for tasks should be unique on the network. A program's queue name is the name of the queue that is registered if it wants to participate in asynchronous communication using Cogent's **qserve** utilities. The domain name is the name of the default DataHub domain from which to read and write points.

It is typical to find the `init_ipc` function called within the first few calls in the program. Here's an example:

```
#!/usr/local/bin/gamma
require_lisp("PhotonWidget");
require_lisp("PhabTemplate");

myname = car(argv);
init_ipc("myname");
```

This program segment first defines the engine to run on the first line, then loads some required files for Photon widget manipulation and Photon Application Builder support. The `argv` variable holds the arguments passed to Gamma. The first item in the list is the name of the executable, which is put in the myname variable. The `init_ipc` function is then called with the registered name being whatever the name of the program happens to be.

Locating Tasks

Using Gamma's IPC communications protocol, a task can be located by name or by id. This protocol allows for synchronous, asynchronous, and semi-asynchronous communications between Gamma, SCADALisp, and other Cogent products such as the Cogent DataHub program.

Locating a task by name can be done with the `locate_task` function. This is similar to using the `qnx_name_locate` function except that, since nserve's names are intended to be unique on a network the node number need not be specified.

```
marko:/home/marko$ gamma -q
Gamma> init_ipc("locate_test");
t
Gamma> tp = locate_task("cadsim",nil);
#< Task:13424 >
```

The return value of the `locate_task` function is a Gamma task type. The task type is an internal representation of the task that was located. There is nothing the user can do with variables of this data type other than to pass them through as arguments to Cogent IPC functions.

To locate a task on a specific node with a specific PID number use the `locate_task_id` function.

Before using either `locate_task` or `locate_task_id`, the `init_ipc` function must have already been called.

Once discussions with a task are completed, the channel should be closed using the `close_task` function.

Transmitting Character Strings

The `send_string` and `send_string_async` functions are used to format a message to be sent to a non-Cogent IPC task. These functions will accept a string (text surrounded by quotes) as a parameter, and will send the contents of the string without the enclosing quotes. Note that the normal `send` function will send the enclosing quotes as part of the message.

Cogent DataHub

The Cogent DataHub program is a high performance data collection and distribution center designed for easy integration with a Gamma application. Just as QNX 4 is an excellent choice for developers of systems that must acquire real-time data, the DataHub program is the right choice for distribution of that data.

Each DataHub instance provides:

- data services to its clients by exception and lookup;
- asynchronous data delivery ensuring client task protection blocking;
- network connection/reconnection issues;
- data services to many clients at once;

- transparent data services to/from Gamma;
- flexible data tag names;
- inherent understanding of data types (as Gamma does);
- time-stamping of data;
- C libraries for the creation of custom clients;
- security access levels on data points; and,
- a confidence value for assigning fuzzy values to data points.

The Cogent DataHub program is:

- a convenient way to disseminate real-time data;
- a RAM resident module holding current data;
- a proven solution with thousands of hours of installed performance; and,
- a great source of information for:
  - historical & relational database;
  - hard disk loggers; and,
  - Cascade Connect real-time connection to MS-Windows.

The Cogent DataHub program is not:

- a historical database;
- a relational database;
- a hard disk logger;
- slow;
- a large memory requirement module; or,
- pre-configured.

Whenever multiple tasks are communicating there is a chance for a deadlock situation. The DataHub instance is at the center of many mission critical applications because it provides real- time data to its clients without the threat of being blocked on the receiving task. A DataHub instance never blocks on a task that is busy. The DataHub instance is always able to receive data from clients because it uses the **qserve** manager to handle outgoing messages. The DataHub instance only ever sends messages to the Cascade QueueServer program, which is optimized to never enter a state where it cannot accept a message from the DataHub instance.

Cogent DataHub Exceptions and Echos

When a new data point is sent to a DataHub instance, the DataHub instance automatically updates its clients that are interested in the point. Some clients get information from the DataHub instance on request only, by polling. Other clients register with the DataHub instance for changes in some or all points, called *exceptions*.

The DataHub instance not only allows its clients to register and receive exceptions on data points, but also provides a special message type called an *echo* that is extremely important in multi-node or multi-task applications.

When the DataHub instance receives a new data point it immediately informs its registered clients of the new data value. The clients will receive an asynchronous exception message. In some circumstances, the client that sent the new data value to the DataHub instance is also registered for an exception on that point. In this case, the originator of the data change will also receive an exception indicating the data change. When there are multiple clients reading and writing the same data point a client may wish to perform an action whenever another client changes the data. Thus, it must be able to differentiate between exceptions which it has originated itself, and ones which originate from other clients. The DataHub instance defines an echo as an exception being returned to the originator of the value change.

In certain circumstances, the lack of differentiation between exceptions and echos can introduce instability into both single and multi-client systems. For example, consider an application that communicates with another Lisp or MMI system, such as Wonderware's InTouch. InTouch communicates via DDE, which does not make the distinction between exceptions and echos. A data value delivered to InTouch will always be re-emitted to the sender, which will cause the application to re-emit the value to the DataHub instance. The DataHub instance will generate an exception back to the application, which will pass this to InTouch, which will re-emit the value to the application, which will send it to the DataHub instance, on so on. A single value change will cause an infinite communication loop. There are many other instances of this kind of behavior in asynchronous systems. By introducing echo capability into the DataHub instance, the cycle is broken immediately because the application can recognize that it should not re-emit a data change that it originated itself.

The echo facility is necessary for another reason. It is not sufficient to simply not emit the echo to the originating task. If two tasks read and write a single data point to the DataHub instance, then the DataHub instance and both tasks must still agree on the most recent value. When both tasks attempt to write the point, one gets an exception and updates its current value to agree with the DataHub instance and the sender. If both tasks simultaneously emit different values, then the task whose message is processed first will get an exception from the first, and the first will get an exception from the second. In effect, the two tasks will swap values, and only one will agree with the DataHub instance. The echo message solves this dilemma by allowing the task whose message was processed second to receive its own echo, causing it to realize that it had overwritten the exception from the other task.

Appendix A. Function List

absolute_path	returns the absolute path of the given file.
access	checks a file for various permissions.
acos	finds the arc cosine of a number.
add_echo_function	assigns functions for echoes on a point.
add_exception_function	assigns functions for exceptions on a point.
add_hook	hooks a function to an event.
add_set_function	sets an expression to be evaluated when a given symbol changes value.
after	performs an action after a period of time.
alist_p	tests for association lists.
allocated_cells	gives the number of allocated and free cells.
and	is the same as the corresponding logical operator (&&).
append	concatenates several lists into a single new list.
apropos	finds all defined symbols in the current interpreter environment.
aref	returns an expression at a given index.
array	constructs an array.
array_p	tests for arrays.
array_to_list	converts an array to a list.
aset	sets an array element to a value at a given index.
asin	finds the arc sine of a number.
assoc	searches an association list for a sublist, using eq.
assoc_equal	searches an association list for a sublist, using equal.
at	performs an action at a given time, or regularly.
atan	finds the arc tangent of a number.
atan2	finds the arc tangent with two arguments.
atexit	evaluates code before exiting a program.
AutoLoad	allows for run-time symbol lookup.
autoload_undefined_symbol	checks undefined symbols for AutoLoad.
AutoMapFunction	maps a C function to a Gamma function.
autotrace_p	is for internal use only.
backquote	corresponds to a quote operator.
band	performs bitwise and operations.
basename	gives the base of a filename.

`bdelete`	deletes a single character from a buffer.
`bin`	converts numbers into binary form.
`binsert`	inserts a value into a buffer.
`block_signal`	starts signal blocking.
`block_timers`	blocks timer firing.
`bnot`	performs bitwise not operations.
`bor`	performs bitwise inclusive or operations.
`breakpoint_p`	is for internal use only.
`bsearch`	searches an array or list for a element.
`buffer`	constructs a buffer.
`buffer_p`	tests for buffers.
`buffer_to_string`	converts a buffer to a string.
`builtin_p`	is for internal use only.
`bxor`	perform bitwise exclusive or operations.
`caaar`	returns that element of a list.
`caadr`	returns that element of a list.
`caar`	returns that element of a list.
`cadar`	returns that element of a list.
`caddr`	returns that element of a list.
`cadr`	returns that element of a list.
`call`	calls a class method for a given instance.
`cancel`	removes a timer from the set of pending timers.
`car`	returns that element of a list.
`cd`	changes the working directory.
`cdaar`	returns that element of a list.
`cdadr`	returns that element of a list.
`cdar`	returns that element of a list.
`cddar`	returns that element of a list.
`cdddr`	returns that element of a list.
`cddr`	returns that element of a list.
`cdr`	returns that element of a list.
`ceil`	rounds a real number up to the next integer.
`cfand`	performs and operations with a confidence factor.
`cfor`	performs or operations with a confidence factor.
`char`	generates an ASCII character from a number.

char_val	generates a character's numeric value.
chars_waiting	checks for characters waiting to be read on a file.
class_add_cvar	adds new class variables.
class_add_ivar	adds an instance variable to a class.
class_name	gives the name of the class.
class_of	gives the class definition of a given instance.
class_p	tests for classes.
ClearAutoLoad	removes all AutoLoad rules.
clock	gets the OS time.
close	closes an open file.
close_task	closes a task opened by locate_task.
conf	queries confidence factors.
cons	constructs a cons cell.
cons_p	tests for cons cells.
constant_p	tests for constants.
copy	makes a copy of the top list level of a list.
copy_tree	copies the entire tree structure and elements of a list.
cos	returns the cosine of a number.
create_state	is part of the SCADALisp exception-driven state machine mechanism.
date	gets the OS date and time; translates seconds into dates.
date_of	is obsolete, see date
dec	converts numbers into base-10 form.
defclass	is the function equivalent of the statement: class.
defmacro	is a Lisp equivalent of the function: macro.
defmacroe	is a Lisp equivalent of the function: macro.
defmethod	is the function equivalent of the function: method.
defun	is a function equivalent of the statement: function.
defune	is a function equivalent of the statement: function.
defvar	defines a global variable with an initial value.
delete	removes an element from an array.
destroy	destroys a class instance.
destroyed_p	tests for destroyed instances.
_destroy_task	should never be used.
difference	constructs a list of the differences between two lists.

directory	returns the contents of a directory.
dirname	returns the directory path of a file.
div	divides two numbers, giving an integer result.
dlclose	closes an open dynamic library.
dlerror	reports errors in dl functions.
dlfunc	reserved for future use.
DllLoad	loads dynamic libraries.
dlmethod	reserved for future use.
dlopen	loads a dynamic library from a file.
drain	modifies end-of-file detection.
enter_state	is part of the SCADALisp exception-driven state machine mechanism.
eq	compares for identity and equivalence.
equal	compares for identity and equivalence.
errno	detects and numbers errors.
error	redirects the interpreter.
eval	evaluates an argument.
eval_count	counts evaluations made since a program started.
eval_list	evaluates each element of a list.
eval_string	evaluates a string.
every	performs an action every number of seconds.
exec	executes a program.
exit_program	terminates the interpreter.
exit_state	is part of the SCADALisp exception-driven state machine mechanism.
exp	calculates an exponent of the logarithmic base (e).
fd_close	closes a open file identified by a file descriptor.
fd_data_function	attaches a write-activated callback to a file.
fd_eof_function	attaches an _eof_-activated callback to a file.
fd_open	opens a file or device and assigns it a file descriptor.
fd_read	reads a buffer or string from an open file identified by a file descriptor.
fd_to_file	creates a file pointer from a descriptor.
fd_write	writes a buffer or string to an open file identified by a file descriptor.
file_date	gives the file modification date.

`file_p`	tests for files.
`file_size`	gives the file size.
`fileno`	creates a file descriptor from a pointer.
`find`	searches a list using the function: eq.
`find_equal`	searches a list using the function: `equal`.
`fixed_point_p`	tests for fixed-point reals.
`floor`	rounds a real number down to its integer value.
`flush`	flushes any pending output on a file or string.
`flush_events`	handles all pending events, then exits.
`fork`	duplicates a process.
`format`	generates a formatted string.
`free_cells`	returns the number of available memory cells.
`funcall`	provides compatibility with other Lisp dialects.
`function_args`	lists the arguments of a function.
`function_body`	gives the body of a user-defined function.
`function_calls`	tells how often a function was called during profiling.
`function_name`	gives the name of a function.
`function_p`	tests for functions.
`function_runtime`	gives the time a function has run during profiling.
`gc`	runs the garbage collector.
`gc_blocksize`	is for internal use only.
`gc_enable`	is for internal use only.
`gc_newblock`	is for internal use only.
`gc_trace`	controls the tracing of garbage collection.
`gensym`	generates a unique symbol.
`getcwd`	gets the current working directory.
`getenv`	retrieves the value of an environment variable.
`gethostname`	gets the computer's host name.
`getnid`	returns the local node number.
`getpid`	returns the program ID.
`getprop`	returns a property value for a symbol.
`getsockopt`	gets a socket option.
`has_cvar`	queries for the existence of a class variable.
`has_ivar`	queries for the existence of an instance variable.
`hex`	converts numbers into hexadecimal form.

init_async_ipc	requests queue information from a task.
init_ipc	sets up necessary data structures for IPC.
insert	inserts a value at a given position.
instance_p	tests for instances.
instance_vars	finds all the instance variables of a class or instance.
int	converts numbers to integer form.
int_p	tests for integers.
intersection	constructs a list of all the elements found in both of two lists.
ioctl	performs control functions on a file descriptor.
is_busy	determines if a file is busy.
is_class_member	checks if an instance or class is a member of a class.
is_dir	determines if a file is a directory.
is_file	determines if a file exists.
is_readable	determines if a file is readable.
is_writable	determines if a file is writable.
isend	sends a synchronous message and doesn't wait for the result.
ivar_type	returns the type of a given instance variable.
kill	sends a signal to a process.
length	counts the number of elements in a list or array.
list	creates lists, evaluating the arguments.
list_p	tests for lists.
list_to_array	converts a list to an array.
listq	creates lists without evaluating the arguments.
load	loads files.
load_lisp	loads Lisp files.
locate_task	finds and connects to tasks by name.
locate_task_id	finds and connects to tasks by task ID and network node.
lock_point	locks or unlocks points.
log	calculates natural logarithms.
log10	calculates base 10 logarithms.
logn	calculates logarithms of a given base.
long_p	tests for long integers.
macro	helps generate custom functions.

`macro_p`	tests for macros.
`make_array`	creates an empty array.
`make_buffer`	creates a new, empty buffer.
`method_p`	tests for methods.
`mkdir`	creates a new sub-directory.
`modules`	is obsolete, and returns nothing of value.
`name_attach`	attaches a name to a task.
`nanoclock`	gets the OS time, including nanoseconds.
`nanosleep`	pauses the interpreter for seconds and nanoseconds.
`nappend`	appends one or more lists, destructively modifying them.
`neg`	negates a number.
`new`	creates a new instance of a class.
`next_event`	blocks waiting for an event, and calls the event handling function.
`next_event_nb`	is the same as next_event, but doesn't block.
`nil_p`	tests for `nil` values.
`NoAutoLoad`	removes selected AutoLoad rules.
`not`	is the same as the corresponding logical operator (`!`).
`notrace`	turns tracing off.
`nremove`	removes list items, destructively altering the list.
`nreplace`	replaces elements in a list, using `eq`.
`nreplace_equal`	replaces elements in a list, using `equal`.
`nserve_query`	puts information from **nserve** into an array.
`nth_car`	iteratively applies the car functions to a list.
`nth_cdr`	iteratively applies the cdr functions to a list.
`number`	attempts to convert an expression to a number.
`number_p`	tests for numbers.
`oct`	converts numbers into octal form.
`open`	attempts to open a file.
`open_string`	allows a string to be used as a file.
`or`	is the same as the corresponding logical operator (`||`).
`parent_class`	returns the closest parent (base) of a class or instance.
`parse_string`	parses an input string.
`path_node`	gives the node number of a path in a QNX 2 path definition.

`pipe`	creates a pipe.
`point_locked`	indicates if a point is locked.
`point_nanoseconds`	gives the nanoseconds from point_seconds that a point value changed.
`point_seconds`	gives the time the point value changed.
`point_security`	gives the security level of a point.
`pow`	raises a base to the power of an exponent.
`pretty_princ`	writes to the standard output file, with formatting.
`pretty_print`	writes Lisp-readable output to the standard output file, with formatting.
`pretty_write`	writes an expression to a file, applying formatting.
`pretty_writec`	writes an expression to a file, applying formatting.
`princ`	writes to the standard output file.
`print`	writes Lisp-readable output to the standard output file.
`print_stack`	prints a Gamma stack.
`profile`	collects statistics on function usage and run time.
`prog1`	groups several statements into one expression.
`progn`	groups several statements into one expression.
`properties`	should never be used.
`pty`	runs programs in a pseudo-tty.
`ptytio`	runs programs in a pseudo-tty, using a termios structure argument.
`quote`	corresponds to a quote operator.
`random`	generates random numbers from 0 to 1.
`raw_memory`	tells the amount of memory in use.
`read`	reads a Lisp expression from a file.
`read_char`	reads the next character from the input file.
`read_double`	reads the next double from the input file.
`read_eval_file`	reads a file, evaluating and counting expressions.
`read_existing_point`	retrieves points.
`read_float`	reads the next float from the input file.
`read_line`	reads a single line of text.
`read_long`	reads the next long value from the input file.
`read_n_chars`	reads and stores characters.
`read_point`	creates and/or retrieves points.
`read_short`	reads the next short value from the input file.

read_until	reads characters, constructing a string as it goes.
real_p	tests for reals.
register_all_points	registers an application to receive exceptions for all points.
register_exception	is not yet documented.
register_existing_point	registers an application to receive exceptions for a single existing point.
register_point	creates and/or registers an application to receive exceptions for a single point.
registered_p	tests for registered points.
remove	removes list items without altering the list.
remove_echo_function	removes an echo function from a symbol.
remove_exception_function	removes an exception function from a symbol.
remove_hook	removes a hooked function.
remove_set_function	removes a set function from a symbol.
rename	renames a file.
require	requires/loads files.
require_lisp	requires/loads Lisp files.
required_file	determines which files would be loaded.
reverse	reverses the order of list elements.
root_path	strips the final file or directory name from a path.
round	rounds a real number up or down to the nearest integer.
rplaca	replaces the car of a list.
rplacd	replaces the cdr of a list.
run_hooks	runs a hooked function.
secure_point	alters the security level on a point.
seek	sets the file position for reading or writing.
send	transmits expressions for evaluation.
send_async	transmits expressions asynchronously.
send_string	transmits strings for evaluation.
send_string_async	transmits a string asynchronously.
ser_setup	sets parameters for a serial port device.
set	assigns a value to a symbol, evaluating both arguments.
set_autotrace	is reserved for future use.

set_breakpoint	is reserved for future use.
set_conf	sets confidence factors.
set_domain	sets the default domain for future calls.
set_random	starts random at a different initial number.
set_security	changes the security level for the current process.
setenv	sets an environment variable for the current process.
setprop	sets a property value for a symbol.
setprops	lists the most recent property value settings.
setq	assigns a value to a symbol, evaluating the second argument.
setqq	assigns a value to a symbol, not evaluating any arguments.
setsockopt	sets a socket option.
shell_match	compares string text to a pattern.
shm_open	opens shared memory objects.
shm_unlink	removes shared memory objects.
shorten_array	reduces or expands the size of an array.
shorten_buffer	reduces the size of a buffer.
signal	defines an expression to be evaluated at an OS-generated signal.
sin	returns the sine of a number.
sleep	suspends execution for seconds.
sort	sorts a list or array, destructively modifying the order.
sqr	finds the square of a number.
sqrt	finds the square root of a number.
stack	lists all functions called so far.
strchr	searches a string for a character, returning the first location.
strcmp	compares strings, case-sensitive.
strerror	retrieves an error message.
stricmp	compares strings, case-insensitive.
string	constructs a string.
string_file_buffer	queries a string file for its internal buffer.
string_p	tests for strings.
string_split	breaks a string into individual words.
string_to_buffer	creates a buffer object from a string.

`stringc`	constructs a string in Lisp-readable form,
`strlen`	counts the number of characters in a string.
`strncmp`	compares two strings and return a numeric result, case-sensitive.
`strnicmp`	compares two strings and return a numeric result, case-insensitive.
`strrchr`	searches a string for a character, returning the last location.
`strrev`	reverses the order of characters in a string.
`strstr`	finds the location of a given substring.
`substr`	returns a substring for a given location.
`sym_alist_p`	tests for symbolic association lists.
`symbol`	constructs a symbol from a string.
`symbol_p`	tests for symbols.
`system`	treats its argument as a system command.
`tan`	returns the tangent of a number.
`taskdied`	calls a function when a task stops.
`task_info`	gets information from a task descriptor.
`taskstarted`	calls a function when a task starts.
`tell`	indicates file position.
`terpri`	prints a newline to an open file.
`time`	gives command execution times.
`timer_is_proxy`	controls timer handling in Gamma.
`tmpfile`	generates temporary output file names.
`tolower`	converts upper case letters to lower case.
`toupper`	converts lower case letters to upper case.
`trace`	turns tracing on.
`trap_error`	traps errors in the body code.
`true_p`	tests for truth value.
`unblock_signal`	ends signal blocking.
`unblock_timers`	unblocks timer firing.
`unbuffer_file`	causes a file to be treated as unbuffered on both input and output.
`undefined_p`	tests for undefined values.
`undefined_symbol_p`	tests for undefined symbols.
`union`	constructs a list containing all the elements of two lists.

`unlink`	deletes a file.
`unread_char`	attempts to replace a character to a file for subsequent reading.
`unregister_point`	stops echo and exception message sending.
`unwind_protect`	ensures code will be evaluated, despite errors in the body code.
`usleep`	suspends execution for microseconds.
`wait`	waits for process exit status.
`when_echo_fns`	indicates the functions for echos on a point.
`when_exception_fns`	indicates the functions for exceptions on a point.
`when_set_fns`	returns all functions set for a symbol.
`whence`	gives input information.
`write`	writes an expression to a file.
`write_existing_point`	writes values to existing points.
`write_n_chars`	writes characters from a buffer to a file.
`write_point`	writes point values, creating points if necessary.
`writec`	writes a Lisp expression to a file.

Appendix B. GNU Lesser General Public License

This is the first released version of the Lesser GPL. It also counts as the successor of the GNU Library Public License, version 2, hence the version number 2.1.

Version 2.1, February 1999

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That's all there is to it!

Symbols and Literals

Data Types and Predicates

— testing for data types.

Unlike many languages, just about every expression in Gamma is a data type. This gives the flexibility to manipulate functions, arrays, lists, classes, instances and so on as if they were data.

The following data types are defined in Gamma. Beside each data type is the name of a function which can be used to test an expression for that type. These functions are called predicates, and will return `t` if the test is true (the expression is that data type), or `nil` if it is false.

Table 3. Data Types and Related Predicates

Type	Predicate	Comments
alist	`alist_p`	An association list. See `assoc`.
array	`array_p`	See `array` and Lists and Arrays.
autotrace	`autotrace_p`	
breakpoint	`breakpoint_p`	
buffer	`buffer_p`	See `buffer`.
builtin	`builtin_p`	
class	`class_p`	See `class`.
cons	`cons_p`	See `cons` and `list`.
constant	`constant_p`	Constants can be assigned or defined. See `defvar` and `::=`.
destroyed instance	`destroyed_p`	See `new (instance)`.
file	`file_p`	See `open` and `open_string`.
fixed-point real	`fixed_point_p`	See Numeric Types.
function	`function_p`	See `function`.
instance	`instance_p`	See `new (instance)`.
integer	`int_p`, `long_p`	See Literals.
list	`list_p`	See `list` and Lists and Arrays.
macro	`macro_p`	See `macro`.
method	`method_p` (obsolete, always returns `nil`)	See `method`.

Type	Predicate	Comments
nil	nil_p	See nil.
number	number_p	Integer and floating point values are both considered numbers. See Literals.
real	real_p	See Literals.
registered	registered_p	See register_point.
string	string_p	See Literals and string.
sym-alist	sym_alist_p	A symbol-indexed association list. See assoc.
symbol	symbol_p	See Literals.
t	true_p	See t.
task descriptor	none	See locate_task.
undefined	undefined_p	See undefined_p.
undefined symbol	undefined_symbol_p	See undefined_symbol_p.

Predicates

Predicates are used to test a Gamma object for a given type, as listed. If a Gamma object is of that type, the predicate will return the value t.

Syntax

```
alist_p (s_exp)
array_p (s_exp)
autotrace_p (s_exp)
breakpoint_p (s_exp)
buffer_p (s_exp)
builtin_p (s_exp)
class_p (s_exp)
cons_p (s_exp)
constant_p (s_exp)
destroyed_p (s_exp)
file_p (s_exp)
fixed_point_p (s_exp)
function_p (s_exp)
instance_p (s_exp)
int_p (s_exp)
list_p (s_exp)
long_p (s_exp)
macro_p (s_exp)
method_p (s_exp)
nil_p (s_exp)
```

```
number_p (s_exp)
real_p (s_exp)
registered_p (s_exp)
string_p (s_exp)
sym_alist_p (s_exp)
symbol_p (s_exp)
true_p (s_exp)
none_p (s_exp)
undefined_p (s_exp)
undefined_symbol_p (s_exp)
```

Arguments

any expression

Returns

`t` or `nil`.

Example

Here is an example for the predicate `function_p`. All the other predicates work in a similar way.

```
Gamma> function_p(div);
t
Gamma> function_p(strcmp);
t
Gamma> function_p(5);
nil
Gamma>
```

undefined_p, undefined_symbol_p

`undefined_p`, `undefined_symbol_p` — test for undefined types and symbols.

Synopsis

```
undefined_p (s_exp)
undefined_symbol_p (s_exp)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

`t` if the value of *s_exp* is not defined; otherwise `nil`.

Description

These two functions perform a similar task, checking to see if the *s_exp* is defined. However, they differ in two important ways:

- `undefined_p` examines the value of *s_exp* directly, whereas `undefined_symbol_p` expects the value of *s_exp* to be a symbol, and examines the value of that resulting symbol.
- `undefined_p` evaluates its argument in a protected scope where any "`Symbol is undefined`" errors will be trapped and disregarded. `undefined_symbol_p` evaluates its argument without protection, so it is possible that a "`Symbol is undefined`" error could be thrown if the evaluation of *s_exp* generates such an error.

Example

```
Gamma> a = #xyz
xyz
Gamma> undefined_p (a);
nil
Gamma> undefined_symbol_p (a);
t
Gamma> xyz = t;
t
Gamma> undefined_symbol_p (a);
nil
```

```
Gamma> undefined_p (y);
t
Gamma> undefined_symbol_p (y);
Symbol is undefined: y
debug 1>
```

See Also

Data Types and Predicates

Literals

— defined for integers, reals, strings, and symbols.

Integers

An integer is any group of digits defining a number between -2e+31 and 2e+31 - 1. It cannot contain a decimal point or an exponent. Integers have several different literal notations, but regardless of notation, all integers are 32 bit signed numbers. They are flagged internally with their respective notations and Gamma attempts to maintain and return the notation when the integer is printed.

Table 4. Integers

Notation	Description	Example
	Decimal notation	539
0b	Binary notation	0b1011
0o	Octal notation	0o462
0x	Hexadecimal notation	0x35fc
' '	Contents are a character.	'M'

Real numbers

A real number is any group of digits defining a number less than -2e+31, greater than 2e +31 - 1, or containing a non-zero mantissa. It can contain a decimal point, and it may end with the letter e followed by a signed exponent.

Table 5. Real numbers

Notation	Description	Example
[0-9].[0-9]e[+|-][0-9]	Double-precision 64 bit floating-point number.	2.56e-7

There are four pre-defined constants in Gamma:

`PI`	The value of pi, approximately `3.14159`.
`E`	The base of the natural logarithm, approximately `2.71828`.
`INF`	Floating point positive infinity.
`NAN`	Floating point not-a-number.

`NAN` is a floating point number that represents an invalid state. For example, `1/x` is a mathematical function that should produce a numeric result. If `x` is `0` then the numeric result will be not a number, but it will still be represented in floating point for the purpose of storage and future math functions.

For example:

```
Gamma> x = NAN;
```

```
nan
Gamma> 1/x;
nan
Gamma> y = "hello";
"hello"
Gamma> 1/y;
Script error during command: 1/y: Non-number in numeric operation:
    1
    "hello"
    /  from String:1
```

Math on `NAN` is legal. It just produces another `NAN`. Math on strings is illegal. But, in the case of `1/0`, we catch that and throw an error. Mathematically the result may be `NAN` or `INF`, but in Gamma division by zero is an error. So you cannot use `1/0` to produce a `NAN` or `INF`.

Strings

A string may have any number of characters. The special forms \n, \t, \f and \r denote newline, tab, form feed, and carriage return respectively. The double quote (") and backslash (\) characters may be embedded in a string by preceding them with a backslash.

Table 6. Strings

Notation	Description	Example
" "	Contents are a string.	"Good morning."

Symbols

Generally, symbol names are made up of alpha-numeric characters and underscores.

Table 7. Symbols

Notation	Description	Example
[a-z,A-Z,0-9]	One or more characters chosen from : a-z, A-Z, 0-9 are valid for symbol names.	Epax15
_	A _ (underscore) is allowed in any part of a symbol name. This symbol is generally used to separate words in a symbol name. The use of this character at the beginning and end of a symbol is reserved for system use.	`my_var_name`
\	Any non-alphanumeric character other than _	Ft\+\$sq

Notation	Description	Example
	must be preceded by a backslash to be used in a symbol name.	

Other Data Types

The literal representation for all other Gamma data types is discussed in the reference entry associated with creating or accessing that data type, as given in the table below.

Table 8. Other Data Types

Data type	Reference entry
Array	`array`
Buffer	`buffer`
List	`list`
Instance	`new`
Function	`function`
Method	`method`
Class	`class`
File	`open`
Task	`locate_task`

Predefined Symbols

— a table.

Table 9. Symbols that are predefined in Gamma

Symbol Name	Description	Accessibility
`_all_tasks_`	The list of tasks opened using `locate_task`.	read-only
`_auto_load_alist_`	A list of rules used by `AutoLoad`.	read/write
`_case_sensitive_`	Used by reader to control case sensitivity. If `nil`, then all symbols are treated as lower-case. Default is `t`.	read/write
`_comma_`	Internal symbol.	not available
`_commasplice_`	Internal symbol.	not available
`_current_input_`	The currently open file for reading.	read-only
`_debug_`	Not used.	not available
`_eof_`	Gamma representation of the end-of-file status from a read operation.	read-only
`_eol_`	Gamma representation of the end-of-line status from a read operation.	read-only
`_error_stack_`	The stack at the time the last error occurred.	read-only
`_eval_silently_`	If set to `t`, then references to undefined symbols are returned as `_undefined_` instead of stopping the program with an error.	read/write
`_eval_stack_`	Contains the definition of the function being currently evaluated.	read-only
`_event_`	The QNX Windows event name.	read-only
`_fixed_point_`	Controls whether calculations with reals are	read/write

Symbol Name	Description	Accessibility
	done in double or fixed-point.	
`_gui_`	The name of the graphical user interface that this version of Gamma was compiled against, as a string.	read-only
`_gui_version_`	The version number of the graphical user interface that this version of Gamma was compiled against, as a string.	read-only
`_ipc_file_`	String file used by IPC functions to create buffers for send/receive/reply sequence.	not available
`_jump_stack_`	Internal symbol.	not available
`_last_error_`	String containing last error.	read-only
`_load_extensions_`	List of strings containing shell-match patterns of acceptable input files.	read/write
`_os_`	The name of the operating system (OS) that this version of Gamma was compiled in, as a string.	read-only
`_os_version_`	The version number of the operating system that this version of Gamma was compiled in, as a string.	read-only
`_os_release_`	The release number of the operating system that this version of Gamma was compiled in, as a string.	read-only
`_require_path_`	List of strings of paths to search for `require` and `require_lisp`.	read-write
`_signal_handlers_`	See `signal`.	read-only
`SIGABRT`	See `signal`.	read-only
`SIGALRM`	See `signal`.	read-only
`SIGBUS`	See `signal`.	read-only
`SIGCHLD`	See `signal`.	read-only

Symbol Name	Description	Accessibility
SIGCONT	See signal.	read-only
SIGFPE	See signal.	read-only
SIGHUP	See signal.	read-only
SIGILL	See signal.	read-only
SIGINT	See signal.	read-only
SIGIO	See signal.	read-only
SIGIOT	See signal.	read-only
SIGKILL	See signal.	read-only
SIGPIPE	See signal.	read-only
SIGPOLL	See signal.	read-only
SIGPWR	See signal.	read-only
SIGQUIT	See signal.	read-only
SIGSEGV	See signal.	read-only
SIGSTOP	See signal.	read-only
SIGTERM	See signal.	read-only
SIGTRAP	See signal.	read-only
SIGTSTP	See signal.	read-only
SIGTTIN	See signal.	read-only
SIGTTOU	See signal.	read-only
SIGURG	See signal.	read-only
SIGUSR1	See signal.	read-only
SIGUSR2	See signal.	read-only
SIGWINCH	See signal.	read-only
timers	An array of active timers, in this format: `[[secs nsecs fires ((s-exp ...)...) number]...]` *secs* The clock time in seconds when the timer was set. *nsecs* The additional nanoseconds when the timer was set.	read-only

Symbol Name	Description	Accessibility
	fires The set interval of time to fire, in seconds. *s-exp* Action(s) associated with the timer, inside a list of lists. *number* The timer number.	
`_undefined_`	The Gamma representation of the undefined symbol state.	read-only
`_unwind_stack_`	The stack at the time that an error was recovered.	read-only
`&noeval , !`	Symbol directing Gamma to not evaluate the next argument.	not available
`&optional , ?`	Symbol directing Gamma to treat the following argument as optional.	not available
`=>&rest , ...`	Symbol directing Gamma to expect an optional number of arguments starting at last argument. Passed as a list.	not available

Reserved Words

— a table.

The following table provides a list of words which are reserved by the Gamma language. No symbols can be defined by the user that are identical to these reserved words.

Table 10. Words reserved in Gamma

Reserved Word	Used In
`class`	Class declaration
collect	`with` loop
do	`with` loop
else	`if` statement
`for`	`for` loop
`function`	Function declaration
`if`	`if` statement
`local`	Local variable declaration
`method`	Method declaration
tcollect	`with` loop
`while`	`while` loop
`with`	`with` loop

t

`t` — a logically true value.

Synopsis

```
t
```

Returns

`t`

Description

The special object, `t`, is a logically true value which has no other meaning. All Gamma objects other than `nil` are logically true, but only the special object `t` is the logical negation of `nil`. `t` is created by a call to not(`nil`), or by reading the symbol `t`.

The predicate `true_p` explicitly tests for the value `t`. However, in all conditional statements, any non-`nil` value is considered to be true for the purpose of the test.

Example

```
Gamma> x = 3;
3
Gamma> x > 2;
t
Gamma> x == 3;
t
Gamma> !nil;
t
Gamma> 10 < 25;
t
Gamma>
```

See Also

, nil

nil

nil — the logically false value.

Synopsis

```
nil
```

Returns

nil

Description

The special value, nil, is a zero-length list. It is the only logically false value in Gamma. All other Gamma values are considered to be logically true. A common mistake for first-time Gamma programmers is to treat the number zero as logically false.

Example

```
Gamma> x = 5;
5
Gamma> x > 10;
nil
Gamma> int_p(x);
t
Gamma> real_p(x);
nil
Gamma> !3;
nil
Gamma> !t;
nil
Gamma>
```

See Also

, t

gamma, phgamma

gamma, **phgamma** — start Gamma and Gamma/Photon from the shell prompt.

Synopsis

```
gamma [-options] [program_name [program_arg]...]

phgamma [-options] [program_name [program_arg]...]
```

Options

`-c` *`command`*
: Execute the named command.

`-C`
: Declare all constants at startup.

`-d`
: Keep file and line # information on all cells .

`-e`
: Do not enter interactive mode.

`-f` *`filename`*
: 'Require' (read and process) the named file and set the `-e` flag. As many files as desired can be processed by repeating this option. Although the file is run just like the executable named in *`program_name`*, the two are not the same, because no program arguments can be passed to a file using the `-f` option. When the file has been completely processed, Gamma moves on to the next option, if any, and will not necessarily enter the interactive mode.

`-F`
: Declare all functions at startup.

`-G`
: Run as Gamma, regardless of name.

`-h`
: Print a help message and exit.

`-H` *`heapsize`*
: Set the heap growth rate increment (default 2000).

`-i` *`filename`*
: 'Require' the named file. This is identical to the `-f` option, except that Gamma will enter the interactive mode after all options have been processed.

`-I`
: Force entry into interactive mode after completion of the named application.

`-L`
: Run as Lisp, regardless of name.

`-m`
: Do not run the main function automatically.

`-p`
: Protect functions from the garbage collector. (Functions should not be redefined.)

`-q`
: Do not print copyright notice.

`-s`
: Set the local stack size in longwords.

`-V`
: Print the version number.

`-X`
: Exit immediately (usually used with `-V`).

`program_name`
: The name of an executable program.

`program_arg`
: The program arguments.

Returns

A Gamma prompt.

Description

This command starts Gamma or Gamma/Photon in interactive mode at the shell prompt. Flags are processed in the order given on the command line, and can appear more than once.

If the name of the executable contains the word 'Lisp', then it will use the Lisp grammar, otherwise it will use the Gamma grammar.

The `-c` and `-f` used together make possible several interesting ways to invoke and use Gamma. For example:

```
gamma -f domainA.g -c "init = methodA(3);" my_application "thing"
```

permits a user to specify a particular file to be processed, perhaps containing application-specific methods, then execute an arbitrary initialization expression, and finally start the intended application with specified arguments.

The `-c` argument used with `-e` has Gamma execute a command and exit without going into interactive mode. For example:

```
gamma -i hanoi.g -c 'princ (hanoi (3), "\n");' -e
```

would load the Tower of Hanoi code, print the solution to the 3-disk hanoi problem, and then exit. (The single quotes are used to hide the double quotes from the shell.)

Example

```
[~/usr/devtools]$ gamma -m
Gamma(TM) Advanced Programming Language
Copyright (C) Cogent Real-Time Systems Inc., 1996-2001. All rights reserved.
Version 4.0 Build 31 at Aug 12 2001 09:57:56
Gamma>
```

Operators

Operator Precedence and Associativity

— a table.

Table 11. Operator Precedence and Associativity

Precedence	Operator	Associativity
Lowest	ELSE	Right
	=	Right
	| |	Left
	& &	Left
	<, >, < =, > =, = =, ! =	Left
	|, &	Left
	-, +	Left
	Unary -, +, !	Left
	^	Left
	+ +, --	Left
	[ ]	Left
	., ..	Left
	( )	Left
Highest	#	Left

The associativity of operators refers to order in which repeated use of the same operator will be evaluated. For example, the expression 1+2+3 will be evaluated as (1+2)+3 since the "+" operator associates the leftmost operator instances first. In contrast, the statement A = B = C will first perform the B = C assignment, and then the result is assigned to A.

Associativity should not be confused with precedence, which determines which one of different operators will be evaluated first. In the example `1+2_3+4`, the multiplication is performed first due to precedence, while the left addition is performed before the rightmost addition due to associativity, causing the expression to be evaluated as `(1+(2_3))+4`.

See Also

Arithmetic Operators, Assignment Operators, Bitwise Operators, Comparison Operators, Increment and Decrement Operators, Logical Operators, Quote Operators

Arithmetic Operators

Arithmetic Operators — (+, -, *, /, %)

Synopsis

```
number + number
number - number
number * number
number / number
number % number
```

Arguments

number

Any integer or real number. Non-numbers are treated as zero.

Returns

The mathematical result of the operation.

Description

These operators perform simple mathematical operations on their arguments.

+ gives the sum of the two arguments.

- gives the difference between the first and second arguments.

***** gives the product of the two arguments.

/ gives the first argument divided by the second argument.

% gives the modulus of the first argument by the second, that is, the remainder of the integer division of the first argument by the second.

Example

```
Gamma> 5 + 6;
11
Gamma> 12 / 5;
2.3999999999999999112
Gamma> div(12,5);
2
Gamma> 19 % 5;
4
```

```
Gamma>
```

Assignment Operators

Assignment Operators — (=, :=, ::=)

Synopsis

```
symbol = s_exp
symbol := s_exp
symbol ::= s_exp
```

Arguments

symbol
Any valid symbol.

s_exp
Any expression.

Returns

The assigned value.

Description

= is used to assign a value to a variable.

:= is used to assign a value only if no value is currently assigned to the *symbol*. If the *symbol* already has a value then the *symbol* keeps its original value.

::= is used to assign a constant. Once the assignment has been made no changes to the *symbol* are allowed. Attempted changes to the *symbol* will generate an error.

Example

```
Gamma> a = 5;
5
Gamma> a := 6;
5
Gamma> a;
5
Gamma> b ::= 7;
7
Gamma> b = 8;
Assignment to constant symbol: b
debug 1>
```

```
Gamma> b ::= 9;
Defvar of defined constant: b
debug 1>
Gamma>
```

See Also

defvar

Binary Operator Shorthands

Binary Operator Shorthands — (+=, -=, *=, /=, %=, &=, ^=, <<=, >>=)

Synopsis

```
symbol += number
symbol -= number
symbol *= number
symbol /= number
symbol %= number
symbol &= number
symbol ^= number
symbol <<= number
symbol >>= number
```

Arguments

symbol
: A symbol with a numeric value.

number
: Any integer or real number.

Returns

The value of the *symbol* as operated on with the *number*.

Description

These operators provide a shorthand way of reassigning values to symbols.

+= gives the sum of the *symbol* and the *number*.

-= gives the difference between the *symbol* and the *number*.

***=** gives the product of the *symbol* and the *number*.

/= gives the *symbol* divided by the *number*.

% gives the modulus of the *symbol* by the *number*, that is, the remainder of the integer division of the *symbol* by the *number*.

&= performs the & operation on the *symbol* and the *number*.

^= performs the ^ operation on the *symbol* and the *number*.

<<= performs the << operation on the *symbol* and the *number*.

>>= performs the >> operation on the *symbol* and the *number*.

Example

```
Gamma> a = 5;
5
Gamma> a += 8;
13
Gamma> a;
13
Gamma>
```

See Also

Arithmetic Operators, Assignment Operators, Bitwise Operators

Bitwise Operators

Bitwise Operators — (<<, >>, ~ , &, |, ^)

Synopsis

```
number << shift;
number >> shift;
~ number
number & number
number | number
number ^ number
```

Arguments

number
: Any number,

shift
: The number of bit shifts to perform.

Returns

An integer which is the result of the particular operation.

Description

<<, >> return the first argument with a left or right bitshift operation performed the number of times of the second argument.

~ returns the binary opposite of the *number*.

& compares each of the corresponding digits of the two *numbers*. If both digits are 1, returns 1 for that place. Otherwise returns 0 for that place.

| compares each of the corresponding digits of the two *numbers*. If either those digits is 1, returns 1 for that place. Otherwise returns 0 for that place.

^ compares each of the corresponding digits of the two *numbers*. If both digits are the same, returns O for that place. If they are different (ie. 0 and 1) returns 1 for that place.

Examples

```
Gamma> bin(10);
0b1010
Gamma> bin(10 << 1);
```

```
0b00010100
Gamma> bin(10 >> 1);
0b0101
Gamma> bin (~10);
0b11111111111111111111111111110101
Gamma> bin(10);
0b1010
Gamma> bin (9);
0b1001
Gamma> bin (9 & 10);
0b1000
Gamma> bin (9 | 10);
0b1011
Gamma> bin (9 ^ 10);
0b0011
Gamma>
```

See Also

band, bnot, bor, bxor

Class Operators

Class Operators — (`.`, `..`)

Synopsis

```
instance.variable = value
instance.variable
instance..variable = value
instance..variable
```

Arguments

instance
: An instance of a class.

variable
: An instance variable name.

value
: A new value to write to the instance variable.

Returns

The value argument.

Description

These operators assign and evaluate object instance values, using familiar C/C++ structure/class reference syntax. The *instance* and its instance *variable* are separated by a period and the assignment is made using the = assignment operator. Using two periods between *instance* and *variable* makes the reader interpret the instance variable.

Using either the `.` or the `..` without the = assignment operator causes the *variable* to be evaluated at that instance.

Examples

```
Gamma> class cmpny { name; address; }
(defclass cmpny nil [][address name])
Gamma> company = new(cmpny);
{cmpny (address) (name)}
Gamma> company.name = "Acme Widgets";
"Acme Widgets"
Gamma> company.name;
```

```
"Acme Widgets"
Gamma> var = symbol("name");
name
Gamma> company..var;
"Acme Widgets"
Gamma>
```

Here is an example of how the `..` syntax can be used to allow an instance of one class to access a method of another class. This can be useful if a parent and child widget have different methods with the same name, and you want an instance of one to use the method of the other.

```
Gamma> class A{}
(defclass A nil [][])
Gamma> class B{}
(defclass B nil [][])
Gamma> class C B{}
(defclass C B [][])
Gamma> method A.get (){princ("Class A's method.\n");}
(defun A.get (self) (princ "Class A's method.\n"))
Gamma> method B.get (){princ("Class B's method.\n");}
(defun B.get (self) (princ "Class B's method.\n"))
Gamma> a = new(A);
{A }
Gamma> a.get();
Class A's method.
t
Gamma> b = new(B);
{B }
Gamma> b.get();
Class B's method.
t
Gamma> (b..A.get)();
Class A's method.
t
Gamma> (a..B.get)();
Class B's method.
t
Gamma> c = new(C);
{C }
Gamma> (c..A.get)();
Class A's method.
t
Gamma> (c..B.get)();
Class B's method.
t
```

```
Gamma>
```

Comparison Operators

Comparison Operators — (!=, <, <=, ==, >, >=)

Synopsis

```
number != number
number &lt; number
number &lt;= number
number == number
number &gt; number
number &gt;= number
```

Arguments

number

Any integer or real number. Non-numbers are treated as zero.

Returns

!= `t` if the first *number* is not equal to the second, else `nil`.

< `t` if the first *number* is less than the second, else `nil`.

<= `t` if the first *number* is less than or equal to the second, else `nil`.

== `t` if the first *number* Is equal to the second, else `nil`.

> `t` if the first *number* is greater than the second, else `nil`.

>= `t` if the first *number* is greater than or equal to the second, else `nil`.

Description

These functions perform a numeric comparison of their arguments. In mathematical (infix) notation, the function would put the first argument on the left side of the comparison, and the second argument on the right side of the comparison.

Example

```
Gamma> 5 < 6;
t
Gamma> 5 > 6;
nil
Gamma> 5.00 == 5;
t
```

```
Gamma> "hello" == string("hel","lo");
t
Gamma> a = 5 + 1;
6
Gamma> a;
6
Gamma> a == 5;
nil
Gamma>
```

See Also

eq, equal, strcmp, stricmp

Evaluation Order Operators

Evaluation Order Operators — `,` `(` `)`

Synopsis

```
symbol , symbol
( symbol operator symbol )
```

Arguments

symbol

Any symbol.

operator

Any operator.

Determine

Sequence of operation.

Description

Operations before a `,` are performed before those after it.

Operations enclosed by `(` and `)` are performed first.

Examples

```
Gamma> x = 3;
3
Gamma> princ("x = ", x, "\n");
x = 3
t
Gamma> (2 + 3) * 4;
20
Gamma> 2 + (3 * 4);
14
Gamma>
```

Increment and Decrement Operators

Increment and decrement operators — (++, --)

Synopsis

```
++symbol
symbol++
--symbol
symbol__
```

Arguments

symbol
A symbol whose value is a number.

Returns

The value of the symbol plus or minus one.

Description

These operators perform auto-increments or decrements on numeric symbols. When the ++ is placed before a symbol, it performs a pre-increment, where the value is incremented and the result is the symbol's value + 1. When ++ is placed after a symbol, it performs a post-increment. Here the result of the operation is the value of the symbol prior to being incremented. The `--` operator works in the same way. These operators only take symbols as arguments. It is not possible to auto-increment or decrement an array element, list element, or instance variable.

Examples

```
Gamma> a = 5;
5
Gamma> ++ a;
6
Gamma> a;
6
Gamma> a ++;
6
Gamma> a;
7
Gamma> a = 5;
5
Gamma> -- a;
```

```
4
Gamma> a;
4
Gamma> a --;
4
Gamma> a;
3
Gamma>
```

Logical Operators

Logical Operators — (!, &&, ||)

Synopsis

```
! s_exp
s_exp && s_exp ...
s_exp || !s_exp ...
```

Arguments

s_exp
Any Gamma or Lisp expression.

Returns

Non-nil or nil.

Description

In Gamma or Lisp, any expression which is not nil is treated as being true (t) for the purpose of boolean logic. Applying ! to any non-nil expression will produce nil. Applying ! to nil must produce an arbitrary non-nil result. The generic non-nil value in Gamma is t.

&& evaluates each of its arguments in order, and continues so long as each argument evaluates to non-nil. If any argument is nil, then nil is returned immediately, without evaluating the rest of the arguments. If no argument is nil, the last argument is returned.

|| returns non-nil if any of its arguments is not nil. Each argument is evaluated in turn, and as soon as a non-nil value is reached, that argument is returned. Subsequent arguments are not evaluated.

Examples

```
Gamma> 6;
6
Gamma> !6;
nil
Gamma> !nil;
t
Gamma> 5<6 && string("hi ","there");
"hi there"
Gamma> 5>6 && string("hi ","there");
nil
```

```
Gamma> x = 5;
5
Gamma> y = 6;
6
Gamma> (x = t) || (y = 0);
t
Gamma> x;
t
Gamma> y;
6
Gamma>
```

See Also

and, not, or

Quote Operators

Quote Operators — (#, `, @)

Synopsis

```
#s_exp
`s_exp
@s_exp
```

Arguments

s_exp
Any Gamma or Lisp expression.

Returns

Does not evaluate the symbol; it returns the protected expression that follows it.

Description

Normally Gamma evaluates every expression as it parses through the code. The # operator protects the contents of an expression from the evaluator. The ` operator does the same thing, but allows for evaluation of sub-expressions. Any sub-expression tagged with @ operator that occurs within a back-ticked (`) expression will be evaluated.

Any error messages involving the @ operator will use the expression `_comma_`. This is because the @ operator in Gamma corresponds to a comma operator (`,`) in Lisp syntax. When a Gamma expression is passed to Lisp, the @ operator is converted to a comma. But if the Lisp comma operator is ever read back into Gamma, it is represented by the symbol `_comma_` to avoid confusion with the (`,`) operator used in Gamma function calls.

Examples

```
Gamma> name = "John";
"John"
Gamma> name;
"John"
Gamma> #name;
name

Gamma> x = 4;
4
Gamma> list (1,x);
```

```
(1 4)
Gamma> #list (1,x);
(list 1 x)
Gamma> list (1,#x);
(1 x)
Gamma> `list (1,x);
(list 1 x)
Gamma> `list (1,@x);
(list 1 4)
Gamma>
```

Symbol Character Operators

Symbol Character Operators — (\, $)

Synopsis

```
\symbol_character
$symbol_character_string
```

Arguments

symbol_character
: A character that is normally not valid within the string of a symbol name.

symbol_character_string
: A symbol name that contains one or more characters that are normally not valid within the string of a symbol name.

Returns

A valid symbol name.

Description

These operators allow you to put non-valid characters into a symbol name. They must be used every time the symbol is written, not just the first time.

**** makes the immediately following character valid.

$ makes the whole string valid, regardless of which individual characters are not normally valid.

Example

```
Gamma>  my\:example1 = 5;
5
Gamma>  x = my\:example1 + 7;
10
Gamma>  $my:example2 = 9;
9
```

Ternary Operator

Ternary Operator — (? :)

Synopsis

```
condition ? s_exp : s_exp
```

Arguments

condition
: Any Gamma or Lisp expression.

s_exp
: Any Gamma or Lisp expression.

Returns

The first *s_exp* if the *condition* is true, otherwise the second *s_exp*.

Examples

```
Gamma> a = t ? 2 : 8;
2
Gamma> a;
2
Gamma> b = (a == 7) ? 2 : 8;
8
Gamma> b;
8
Gamma>
```

Statements

class

class — defines a class.

Synopsis

```
class class_name [parent]
{
[instance_var [= initial_value];]
...

[static:class_var[= initial_value];]
...

}
```

Arguments

class_name
: The name of the new class.

parent
: The parent (base) class.

class_var
: Class variable definition.

instance_var
: Instance variable definition. This is provided in the form of a list of variable definitions. Each variable definition is either a variable name or a list which contains a variable name and a default value expression. Whenever a new instance is formed, the default value expression is evaluated to the default value. If no default value is given, the instance variable's value will be `nil`.

initial_value
: Initial value given to *instance_var*, if none then `nil` is assigned to that instance variable.

Returns

A class definition.

Description

This function constructs a class definition and binds the class-name symbol in the current scope to refer to that class. The class mechanism allows only a single parent (base) class.

None of the arguments to `class` is evaluated. If *`instance_vars`* are defined with the same names as inherited variables, the inherited variables are overridden and cannot be accessed by instances of this class.

- The `class` statement creates a new class.
- If the parent (base) class is omitted, or is `nil`, then the resulting class has no parent (base).
- Each instance variable consists of a name (a symbol) and an optional initial value that will be assigned whenever a new instance of the class is created using the new function.
- The resulting class definition, which is a data object in its own right, will be assigned to the symbol, name.

Example

This example creates two classes: a base class, RegPolygon; and a class derived from it, Square. RegPolygon has two attributes: sides and length. When Square is created, its parent (base) class (RegPolygon) is explicitly assigned. In addition, the attibute sides is assigned a value of 4.

```
Gamma> class RegPolygon{sides; length;}
(defclass RegPolygon nil [][length sides])
Gamma> class Square RegPolygon {sides = 4;}
(defclass Square RegPolygon [][length (sides . 4)])
```

This example creates a class with instance variables and class variables.

```
Gamma> class Other {ivar1; ivar2; static: cvar1; cvar2;}
(defclass Other nil [cvar1 cvar2][ivar1 ivar2])
Gamma>
```

See Also

Class Operators, `class_add_cvar`, `class_add_ivar`, `method`, `new`

condition

`condition` — tests conditions.

Synopsis

```
condition {case condition: statement
           [case condition: statement]
            ...
           [default: statement]}
```

Arguments

condition
: Any Gamma or Lisp expression.

statement
: Any Gamma statement.

Returns

The return value of the *statement* that corresponds to the first true *condition* or the default. Otherwise `nil`.

Description

This statement is similar to the `switch` statement, except that it takes no arguments. It checks the truth value of each *condition* in turn. The first true *condition* encountered returns with the return value of the passed *statement*. If no *condition* is true, it returns the return value of the default *statement*, (or `nil`, if no default statement is given).

The words "case" and "default" and the symbols {, :, and } are unchanging syntactical elements.

Example

```
Gamma> a = 5;
5
Gamma> b = 9;
9
Gamma> condition {case a == b: princ("Equal\n");
            case a != b: princ("Unequal\n");}
Unequal
t
Gamma>
```

Also see the example in `switch`.

See Also

`switch`

for

`for` — checks a condition and performs a statement.

Synopsis

```
for (setup ; condition ; iteration) statement
```

Arguments

setup
: An iteration setup, usually a variable with an initial value.

condition
: The condition to test.

iteration
: Any Gamma expression, usually used to increment the variable in *setup*.

statement
: Any Gamma statement.

Returns

The value of the *condition*.

Description

This statement is essentially identical to a `for` loop in C, and the syntax is the same. It checks a condition iteratively, and executes a statement when the condition is true.

Example

This `for` loop counts from 0 to 10, printing out the value of i as it loops.

```
for (i=0;i<=10;i++)
{
   princ("value of i: ", i, "\n");
}
```

See Also

Statements, `while`, `with`

function

`function` — creates a new function.

Synopsis

```
function name ([argument [,argument]... ]) statement
```

Arguments

name
The name of the function.

argument
A symbol that names the argument.

statement
The body of the function.

Returns

A named function definition in Lisp syntax. When a function is called, the return value is the value of the last expression to be evaluated in the function body.

Description

The `function` statement declares a new function. All `function` arguments are implicitly local to the scope of the function. The argument list is denoted by parentheses, and contains zero or more argument definitions, separated by commas. Each *argument* can be a symbol, which is the name of the argument, along with any combination of the following modifiers:

! before the *argument* indicates that this argument will not be evaluated when the function is called.

? after the *argument* indicates that this argument is optional. Only the first optional argument has to be marked as optional. All arguments after that are implicitly optional. An optional argument may have a default value, specified by appending = expression after the question mark.

The only way to test whether an optional function parameter has been provided is by using the predicate `undefined_p`, which tests for the `_undefined_` value.

... after the *argument* indicates that this argument is a "catch-all" argument used to implement variable length argument lists. Only the last argument in the argument list can have `...` after it. An argument modified by `...` will always be either `nil`, or a list containing all arguments from this position onward in the function call.

When a function is called, its arguments are bound in a new local scope, overriding previous definitions of those symbols for the duration of the function.

Example

This function, with one argument, returns an integer at least one greater than the argument.

```
function next (n)
{
 ceil(n) + 1;
}
```

This function prints its first two arguments and optionally prints a new line (which is printed by default). It returns a string concatenation of the first two arguments.

```
function print_two (first, second, newline?=t)
{
 princ(first, " ", second);
 if (newline)
  terpri();

 string(first, " ", second);
}
```

This function adds all of its arguments. It insists on having at least one argument. Notice that the optional character '?' and the rest character '...' are combined in the second argument.

```
function add_all (first, others...?)
{
 local sum,x = 0;
 sum = first;
 if ( !undefined_p(others) )
 {
  for(x=others;x;x=cdr(x))
   sum = sum + car(x);
 }
 sum;
}
```

See Also

`method`, Statements

if

`if` — conditionally evaluates statements.

Synopsis

```
if (condition) statement [else statement]
```

Arguments

condition
: A Gamma or Lisp expression to test.

statement
: A statement to perform if the condition is non-`nil`.

Returns

The evaluation of the *statement* that corresponds to the satisfied *condition*.

Description

The `if` statement evaluates its *condition* and tests the result. If the result is non-`nil`, then the *statement* is evaluated and the result returned.

The `else` option allows for another statement. If the *condition* is `nil`, the `else` statement (if included) is evaluated and the result returned. This statement could be another `if` statement with another condition and `else` statement, etc., permitting multiple `else/if` constructs. The entire `else` option can be omitted if desired.

- If the *condition* is `nil` and no else *statement* exists, `nil` is returned.
- The `else` part of a nested `if` statement will always be associated with the closest `if` statement when ambiguity exists. Ambiguity can be avoided by explicitly defining code blocks (using curly brackets).
- In interactive mode Gamma has to read two tokens (`if` and `else`) before it will process the statement. If you are not using an `else` part, you have to enter a second semicolon (;) to indicate that the `if` statement is ready for processing.

Example

```
Gamma> x = 5;
5
Gamma> y = 6;
6
```

```
Gamma> if (x > y) princ("greater\n"); else princ("not greater\n");
not greater
t
Gamma>
```

The following code:

```
name = "John";
age = 35;

if ((name == "Hank") || (name == "Sue"))
{
    princ("Hi ", name,"\n");
}
else if ((name == "John") && (age < 20))
{
    princ("Hi ", name," Junior\n");
}
else if ((name == "John") && (age >= 20))
{
    princ("Hi ", name," Senior\n");
}
else
{
    princ("I don't know you\n");
}
```

Will produce the following results:

```
Hi John Senior
```

See Also

Statements, for, while

local

`local` — allows for implementing local variables within functions.

Synopsis

```
local !variable [= s_exp] [, !variable [= s_exp]...];
```

Arguments

variable
: A symbol.

s_exp
: Any Gamma or Lisp expression.

Returns

The value of the *s_exp*, or `nil` if no value was assigned.

Description

This statement is provided to allow other grammars to implement local variables within functions. It defines new local variables in the current scope, overriding any outer scope that may also define those variables. Each `local` variable consists of a variable name (a symbol) and an optional initial value.

To test whether a symbol is bound in the current scope, use the predicate `undefined_p`.

Example

```
Gamma> i = 5;
5
Gamma> function print_three_local ()
{
 local i;
 for(i=1;i<=3;i++)
 {
  princ("value of i is: ", i, "\n");
 }
}
<function definition>
Gamma> function print_three_global ()
{
// local i;
```

```
 for(i=1;i<=3;i++)
 {
  princ("value of i is: ", i, "\n");
 }
}
<function definition>
Gamma> i;
5
Gamma> print_three_local();
value of i is: 1
value of i is: 2
value of i is: 3
3
Gamma> i;
5
Gamma> print_three_global();
value of i is: 1
value of i is: 2
value of i is: 3
3
Gamma> i;
4
Gamma>
```

This example shows the variable `i` receiving the value of 5. The two functions are defined identically, except for their names and where the second function comments out the 'local' command. When the first function is run the internal scoping using the local directive protects the value of `i` globally. When the function returns, `i` remains at 5, even though it was the value 1,2 and 3 within the scope of that function.

The second function has the 'local' directive commented out (using `//`), so the global variable `i` is modified. When the function returns and we check the value of `i`, it is 4. The 'for-loop' within the second function incremented the value of `i` until it failed the `i<=3` comparison. After the second function is run the value of `i` is 4. The global variable `i` has *not* been protected in the second function.

method

`method` — defines a method for a given class.

Synopsis

```
method class.method_name ([argument [, argument]...]) statement
```

Arguments

class
: The class for which this method is defined.

method_name
: The name of the method.

arguments
: The argument list for this method. This does not include the implied argument self, nor is self defined when the arguments are bound as the method is called.

statement
: The body code statment for this method. Within this statement the special variable `self` is defined as the instance on which this method is being applied.

Returns

A function definition of the resulting method function.

Description

This statement defines a method function for a given class. If a method already exists for this class with this name, the previous definition will be replaced. If a method of the same name exists for any parent (base) class of the given class, it will be overridden for instances of this class only. In Gamma methods are run using the syntax:

```
instance.method_name(arguments);
```

which is the familiar *object.method* syntax used in C++.

- The `method` syntax creates a new method for a particular class. It is an error to omit the class.
- The argument list for `method` is identical to the argument list for `function`.

Example

```
Gamma> class RegPolygon{sides; length;}
(defclass RegPolygon nil [][length sides])
```

```
Gamma> method RegPolygon.perimeter (){.sides * .length;}
(defun RegPolygon.perimeter (self) (* (@ self sides) (@ self length)))
Gamma> class Square RegPolygon {sides = 4;}
(defclass Square RegPolygon [][length (sides . 4)])
Gamma> method Square.area (){sqr(self.length);}
(defun Square.area (self) (sqr (@ self length)))
Gamma> sqB = new(Square);
{Square (length) (sides . 4)}
Gamma> sqB.length = 3;
3
Gamma> sqB.perimeter();
12
Gamma> sqB.area();
9
Gamma>
```

See Also

Class Operators, `class`, `defun`, `new`

progn, prog1

progn, prog1 — group several statements into one expression.

Synopsis

```
progn {!statement [!statement] ...}
prog1 {!statement [!statement] ...}
```

Arguments

statement
Any valid Gamma statement.

Returns

progn: the return value of the last statement.

prog1: the return value of the first statement.

Description

These two syntactical elements are not statements, but they transform a group of one or more statements into a single Gamma expression. The value of the resulting expression is the return value of the last statement for progn or the first statement for prog1. This is useful for performing complex actions where only a single expression is permitted, such as in a callback. No new scope is entered for a progn or a prog1.

The syntax of these unique elements uses curly braces { }, but don't confuse them with statements. They behave exactly like expressions.

Example

```
Gamma> a = 2;
2
Gamma> b = 5;
5
Gamma> progn{a = 3; princ("a: ",a,"\n"); c = a + b; princ("c: ",c,"\n");};
a: 3
c: 8
t
Gamma> string( prog1{a = 5; b = 1;} );
"5"
Gamma> a;
```

```
5
Gamma> b;
1
Gamma>
```

protect unwind

`protect unwind` — evaluates protected code, despite errors.

Synopsis

```
protect statement unwind statement
```

Arguments

statement
Any Gamma or Lisp statement.

Returns

If no error occurs, the result of evaluating the protect *statement* and the unwind *statement*. If an error occurs, the result of the unwind *statement* only.

Description

This function ensures that a piece of code will be evaluated, even if an error occurs within the protect *statement* code. This is typically used when an error might occur but cleanup code has to be evaluated even in the event of an error. The error condition will not be cleared by this statement. If an error occurs, control will be passed to the innermost `trap_error` function or to the outer level error handler immediately after the unwind *statement* is evaluated.

Example

This code will close its file and run a `write_all_output` function even if an error occurs.

```
if (fp=open("filename","w"))
{
        protect close(fp); unwind write_all_output();
}
```

See Also

`error`, Statements, `try catch`, Tutorial II Error Handling

switch

`switch` — tests arguments with conditions.

Synopsis

```
switch (symbol) {case condition:
                      statement
                     [statement...]

                 [case condition:
                       statement
                      [statement...]]
                  ...

                 [default:
                       statement
                      [statement...]]}
```

Arguments

symbol
: A symbol with a value to test against the value of the *condition*(s).

condition
: Any Gamma or Lisp expression.

statement
: Any Gamma statement.

Returns

The return value of the *statement* that corresponds to the first satisfied *condition* or the default. Otherwise `nil`.

Description

This statement is similar to the `condition` statement, except that it takes an argument. It checks the value of the passed *symbol* against the value of the *condition* for each case in turn. The first match returns the return value of the corresponding *statement*. If there is no match, it returns the return value of the default *statement*, if any.

The words "case" and "default" and the symbols {, :, and } are unchanging syntactical elements.

Example

```
Gamma> a = "on";
"on"
Gamma> b = 6;
6
Gamma> c = "Nothing";
"Nothing"
Gamma> switch(a) {case "on": 75; case "off": 20; default: 0;}
75
Gamma> switch(b) {case "on": 40; case "off": 10; default: princ("Huh?\n");}
Huh?
t
Gamma> switch(c) {case "on": 1; case "off": 0;}
nil
Gamma>
```

```
#!/usr/cogent/bin/gamma


/*
  This example demonstrates the switch and condition
  statements.  The switch statement checks the command
  line argument and prints a response.  The case argument
  checks the command line argument and the result of the
  switch statement.
*/

function main ()
{
        a =  number ((cadr(argv)));

        switch (a)
        {
          case 1:
                princ ("One\n");
          case 2:
                princ ("Two\n");
          case 2+1:
                princ ("Three\n");
          case 4:
                princ ("Four\n");
          default:
                princ ("Something else: ", a, "\n");
        }
```

```
        condition
        {
          case a == 1:
                princ ("Condition a == 1\n");
          case cadr(argv) == "Hello":
                princ ("Condition a == Hello\n");
          default:
                princ ("No condition met\n");
        }
}
```

See Also

condition

try catch

`try catch` — catches errors in the body code.

Synopsis

```
try statement catch statement
```

Arguments

statement
Any Gamma or Lisp statement.

Returns

If no error occurs, the result of evaluating the `try` *statement*. If an error occurs, the result of the `catch` *statement*.

Description

This statement catches any errors that may occur while evaluating the `try` *statement* code. If no error occurs, then `try catch` will finish without ever evaluating the `catch` *statement*. If an error does occur, `try catch` will evaluate the catch *statement* code immediately and the error condition will be cleared. This is usually used to protect a running program from a piece of unpredictable code, such as an event handler. If the error is not caught it will be propagated to the top-level error handler, causing the interpreter to go into an interactive debugging session.

Example

The following code:

```
#!/usr/cogent/bin/gamma

try
{
   2 + nil;
}
catch
{
   princ("Error:\n", _error_stack_, "\n");
}
```

Will give these results:

```
Error:
```

```
((trap_error #0=(+ 2 nil) (princ Error:
 _error_stack_
)) #0#)
```

The following piece of code will run an event loop and protect against an unpredictable event.

```
while(t)
{
     try (next_event()) catch (print_trapped_error());
}

function print_trapped_error ()
{
     princ("Error:\n", _error_stack_, "\n");
     princ("Clearing error condition and continuing.\n");
}
```

See Also

error, Statements, trap_error, protect unwind, Tutorial II Error Handling

while

`while` — iterates, evaluating a statement.

Synopsis

```
while (condition) statement
```

Arguments

`condition`
: Any Gamma or Lisp expression.

`statement`
: Any Gamma or Lisp statement.

Returns

The value of *`condition`* at the final iteration.

Description

This function iterates until its *`condition`* evaluates to `nil`, evaluating the *`statement`* at each iteration. The *`condition`* is evaluated before the *`statement`*, so it is possible for a `while` loop to iterate zero times.

Example

```
Gamma> x = 0;
0
Gamma> while (x < 5) { princ (x, "\n"); x++; }
0
1
2
3
4
4
Gamma> x;
5
Gamma>
```

See Also

`for`, `if`, Statements

with

`with` — traverses an array or list performing a statement.

Synopsis

```
with symbol in|on s_exp do statement

with symbol1 in|on s_exp symbol2 = collect|tcollect statement
```

Arguments

symbol
: Any Gamma or Lisp symbol.

s_exp
: Any Gamma or Lisp expression.

statement
: Any statement.

Returns

`nil` when using the do option, and the result of the *statement* when using the `collect` or `tcollect` option.

Description

`with` *symbol* `in|on` *s_exp* `do` *statement*

- A `with` loop using the iteration style `in` traverses an array or list as defined by an expression (*s-exp*), performing the *statement* with the iteration *symbol* assigned to each element of the array or list in turn.
- A `with` loop using the iteration style on traverses a list defined by an expression (*s-exp*), performing the *statement* with the iteration *symbol* assigned to the car and then successive cdrs of the list.
- The iteration *symbol* is local in scope to the `with` statement.

`with` $symbol_1$ `in|on` *s_exp* $symbol_2$ `= collect|tcollect` *statement*

- A `with` loop using the `collect` directive will collect the results of the *statement* for each iteration, and produce an array or list (depending on the type of the original array or list), whose elements correspond on a one-to-one basis with the elements of the original array or list.
- A `with` loop using the `tcollect` directive will collect the results of the *statement* at each iteration, ignoring `nil` results in the body. The resulting array or list will not have a

one-to-one correspondence with the original array or list.

- The result of a `with` loop using `collect` or `tcollect` will be assigned to *symbol*$_2$, which is not local in scope to the `with` statement. The iteration *symbol*$_1$ is local in scope to the `with` statement.

Examples

```
Gamma> A = array(1,2,3,4);
[1 2 3 4]
Gamma> with x in A do
{
x = x + 1;
princ(x, "\n");
}
2
3
4
5
nil

Gamma>

Gamma>  L = list (1, 2, 3, 4, 5, 6);
(1 2 3 4 5 6)
Gamma> with x on L do (princ(x,"\n"));
(1 2 3 4 5 6)
(2 3 4 5 6)
(3 4 5 6)
(4 5 6)
(5 6)
(6)
nil
nil
Gamma> with x in L y = collect x + 2;
(3 4 5 6 7 8)
Gamma> y;
(3 4 5 6 7 8)
Gamma> with x in L y = tcollect x < 4 ? x : nil;
(1 2 3)
Gamma> y;
(1 2 3)
Gamma>
```

See Also

`for`, `if`, Statements

Core Functions

call

`call` — calls a class method for a given instance.

Synopsis

```
call (instance, method, !argument...)
call (instance, class, method, !argument...)
```

Arguments

instance
: An instance of a class.

method
: A method name defined for the class of the instance.

class
: A class name.

argument
: The arguments to the method.

Returns

The result of calling the named method on the given instance with the provided arguments.

Description

This function explicitly calls a class method for the provided instance, using the same argument list as would be required for a call using `(instance method ...)` syntax in Lisp, or the `instance.method (...)` syntax in Gamma. The second syntax of this function provides a means for calling an explicit class method even if the class of the instance overloads the method name. Notice that the arguments to call are all evaluated.

Example

This example is based on the class and method developed in `method`.

```
Gamma> call(sqB, Square, #perimeter);
12
Gamma> call(sqB, Square, #area);
9
```

```
Gamma>
```

See Also

method

class_add_cvar

`class_add_cvar` — adds new class variables.

Synopsis

```
class_add_cvar (class variable init_value? type?);
```

Arguments

`class`
: The class receiving the new class variable.

`variable`
: The new variable to add to the class.

`init_value`
: Optional argument for initial value of the variable.

`type`
: Optional argument for the type of variable.

Returns

The value of the new argument.

Description

This function adds new class variables to either binary (built-in) or user-defined classes. Class variables are special variables that are available to be set/read by any instance of the class, as well as any derived classes or their instances, whether they were created before or after the class variable was defined.

Example

This example is based on the class and method developed in `method`.

```
Gamma> class_add_cvar(RegPolygon, #linethickness, 2);
2
Gamma> polyD = new(RegPolygon);
{RegPolygon (length) (sides)}
Gamma> polyD.linethickness;
2
Gamma> sqB.linethickness;
```

```
2
Gamma>
```

See Also

class_add_ivar

class_add_ivar

`class_add_ivar` — adds an instance variable to a class.

Synopsis

```
class_add_ivar (class, variable, init_value?, type?)
```

Arguments

class
: A class.

variable
: A symbol to be used as the instance variable name.

init_value
: Any Gamma or Lisp expression to be used as an initial value.

type
: An integer number which will be stored with the instance variable. This type is not used by the interpreter, and may be anything.

Returns

The value of the *init_value*.

Description

This function dynamically adds an instance variable to a class. All instances of that class which are created after this call will contain this instance variable. All instances created before this call will not contain this instance variable. This function is typically called on a class before any instances are created. It is too late to call this function within an instance constructor. All subclasses of this class will inherit the new instance variable. If the ivar already exists on the class, the only effect of this function is to change the default value.

Example

This example is based on the class and method developed in `method`. The instance sqB does not have "color" as an instance variable because it was created before the instance variable "color" was added.

```
Gamma> class_add_ivar(Square, #color, "red", 12);
"red"
Gamma> sqC = new(Square);
{Square (color . "red") (length) (sides . 4)}
```

```
Gamma> sqB;
{Square (length . 3) (sides . 4)}
Gamma>
```

See Also

instance_vars

class_name

`class_name` — gives the name of the class.

Synopsis

```
class_name (class|instance)
```

Arguments

class|instance

A class or instance of a class.

Returns

The name of the class, as a symbol.

Example

This example is based on the class and method developed in `method`.

```
Gamma> y = Square;
(defclass Square RegPolygon [(area .(defun Square.area (self)
                             (sqr (@ self length))))][length (sides . 4)])
Gamma> class_name(y);
Square
Gamma> box = new(Square);
{Square (length) (sides . 4)}
Gamma> class_name(box);
Square
Gamma>
```

See Also

`class_of`

class_of

class_of — gives the class definition of a given instance.

Synopsis

```
class_of (instance)
```

Arguments

instance
: An instance of a class.

Returns

The class of the *instance*.

Description

This function returns the class definition of the *instance*. If the *instance* belongs to a derived class, the most precise class definition is returned (the class which was used to create the instance through a call to new).

Example

This example is based on the class and method developed in method.

```
Gamma> class_of(sqB);
(defclass Square RegPolygon [(area . (defun Square.area (self)
                              (sqr (@ self length))))][length (sides . 4)])
Gamma>
```

See Also

class_name

defclass

`defclass` — is the function equivalent of the `class` statement.

See

`class`

defmacro, defmacroe

`defmacro, defmacroe` — are the Lisp equivalents of the `macro` function.

Synopsis

```
defmacro (!name, !args, !expression...)
defmacroe (name, args, expression...)
```

This version of the `macro` function is only supported by Lisp. See `macro`.

defun, defune,

`defun`, `defune` — are the function equivalents of the `function` statement.

See

`function`

defmethod

`defmethod` — is the function equivalent of the `method` statement.

See

`method`

defvar

`defvar` — defines a global variable with an initial value.

Synopsis

```
defvar (!symbol, value, constant_p?)
```

Arguments

symbol

A variable name which has not yet been assigned a value.

value

Any s_exp.

constant_p

If non-`nil`, the symbol will be assigned as a constant.

Returns

The value of the symbol.

Description

This function defines a global variable with an initial value. If the *constant_p* argument is present and non-`nil`, then the *symbol* becomes a constant, and any attempt to set its value in any scope will fail. If the *symbol* already has a value and *constant_p* is non-`nil` or absent, then `defvar` will return immediately with the current value of the *symbol*. If *constant_p* is non-`nil` and the *symbol* already has a value, then an error is generated.

The intent of `defvar` is to provide a value for a symbol only if that symbol has not yet been defined. This allows a Gamma or Lisp file to contain default symbol values which may be overridden before the file is loaded.

Example

```
Gamma> defvar(a,7,t);
7
Gamma> a;
7
Gamma> a = 5;
Assignment to constant symbol: a
debug 1>

Gamma> b = 9;
```

```
9
Gamma> defvar(b,10);
9
Gamma> b;
9
Gamma>
```

See Also

set

destroy

`destroy` — destroys a class instance.

Synopsis

```
destroy (instance)
```

Arguments

instance
: An instance of any class.

Returns

`t` when successful, else error.

Description

This function destroys instances of classes. When a class instance is destroyed, its data type changes to *destroyed instance* You can test for a destroyed instance by using the predicate `destroyed_p`.

Example

```
Gamma> class RegPolygon{sides; length;}
(defclass RegPolygon nil [][length sides])
Gamma> polyA = new(RegPolygon);
{RegPolygon (length) (sides)}
Gamma> destroy (polyA);
t
Gamma> polyA;
#<Destroyed Instance>
Gamma> destroyed_p(polyA);
t
Gamma>
```

See Also

`class`, `new`

eq, equal

eq, equal — compare for identity and equivalence.

Synopsis

```
eq (s_exp, s_exp)
equal (s_exp, s_exp)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

eq returns t if the two arguments are exactly the same Gamma or Lisp element, otherwise nil. equal returns t if the two arguments "look" the same but are not necessarily pointers to the same memory.

Description

The interpreter's storage mechanism allows a particular element to be referenced from more than one location. Functions like cons and list do not copy their arguments, but simply construct a higher level entity (in these cases a list) which refers to their arguments. The copy function will create a new top-level structure but maintain references to the sub-elements of the original list. The eq function tests to see whether two elements are in fact references to the same element. The equal function determines whether two elements have identical contents, but are not necessarily references to the same element. All things which are eq are also equal. Things which are equal are not necessarily eq.

The equal function will travel lists, arrays and instances to compare sub-elements one at a time. The two elements will be equal if all of their sub-elements are equal. Numbers are compared based on actual value, so that equal(3, 3.0) is t. Strings are compared using strcmp.

Symbols are always unique. A symbol is always eq to itself.

Example

```
Gamma> a = #acme;
acme
Gamma> b = #acme;
acme
```

```
Gamma> equal(a,b);
t
Gamma> eq(a,b);
t

Gamma> a = "acme";
"acme"
Gamma> b = "acme";
"acme"
Gamma> equal(a,b);
t
Gamma> eq(a,b);
nil

Gamma> equal(5,5);
t
Gamma> eq(5,5);
nil

Gamma> x = list(#acme, list(1,2,3), "hi");
(acme (1 2 3) "hi")
Gamma> y = copy (x);
(acme (1 2 3) "hi")
Gamma> equal(x,y);
t
Gamma> eq(x,y);
nil
Gamma> equal(cadr(x),cadr(y));
t
Gamma> eq(cadr(x),cadr(y));
t
Gamma>
```

See Also

Comparison Operators

error

`error` — redirects the interpreter.

Synopsis

```
error (string)
```

Arguments

`string`
A string.

Returns

This function does not return.

Description

The `error` function causes the interpreter to immediately stop what it is doing and to jump to the innermost `trap_error`, `unwind_protect`, interactive session or interprocess communication event handler. The value of `_last_error_` is set to the argument string.

Example

This function will return its argument if the argument is a number, or generate an error and never return if the argument is not a number.

```
function check_number (n)
{
    if (!number_p(n))
 {
           error(string(n," is not a number."));
 }
    n;
}
```

This statement will immediately cause an error if the user presses **`Ctrl-C`** at the keyboard. This is useful for breaking a running program and going to a debugging prompt.

```
signal (SIGINT, #(error ("Keyboard Interrupt")))
```

See Also

`trap_error`, `unwind_protect`

eval

`eval` — evaluates an argument.

Synopsis

```
eval (s_exp)
```

Arguments

s_exp
Any Gamma or Lisp expression.

Returns

The result of evaluating the argument. Note that the argument is also evaluated as part of the function calling mechanism.

Description

The `eval` function forms the basis for running a Gamma program. Every data type has a defined behavior to the `eval` call. These are:

- **symbol** Look up the symbol in the current scope and return the value bound to the symbol. If the symbol is not bound, generate an "Undefined symbol" error.
- **list** Evaluate the first element of the list. If the result is a function, call that function with the rest of the list as arguments. If the first element evaluates to an instance of a class, look up the second element as the method name and resolve that method name in the class or its ancestors. Call the method with the instance bound to self and all other list elements as arguments.
- **all others** All other data types evaluate to themselves.

The `eval` function can be useful when constructing code which must be conditionally executed at a later date, and passed about as data until that time. It may be useful to provide a piece of code as an argument to a generic function so that the function can evaluate it as part of its operation.

Example

Note: The # operator is used to protect an expression from evaluation. See Quote Operators for more information.

```
Gamma> a = 5;
```

```
5
Gamma> b = #a;
a
Gamma> b;
a
Gamma> eval(b);
5
Gamma>
```

See Also

eval_list

eval_list

`eval_list` — evaluates each element of a list.

Synopsis

```
eval_list (list)
```

Arguments

list
: A list.

Returns

A new list whose elements are the results of evaluating each of the elements of the argument *list* in turn.

Description

Evaluates each element of the *list*. Returns the results as a new list whose elements correspond on a one-to-one basis with the elements of the *list*.

Example

The # operator is used to protect an expression from evaluation. See Quote Operators for more information.

```
Gamma> a = 5;
5
Gamma> b = 3;
3
Gamma> c = list (#a, #b, "Their sum", #(a+b));
(a b "Their sum" (+ a b))
Gamma> eval_list(c);
(5 3 "Their sum" 8)
Gamma>
```

See Also

eval

eval_string

`eval_string` — evaluates a string.

Synopsis

```
eval_string (string, use_parser?)
```

Arguments

string
: A string.

use_parser
: `t` specifies that the string should be parsed as Gamma code instead of LISP code.

Returns

The result of evaluating the *string* as if it were a Lisp expression.

Description

This function evaluates a string as if it were a Lisp expression, regardless of whether the file syntax is Gamma or Lisp.This function could be written in Lisp as:

```
(defun eval_string (string) (let ((x (parse_string string))) (eval
x)))
```

Example

```
Gamma> eval_string("(+ 5 6)");
11
Gamma> testvalue = 75;
75
Gamma> eval_string("testvalue");
75
Gamma>
```

force, forceq, forceqq

force, forceq, forceqq — assign a value to a symbol, forcing the evaluation of change functions for the symbol.

Synopsis

```
force (symbol, s_exp)
forceq (!symbol, s_exp)
forceqq (!symbol, !s_exp)
```

Arguments

symbol
A symbol.

s_exp
Any Gamma or Lisp expression.

Returns

The *s_exp* argument.

Description

These functions are idential to the set, setq, and setqq, functions, except in addition to assigning a value to a symbol, and being the functional equivalent of the = (assignment) operator, these functions force Gamma to evaluate the change functions for the symbol even if the value has not changed.

This function is particularly useful when working with DataHub points that contain arrays. Gamma handles arrays from the DataHub program by mapping them automatically into Gamma arrays, so you can address individual elements. However, in Gamma, if you have a DataHub array point, represented as `$default:myarray`, you can modify an element of the array normally, such as `$default:myarray[0] = 17`; but that does not automatically write back to the DataHub instance, so nothing gets updated. You have to rewrite the point. Logically you would do this: `$default:myarray = $default:myarray`; to reassign the point. But this is a null operation since you are just assigning the same value again to the point. Using `force`, `forceq`, `forceqq` like this: `force(#$default:myarray, $default:myarray);` forces the point change to be sent back to the DataHub instance.

The `force` function evaluates both of its arguments, `forceq` evaluates only its second argument, and `forceqq` evaluates neither of its arguments. A symbol's value is the value returned as a result of evaluating that symbol. Symbols constitute the Lisp mechanism for representing variables. These functions can only affect the value of a symbol in the current scope.

See Also

Assignment Operators, set, setq, setqq

funcall

`funcall` — provides compatibility with other Lisp dialects.

Synopsis

```
funcall (function, args)
```

Arguments

function
  A function definition.

args
  The arguments to the function.

Returns

The result of the function.

Description

This is provided for compatibility with some other dialects of Lisp. Gamma's version of Lisp, SCADALisp, does not need this function as function definitions can be bound directly to any symbol and called by naming that symbol.

Occasionally this function can use useful in Gamma if a large number of variable arguments are being passed to a function. The called function is named as the first argument and the list of arguments to pass to it are passed as a list in the second arg.

Example

```
Gamma> funcall(atan2, list(5,3));
1.0303768265243125057
Gamma> function plus6 (a,b,c,d,e,f) a+b+c+d+e+f;
(defun plus6 (a b c d e f) (+ (+ (+ (+ (+ a b) c) d) e) f))
Gamma> funcall(plus6, list(1,2,3,4,5,6));
21
Gamma>
```

See Also

`defun`, `function`

function_args

`function_args` — lists the arguments of a function.

Synopsis

```
function_args (function)
```

Arguments

function
: Any function name.

Returns

A list of the arguments of *function*.

Description

This function lists the arguments of any function. Each argument is returned in the form of an association list, whose first element is the function argument, and whose second element represents the argument modifier(s), if any. The hex numbers that correspond to function modifiers are as follows:

- **0x20000000** Optional (?).
- **0x40000000** Variable length argument (...).
- **0x80000001** Not evaluated (!).

Example

```
Gamma> function_args(getprop);
((symbol 0) (property 0))
Gamma> function_args(drain);
((file 0) (t_or_nil 0))
Gamma> function_args(gc);
nil
Gamma> function_args(defvar);
((symbol -2147483648) (value 0) (constant? 536870912))
Gamma> function_args(read);
((file 0))
Gamma> function g (a,b,c) {((a * b)/c);}
(defun g (a b c) (/ (* a b) c))
Gamma> function_args(g);
((a 0) (b 0) (c 0))
```

```
Gamma>
```

See Also

function_body, function_name

function_body

`function_body` — gives the body of a user-defined function.

Synopsis

```
function_body (function)
```

Arguments

function

Any function.

Returns

The function definition in Lisp syntax if the function is user-defined, else `nil`.

Description

This function shows the body of a user-defined function in Lisp syntax.

Example

```
Gamma> function g(a,b,c) {(a * b)/c;}
(defun g (a b c) (/ (* a b) c))
Gamma> function_body(g);
#0=((/ (* a b) c))
Gamma> function h(r,s) {sin(r)/cos(s) * tan(s);}
(defun h (r s) (* (/ (sin r) (cos s)) (tan s)))
Gamma> function_body(h);
#0=((* (/ (sin r) (cos s)) (tan s)))
Gamma> function_body(sort);
nil
Gamma>
```

See Also

`function_args`, `function_name`

function_name

`function_name` — gives the name of a function.

Synopsis

```
function_name (function)
```

Arguments

function
Any function.

Returns

The name of the function.

Example

```
Gamma> function grand(a,b,c) {(a * b)/c;}
(defun grand (a b c) (/ (* a b) c))
Gamma> function_name(grand);
grand
Gamma> s = grand;
(defun grand (a b c) (/ (* a b) c))
Gamma> function_name(s);
grand

Gamma> function f () { nil; }
(defun f () nil)
Gamma> function g (x) { princ (function_name(x), "\n"); }
(defun g (x) (princ (function_name x) "\n"))
Gamma> g (f);
f
t
Gamma>
```

See Also

function_args, function_body

getprop

`getprop` — returns a property value for a symbol.

Synopsis

```
getprop (symbol, property)
```

Arguments

symbol
: A symbol.

property
: A symbol naming the property to be fetched.

Returns

The value of the property for the given symbol, or `nil` if the property is not defined.

Description

Return the value of the property for the given symbol. Once a property has been set for a symbol, it will remain as long as the Gamma program is running.

Example

```
Gamma> tag001 = 5.5;
5.5
Gamma> setprop(#tag001, #maxlimit,10);
nil
Gamma> getprop(#tag001, #maxlimit);
10
Gamma> getprop(#tag001, #minlimit);
nil
Gamma>
```

See Also

`properties`, `setprop`, `setprops`

has_cvar

has_cvar — queries for the existence of a class variable.

Synopsis

```
has_cvar (instance|class, variable)
```

Arguments

instance|class
: An instance of a class; or a class.

variable
: An class variable name, as a symbol.

Returns

`t` if any instance, class or any parent (base) class contains the variable, otherwise `nil`.

Description

This function checks for the existence of class variables for a class or instance of a class. It searches all parent (base) classes.

Example

This example is based on the class and method developed in `method` and `class_add_cvar`. The variable name is preceded by # to prevent evaluation. See Quote Operators for more information.

```
Gamma> RegPolygon;
#0=(defclass
    RegPolygon nil [(linethickness . 2)
                    (perimeter . (defun RegPolygon.perimeter (self)
                                  (* (@ self sides) (@ self length))))]
                   [length sides])
Gamma> polyD;
{RegPolygon (length) (sides)}
Gamma> Square;
(defclass Square RegPolygon [(area . (defun Square.area (self)
                                      (sqr (@ self length))))]
                            [length (sides . 4)])
Gamma> sqB;
{Square (length) (sides . 4)}
```

```
Gamma> has_cvar(RegPolygon, #linethickness);
t
Gamma> has_cvar(polyD, #linethickness);
t
Gamma> has_cvar(Square, #linethickness);
t
Gamma> has_cvar(sqB, #linethickness);
t
Gamma>
```

See Also

class_add_cvar

has_ivar

has_ivar — queries for the existence of an instance variable.

Synopsis

```
has_ivar (instance|class, variable)
```

Arguments

instance|class
An instance of a class; or a class.

variable
An instance variable name, as a symbol.

Returns

t if the instance or class contains the named instance variable, or if any parent (base) of the class contains the instance variable, otherwise nil.

Description

This function queries an instance or class to determine whether a given instance variable exists for that instance or class. When querying classes, if any parent (base) of that class contains the given instance variable, this function returns t. It is possible for a class to contain an instance variable, and an instance of that class not to contain it, but only if class_add_ivar was called after the instance was created. See class_add_ivar for details.

Example

This example is based on the class and method developed in method. The variable name is preceded by # to prevent evaluation. See Quote Operators for more information.

```
Gamma> Square;
(defclass Square RegPolygon [(area . (defun Square.area (self)
                                       (sqr (@ self length))))]
                            [length (sides . 4)])
Gamma> sqB;
{Square (length) (sides . 4)}
Gamma> has_ivar(Square, #sides);
t
Gamma> has_ivar(Square, #perimeter);
```

```
nil
Gamma> has_ivar(sqB, #area);
nil
Gamma> has_ivar(sqB, #length);
t
Gamma>
```

See Also

class_add_ivar

instance_vars

`instance_vars` — finds all the instance variables of a class or instance.

Synopsis

```
instance_vars (instance|class)
```

Arguments

instance|class
An instance of a class, or a class.

Returns

An array of all instance variables defined for the given *instance* or *class*. If an instance is queried, then the values of all instance variables for that instance are also reported.

Description

Queries the instance variables of a class or instance.

Example

This example is based on the class and method developed in `method`, `class_add_ivar` and `class_add_cvar`.

```
Gamma> polyD;
{RegPolygon (length) (sides)}
Gamma> sqB;
{Square (length) (sides . 4)}
Gamma> instance_vars(RegPolygon);
[length sides]
Gamma> instance_vars(polyD);
[(length) (sides)]
Gamma> instance_vars(Square);
[length (sides . 4)]
Gamma> instance_vars(sqB);
[(length) (sides . 4)]
Gamma>
```

See Also

`class`, `class_add_cvar`, `class_add_ivar`

is_class_member

is_class_member — checks if an instance or class is a member of a class.

Synopsis

```
is_class_member (instance|class, class)
```

Arguments

instance|class
: An instance of a class; or a class.

class
: A class.

Returns

t if the *instance* or *class* is a member of the *class*, else nil.

Description

This function checks if a given instance or class is a member (an instance or derived class) of another class.

Example

This example is based on the classes developed in class.

```
Gamma> sqB = new(Square);
{Square (length) (sides . 4)}
Gamma> is_class_member(sqB, Square);
t
Gamma> is_class_member(Square, RegPolygon);
t
Gamma> is_class_member(sqB, RegPolygon);
t
Gamma> polyF = new(RegPolygon);
{RegPolygon (length) (sides)}
Gamma> is_class_member(polyF, Square);
nil
Gamma>
```

See Also

new

ivar_type

ivar_type — returns the type of a given instance variable.

Synopsis

```
ivar_type (instance, variable)
```

Arguments

instance

A class instance.

variable

An instance variable name, as a symbol.

Returns

nil if the instance does not contain the variable, or the instance variable type, as assigned by class_add_ivar.

Description

This function returns the instance variable type for a given instance variable. The instance variable type is not used internally by the Gamma or Lisp engine.

Example

```
Gamma> ivar_type(Osinfo,#cpu);
1
```

See Also

class_add_ivar

macro

`macro` — helps generate custom functions.

Synopsis

```
macro name (args) statement
```

Arguments

name
: The name of the macro.

args
: An argument list.

statement
: The body of the macro.

Returns

A named macro definition in Lisp syntax.

Description

This function lets Gamma generate custom functions. The most common type of macro is one that will call different functions for different kinds of arguments. Once the macro has been called on a specific kind of argument, successive calls to the macro for that kind of argument will not be processed by the macro at all, but will be handed straight over to its corresponding function.

One advantage is speed, as the macro code is only executed once. Thereafter only the corresponding function code is executed.

Example

1. Define a macro. This macro checks its arguments to see if they are symbols or strings, and performs correspondingly different operations on them.

```
macro symbol_number (!x,!y)
{
   if (symbol_p(x) && symbol_p(y))
      string(string(x),string(y));
   else if (symbol_p(x) && number_p(y))
      `setq(@x,@y);
   else if (number_p(x) && symbol_p(y))
```

```
      `setq(@y,@x);
   else if (number_p(x) && number_p(y))
      y + x;
   else
      error(string("Error: I accept only symbols and numbers."));
}
```

2. Calling the macro gives these results:

```
Gamma> symbol_number(st,art);
"start"
Gamma> symbol_number(myvalue,35);
35
Gamma> myvalue;
35
Gamma> symbol_number(40,yourvalue);
40
Gamma> yourvalue;
40
Gamma> symbol_number(35,40);
75
Gamma>
```

3. Define a function that includes the macro, and then call that function.

```
Gamma> function f(x,y) {symbol_number(b,3);}
(defun f (x y) (symbol_number b 3))
Gamma> f(#r,7);
3
Gamma>
```

4. Check the function definition. Note that the macro code is now gone. In its place is `setq`, the function it calls for the specified kind of argument.

```
Gamma> f;
(defun f (x y) (setq b 3))
Gamma>
```

See Also

function

new

new — creates a new instance of a class.

Synopsis

```
new (class)
```

Arguments

class
The name of an existing class.

Returns

A new instance of the *class*.

Description

The new function creates a new instance of the specified class and initializes any instance variables which have default values associated with them, or assigns them to nil if there is no default specified.

An instance is represented by an open brace, followed by the class name, followed by a sequence of dotted pairs (dotted lists of two elements), each containing an instance variable name and a value, followed by a closing brace. Note that (x . nil) is the same as (x). For example, an object of the class PhPoint would be {PhPoint (x . 5) (y . 0)}.

An instance can be destroyed by destroy.

Example

```
Gamma> class RegPolygon{sides; length;}
(defclass RegPolygon nil [][length sides])
Gamma> class Square RegPolygon {sides = 4;}
(defclass Square RegPolygon [][length (sides . 4)])
Gamma> polyA = new(RegPolygon);
{RegPolygon (length) (sides)}
Gamma> sqC = new(Square);
{Square (length) (sides . 4)}
Gamma>
```

See Also

class, destroy

parent_class

`parent_class` — returns the closest parent (base) of a class or instance.

Synopsis

```
parent_class (instance|class)
```

Arguments

instance|class
: An instance of a class; or a class.

Returns

The closest parent (base) class of the *instance* or *class*.

Description

This function returns the closest (immediate) parent (base) class of the class or instance provided.

Example

```
Gamma> class RegPolygon{sides; length;}
(defclass RegPolygon nil [][length sides])
Gamma> class Square RegPolygon {sides = 4;}
(defclass Square RegPolygon [][length (sides . 4)])
Gamma> class BigSquare Square {length = 30;};
(defclass BigSquare Square [][(length . 30) (sides . 4)])
Gamma> polyA = new(RegPolygon);
{RegPolygon (length) (sides)}
Gamma> sqC = new(Square);
{Square (length) (sides . 4)}
Gamma> bigD = new(BigSquare);
{BigSquare (length . 30) (sides . 4)}
Gamma> parent_class(polyA);
nil
Gamma> parent_class(sqC);
(defclass RegPolygon nil [][length sides])
Gamma> parent_class(bigD);
(defclass Square RegPolygon [][length (sides . 4)])
Gamma> parent_class(Square);
(defclass RegPolygon nil [][length sides])
```

```
Gamma> parent_class(BigSquare);
(defclass Square RegPolygon [][length (sides . 4)])
Gamma>
```

See Also

class

print_stack

`print_stack` — prints a Gamma stack.

Synopsis

```
print_stack (file?, stack)
```

Arguments

file
: The name of a file.

stack
: The stack you wish to print.

Returns

`t` if successful, else `nil`.

Description

This function causes Gamma to print a stack, such as `_error_stack_`, `_eval_stack_`, `_jump_stack_`, or `_unwind_stack_`. See Predefined Symbols for more details about these.

Example

```
Gamma> try (2 + nil); catch print_stack(_eval_stack_);
trap_error + print_stack
t
Gamma>
```

See Also

Predefined Symbols

properties

`properties` — should never be used.

Synopsis

```
properties (symbol)
```

Arguments

`symbol`
Any symbol.

Returns

The property list for the given symbol.

Description

This function should never be used. Property lists are designed to be handled by the `getprop` and `setprop` functions. Property lists may be represented internally by a number of mechanisms, so the type and structure of the return from this function may change at any time.

See Also

`getprop`, `setprop`, `setprops`

quote, backquote

`quote`, `backquote` — correspond to Quote Operators.

Synopsis

```
quote (s_exp)
backquote (s_exp)
```

Arguments

s_exp
Any Gamma or Lisp expression.

Returns

The *s_exp*, without evaluation.

Description

These are the functional equivalents of the Quote Operators. `quote` is identical to the # quote operator. `backquote` is identical to the ` quote operator.

See

Quote Operators

require, load

`require, load` — load files.

Synopsis

```
require (filename)
load (filename)
require_lisp (filename)
load_lisp (filename)
required_file (filename)
_require_path_ (filename)
```

Arguments

filename
The name of a file, as a string.

Returns

The name of the file, as a string.

Description

The `require` function loads the named file the first time that it is called. Subsequent calls to `require` with the same filename will simply be ignored. This provides a means for specifying dependencies for applications containing multiple files.

The `load` function loads the named file every time it is called. It attempts to open the named file, read expressions and evaluate them one at a time until the end of file is reached. `load` attempts to find the file by prepending each of the entries in `_require_path_` to the filename. If the file is not found, then `load` appends each of the entries in `_load_extensions_` to the path resulting from concatenating `_require_path_` and filename. If the file is still not found, `nil` is returned. If a different grammar has been defined for the loader, then that grammar will be used to read the file.

`require_lisp` and `load_lisp` operate similarly to `require` and `load`, except they treat any file as a Lisp file. This is helpful when using Lisp libraries with alternate grammars such as Gamma or user-defined grammars.

`required_file` determines which file would be loaded as the result of a call to `require` or `require_lisp`, but does not actually load it. This can be useful in debugging to determine where a particular function or file is coming from.

The pre-defined global variable `_require_path_` contains a list of the paths to be searched to find the specified filename. This variable is initialized to ("" "/usr/cogent/lib"), which references the current directory and the standard location for cogent libraries. The list of paths can be augmented with:

```
_require_path_ = cons ("my_directory_name", _require_path_);
```

Example

```
Gamma> require("x/myfile.dat");
"x/myfile.dat"
Gamma> require("x/myfile.dat");
t
Gamma> load("x/myfile.dat");
"x/myfile.dat"
Gamma> required_file("x/myfile.dat");
t
Gamma> require_lisp("myfileli.dat");
nil
Gamma>
```

See Also

Loading Files

set, setq, setqq

`set`, `setq`, `setqq` — assign a value to a symbol.

Synopsis

```
set (symbol, s_exp)
setq (!symbol, s_exp)
setqq (!symbol, !s_exp)
```

Arguments

symbol
: A symbol.

s_exp
: Any Gamma or Lisp expression.

Returns

The *s_exp* argument.

Description

These functions assign a value to a symbol, and are the functional equivalent of the = (assignment) operator. Normally in Gamma the = operator is used for assignment, but these functions give more control over evaluation of symbols and expressions at the point of assignment.

The `set` function evaluates both of its arguments. `setq` evaluates only its second argument and `setqq` evaluates neither of its arguments. The most commonly used of these functions is `setq`. A symbol's value is the value returned as a result of evaluating that symbol. Symbols constitute the Lisp mechanism for representing variables. These functions can only affect the value of a symbol in the current scope.

Example

```
Gamma> setq(y, 6);
6
Gamma> setq(x, #y);
y
Gamma> set(x, 5);
5
Gamma> x;
y
```

```
Gamma> y;
5
Gamma>
```

See Also

Assignment Operators, `force`

setprop

`setprop` — sets a property value for a symbol.

Synopsis

```
setprop (symbol, property, value)
```

Arguments

symbol
: The symbol whose property will be set.

property
: A symbol which identifies the property to be set.

value
: The new value of the property.

Returns

The previous value for that property, or `nil` if there was no previous value.

Description

All symbols in Gamma may have properties assigned to them. These properties are not limited by the scope of the symbol, so that a symbol's property list is always global. A property consists of a (name . value) pair. Property lists are automatically maintained by `setprop` to ensure that each property name is unique for a symbol. A symbol may have any number of properties. A property for a symbol is queried using `getprop`.

The *symbol* and *property* are normally protected from evaluation when setting properties, using the # operator.

Example

```
Gamma> setprop(#weight,#hilimit,1000);
nil
Gamma> setprop(#weight,#hiwarning,950);
nil
Gamma> setprop(#weight,#lowlimit,500);
nil
Gamma> setprop(#weight,#lowwarning,550);
nil
Gamma> getprop(#weight,#hilimit);
1000
```

```
Gamma> getprop(#weight,#lowwarning);
550
Gamma>
```

See Also

getprop, properties, setprops

setprops

`setprops` — lists the most recent property value settings.

Synopsis

```
setprops (symbol, properties)
```

Arguments

symbol
: The symbol whose properties will be listed.

properties
: Any property.

Returns

A list of properties with their most recent values, as associated pairs.

Description

This function is used to get a list of all the properties and their associated values as (name . value) pairs. It is called using any of the symbol's properties. The list contains current values in order from the most to least recently entered.

The *symbol* and *property* are normally protected from evaluation when setting properties, using the # operator.

Example

```
Gamma> setprop(#weight,#hilimit,1000);
nil
Gamma> setprop(#weight,#lowlimit,500);
nil
Gamma> setprop(#weight,#warning,950);
nil
Gamma> setprop(#weight,#warning,975);
950
Gamma> setprops(#weight,#hilimit);
((warning . 975) (lowlimit . 500) (hilimit . 1000))
Gamma>
```

See Also

setprop

trap_error

`trap_error` — traps errors in the body code.

Synopsis

```
trap_error (!body, !error_body)
```

Arguments

body
: Any Gamma or Lisp expression.

error_body
: Any Gamma or Lisp expression.

Returns

The result of the *body*, unless an error occurs during its evaluation, in which case the result of evaluating the *error_body*.

Description

This function traps any errors which occur while evaluating the *body* code. If no error occurs, then `trap_error` will finish without ever evaluating the *error_body*. If an error does occur, `trap_error` will evaluate the *error_body* code immediately and the error condition will be cleared. This is usually used to protect a running program from a piece of unpredictable code, such as an event handler. If the error is not trapped it will be propagated to the top-level error handler where it will cause the interpreter to go into an interactive debugging session.

Example

The following piece of code will run an event loop and protect against an unpredictable event.

```
while(t)
{
 trap_error(next_event(),print_trapped_error());
}

function print_trapped_error ()
{
 princ("Error\n", _error_stack_, "\n occurred...\n");
 princ("Clearing error condition and continuing.\n");
```

```
}
```

See Also

error, unwind_protect, try catch

unwind_protect

`unwind_protect` — ensures code will be evaluated, despite errors in the body code.

Synopsis

```
unwind_protect (!body, !protected_body)
```

Arguments

body
: Any Gamma or Lisp expression.

protected_body
: Any Gamma or Lisp expression.

Returns

The result of evaluating the *protected_body* code. If an error occurs then this function does not return.

Description

This function ensures that a piece of code will be evaluated, even if an error occurs within the *body* code. This is typically used when an error might occur but cleanup code has to be evaluated even in the event of an error. The error condition will not be cleared by this function. If an error occurs then control will be passed to the innermost `trap_error` function or to the outer level error handler immediately after the *protected_body* is evaluated.

Example

The following code will close its file and run a `write_all_output` function even if an error occurs.

```
if (fp=open("filename","w"))
{
 unwind_protect(write_all_output(),close(fp));
}
```

See Also

`error`, `trap_error`, `protect unwind`

whence

whence — gives input information.

Synopsis

```
whence (s_exp)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

A list whose car is the input source, and whose cdr is an integer showing the sequential input order of the expression.

Description

This function checks the input source and sequence of any given Gamma expression. It returns this information in the form of a list. The sequence number is assigned the first time the expression is used, and does not change. The whence call itself is a Gamma expression, and thus generates a sequence number each time it is called.

This function requires Gamma to be running in debugging mode. To start debugging mode, you must include the **-d** option when starting Gamma.

Example

```
[~/w/devel/lisp]$ gamma -d
Gamma(TM) Advanced Programming Language
Copyright (C) Cogent Real-Time Systems Inc., 1996. All rights reserved.
Version 2.4 Build 147 at Sep 13 1999 17:15:51
Gamma> c = 12;
12
Gamma> d = 14;
14
Gamma> whence(c);
("stdin" 1)
Gamma> whence(d);
("stdin" 2)
Gamma> f = 16;
```

```
16
Gamma> whence(f);
("stdin" 6)
Gamma>
```

Lists and Arrays

append

append — concatenates several lists into a single new list.

Synopsis

```
append (list...)
```

Arguments

list
: One or more lists.

Returns

A new list whose elements are the all of the elements in the given lists, in the order that they appear in the argument lists.

Description

This function concatenates all of the argument lists into a single new list, in the order the arguments are given. Each list is appended to the preceding list by assigning it to the cdr of the last element of that list. The appending is non-destructive; for a destructive version of append use nappend.

Example

```
Gamma> append (list(1,2,3), list(4,5));
(1 2 3 4 5)
Gamma> append (list(#a,#c,#g), list(#b,#d,#z));
(a c g b d z)
Gamma>
```

See Also

nappend

aref

aref — returns an array expression at a given index.

Synopsis

```
aref (array, index)
```

Arguments

array
An array.

index
A number giving the index into the array, starting at zero.

Returns

The array element at the given index in the array.

Description

The index starts at zero, and extends to the length of the array minus one. If the index is not valid in the array, nil is returned, but no error is generated.

Note: This function is identical to the square bracket syntax for referencing array elements, with the syntax:

```
array[index]
```

Example

```
Gamma> x = array (1, 5, #d, "farm");
[1 5 d "farm"]
Gamma> aref (x, 0);
1
Gamma> aref (x, 8);
nil
Gamma> x[3];
"farm"
Gamma>
```

See Also

array, aset, delete, insert, sort

array

`array` — constructs an array.

Synopsis

```
array (s_exp?...)
```

Arguments

s_exp
    Any Gamma or Lisp expression.

Returns

An array containing all of the arguments.

Description

An array is represented as a sequence of objects surrounded by square brackets, as in [1 2 a (4 5)]. The objects within the brackets are not evaluated. To refer to or access an array, it must be assigned to a symbol.

This function constructs an array of all of the arguments, in the order given. The arguments are evaluated when the `array` function is called, but once the array has been constructed the array objects are not evaluated.

It is possible to create an empty array, and fill it later. It will expand as necessary when array objects are added.

Example

```
Gamma> array(#a, 5, nil, 4 + 3, "goodbye");
[a 5 nil 7 "goodbye"]
Gamma> y = array(5 * 2, #symbol, 432, "string", nil);
[10 symbol 432 "string" nil]
Gamma> z = array(#c, y);
[c [10 symbol 432 "string" nil]]
Gamma> x = array();
[]
Gamma> x[5] = 19;
19
Gamma> x;
[nil nil nil nil nil 19]
Gamma>
```

See Also

`aset`, `aref`, `insert`, `delete`, `sort`

array_split

`array_split` — partitions a list or array into multiple lists or arrays.

Synopsis

```
array_split (list_or_array, nparts);
```

Arguments

list_or_array
: Any list or array to be partitioned into multiple lists or arrays.

nparts
: A number indicating the number of resulting arrays, or a function returning an index indicating which result part should contain each input element.

Returns

The input *list_or_array*, broken into parts. If the input is a list, the result will be a list of lists. If the input is an array, the result will be an array of arrays.

Description

This function partitions a collection into either a specified number of sub-collections, or into a set of sub-collections based on an indexing function. If the number of parts is specified as a number, the result will be a collection of at most that many sub-collections.

If the number of parts is specified as a function, then it must be a function taking two arguments and returning an integer. The return integer indicates the index of the sub-collection to which the input element is assigned. The indexing function has the form:

```
function (index, element)
```

Returning a partition index, where:

index
: The index of this element within the input *list_or_array*, starting from zero.

element
: The element of the input *list_or_array* corresponding to this index.

Examples

```
Gamma> players = [ "Matthews", "Marner", "Tavares", "Nylander",
"Barrie", "Hyman", "Kapanen", "Kerfoot", "Rielly", "Spezza",
"Mikheyev", "Muzzin", "Johnsson", "Holl" ];
```

```
[ "Matthews", "Marner", "Tavares", "Nylander", "Barrie",
"Hyman", "Kapanen", "Kerfoot", "Rielly", "Spezza",
"Mikheyev", "Muzzin", "Johnsson", "Holl" ]
Gamma> n = 3;
3

// Split the array into N subarrays, filling from first to last
Gamma> array_split(players, n)
[[Matthews Marner Tavares Nylander Barrie]
 [Hyman Kapanen Kerfoot Rielly Spezza]
 [Mikheyev Muzzin Johnsson Holl]]


// Split the array into subarrays by the first letter of each element
Gamma> array_split(players, function(i,x)
  { local c = tolower(x[0]) - 'a'; c < 0 ? 26 :  (c > 25 ? 26 : c); })
[nil [Barrie] nil nil nil nil nil [Hyman Holl] nil [Johnsson]
     [Kapanen Kerfoot] nil [Matthews Marner Mikheyev Muzzin]
     [Nylander] nil nil nil [Rielly] [Spezza] [Tavares]]


// Split the array into approximately equal subarrays
// in a round-robin fashion
Gamma> array_split(players, function(i,x) { i%n; })
[[Matthews Nylander Kapanen Spezza Johnsson]
 [Marner Barrie Kerfoot Mikheyev Holl]
 [Tavares Hyman Rielly Muzzin]]
```

array_to_list

`array_to_list` — converts an array to a list.

Synopsis

```
array_to_list (array);
```

Arguments

array
: Any array.

Returns

The array converted to a list.

Description

This convenience function converts the top level of an array to a list. Lower level arrays in the resulting list will remain unchanged unless converted separately.

Example

```
Gamma> a = array(1,2,3);
[1 2 3]
Gamma> b = array(4,5,6);
[4 5 6]
Gamma> c = array(7,8,9);
[7 8 9]
Gamma> d = array(a,b,c);
[[1 2 3] [4 5 6] [7 8 9]]
Gamma> e = array_to_list(d);
([1 2 3] [4 5 6] [7 8 9])
Gamma> list_p(e);
t
Gamma> list_p(a);
nil
Gamma>
```

See Also

list_to_array

aset

`aset` — sets an array element to a value at a given index.

Synopsis

```
aset (array, index, value)
```

Arguments

array
: An array.

index
: A numeric index into the array.

value
: The new value to be placed in the array.

Returns

The *value* argument.

Description

Sets an *array* element to the *value* at the *index*. If the index is past the end of the array, then the array will be extended with `nil`s to the index and the *value* inserted.

This function can also be called using square bracket syntax for referencing array elements, with the syntax:

```
array[index]
```

Example

```
Gamma> x = array (3, 5, #b, nil);
[3 5 b nil]
Gamma> aset(x, 3, 7);
7
Gamma> x;
[3 5 b 7]
Gamma> x[0] = 9;
9
Gamma> x;
[9 5 b 7]
Gamma>
```

See Also

`array`, `aref`, `insert`, `delete`, `sort`

assoc, assoc_equal

assoc, assoc_equal — search an association list for a sublist.

Synopsis

```
assoc (s_exp, list)
assoc_equal (s_exp, list)
```

Arguments

s_exp

Any Gamma or Lisp expression.

list

An association list.

Returns

A list whose members are the remainder of the association list starting at the element whose car is eq or equal to the *s_exp*.

Description

An association list is a list whose elements are also lists, each of which typically contains exactly two elements. assoc searches an association list for a sublist whose car is eq to the given *s_exp*. assoc_equal uses equal instead of eq for the comparison. If no matching sublist is found, returns nil.

A symbol-indexed association list (or sym-alist) is an association list where the car of each element is a symbol. This is a common construct for implementing property lists and lookup tables. Since symbols are always unique, sym-alists can be searched with assoc instead of assoc_equal.

Example

```
Gamma> a = 10;
10
Gamma> b = 20;
20
Gamma> c = 30;
30
Gamma> x = list (list(a,15), list(b,25), list(c, 35));
((10 15) (20 25) (30 35))
Gamma> assoc (b,x);
```

```
((20 25) (30 35))
Gamma> assoc (20,x);
nil
Gamma> assoc_equal(20,x);
((20 25) (30 35))
Gamma>
```

See Also

car, cdr, eq, equal, Data Types and Predicates

bsearch

`bsearch` — searches an array or list for a element.

Synopsis

```
bsearch (list_or_array, key, compare_function)
```

Arguments

list_or_array

A list or array whose elements are sorted.

key

The list or array element to search for.

compare_function

A function used to compare the *key* with the array elements.

Returns

An association list composed of the *key* and it's position in the array.

Description

This function performs a binary search on an array based on a comparison function you provide. The *compare_function* must return a negative number if the value is ordinally less than the list or array element, 0 if the two are equal and a positive number if the value is ordinally greater than the list or array element. The *array* or *list* must be sorted in an order recognizable by the *compare_function* for this function to work.

Example

```
Gamma> function comp (x,y) {x - y;}
(defun comp (x y) (- x y))
Gamma> Ax = array(9,2,11,31,13,8,15,95,17,5,19,6,21);
[9 2 11 31 13 8 15 95 17 5 19 6 21]
Gamma> Sx = sort(Ax,comp);
[2 5 6 8 9 11 13 15 17 19 21 31 95]
Gamma> bsearch(Sx,19,comp);
(19 . 9)
Gamma> bsearch(Sx,5,comp);
(5 . 1)
Gamma>
```

See Also

sort

car, cdr, and others

car, cdr, and others — return specific elements of a list.

Synopsis

```
car (list)
cdr (list)
caar (list)
cadr (list)
cdar (list)
cddr (list)
caaar (list)
caadr (list)
cadar (list)
caddr (list)
cdaar (list)
cdadr (list)
cddar (list)
cdddr (list)
```

Arguments

list

Any list.

Returns

An element of the *list* or nil.

Description

The car function returns the first element of a list. The cdr function returns all of the list except for the first element. The remaining functions in this group are simply shortcuts for the common combinations of car and cdr. The shortcut functions are read from left to right as nested car and cdr calls. Thus, a call to caddr (mylist) would be equivalent to car (cdr (cdr (mylist))). If the argument is not a list, the result is nil. The cdr function will only return a non-list result in the case of a dotted pair.

Example

```
Gamma> car(list(1,2));
1
Gamma> cdr(list(1,2));
```

```
(2)
Gamma> cdr(cons(1,2));
2
Gamma> caadr (list (1, list(2, 3, list(4, 5), 6)));
2
Gamma> cdadr (list (1, list(2, 3, list(4, 5), 6)));
(3 (4 5) 6)
Gamma>
```

See Also

cons, list, nth_car, nth_cdr

cons

cons — constructs a cons cell.

Synopsis

```
cons (car_exp, cdr_exp)
```

Arguments

car_exp
: Any Gamma or Lisp expression.

cdr_exp
: Any Gamma or Lisp expression.

Returns

A list whose car is *car_exp* and whose cdr is *cdr_exp*.

Description

This function constructs a list whose car and cdr are *car_exp* and *cdr_exp* respectively. This construction is also known as a *cons cell*. If the *cdr_exp* is a list, this has the effect of increasing the list by one member, that is, adding the *car_exp* to the beginning of the *cdr_exp*.

Example

```
Gamma> a = list(2,3,4);
(2 3 4)
Gamma> b = 5;
5
Gamma> cons(b,a);
(5 2 3 4)
Gamma> cons(a,b);
((2 3 4) . 5)
Gamma> cons(5,nil);
(5)
Gamma>
```

See Also

Data Types and Predicates

copy

copy — makes a copy of the top list level of a list.

Synopsis

```
copy (s_exp)
```

Arguments

s_exp
Any Gamma or Lisp expression.

Returns

A copy of the top list level of the argument.

Description

This function makes a copy of the top list level of the argument if the argument is a list, otherwise it simply returns the argument. This produces a new list which is equal to the previous list, and whose elements are eq. That is, the elements are not copied but simply reside in both the original and the copy.

Example

```
Gamma> a = list(1, list(2,3,list(4),5));
(1 (2 3 (4) 5))
Gamma> b = copy(a);
(1 (2 3 (4) 5))
Gamma> cadr(a);
(2 3 (4) 5)
Gamma> equal(cadr(a),cadr(b));
t
Gamma> eq(cadr(a),cadr(b));
t
Gamma>
```

See Also

copy_tree, eq, equal

copy_tree

copy_tree — copies the entire tree structure and elements of a list.

Synopsis

```
copy_tree (s_exp)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

A copy of the entire tree structure and elements of the argument, if it is a list. Otherwise, the argument.

Description

This function makes a recursive copy of the entire tree structure of the argument if the argument is a list, otherwise it simply returns the argument. This produces a new list which is equal to the previous list, and whose elements are equal, but not eq. That is, the elements are all copied down to the level of the non-list leaves. They are equal to the original elements, but they are different elements. Thus they are equal but not eq.

Example

```
Gamma> a = list(1,list(2,3,list(4),5));
(1 (2 3 (4) 5))
Gamma> b = copy_tree(a);
(1 (2 3 (4) 5))
Gamma> cadr(a);
(2 3 (4) 5)
Gamma> equal(cadr(a),cadr(b));
t
Gamma> eq(cadr(a),cadr(b));
nil
Gamma>
```

See Also

copy, eq, equal

delete

`delete` — removes an element from an array.

Synopsis

```
delete (array, position)
```

Arguments

array
: An array.

position
: An integer giving the zero-indexed position of the array element to delete.

Returns

The deleted array element, or `nil` if none was deleted. The return value will also be `nil` if the deleted element was `nil` itself.

Description

This function removes an element from an *array* and compresses the rest of the array to reduce its overall length by one. If the position is beyond the bounds of the array, nothing happens. This function is destructive.

Example

```
Gamma> a = [1,2,3,4,5];
[1 2 3 4 5]
Gamma> delete(a,3);
4
Gamma> a;
[1 2 3 5]
Gamma>
```

See Also

insert

difference

`difference` — constructs a list of the differences between two lists.

Synopsis

```
difference (listA, listB)
```

Arguments

listA
A list.

listB
A list.

Returns

All elements in *listA* that are not in *listB*.

Description

Constructs a new list that contains all of the elements in *listA* not contained in *listB* as compared by the function eq.

Example

```
Gamma> a = 1;
1
Gamma> b = 2;
2
Gamma> c = 3;
3
Gamma> d = 4;
4
Gamma> e = 5;
5
Gamma> A = list (a, b, c);
(1 2 3)
Gamma> B = list (b, d, e, c);
(2 4 5 3)
Gamma> difference (A, B);
(1)
Gamma> difference (B, A);
(4 5)
```

```
Gamma>
```

See Also

eq, equal, intersection, union

find, find_equal

find, find_equal — search a list using the eq and equal functions.

Synopsis

```
find (s_exp, list)
find_equal (s_exp, list)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

list
: A list to be searched.

Returns

The tail of the *list* starting at the matching element. If no match is found, nil.

Description

The find function searches the *list* comparing each element to the *s_exp* with the function eq. The find_equal function uses equal instead of eq for the comparison.

Example

```
Gamma> find(#a,#list(d,x,c,a,f,t,l,j));(a f t l j)
Gamma> find("hi", #list("Bob","says", "hi"));
nil
Gamma> find_equal("hi",#list("Bob","says","hi"));
("hi")
Gamma>
```

See Also

eq, equal

insert

`insert` — inserts an array value at a given position.

Synopsis

```
insert (array, position|compare_function, value)
```

Arguments

array
: An array.

position
: A number giving the zero-based position of the new element within the array, or a function.

compare_function
: A function on two arguments used to compare elements in the list or array.

value
: Any Gamma or Lisp expression.

Returns

The *value* inserted.

Description

The `insert` function widens an array at the given *position* and inserts the *value*. If a *compare_function* is used, it must return a negative number if the value is ordinally less than the array element, 0 if the two are equal and a positive number if the value is ordinally greater than the array element. The *value* will be inserted using a binary insertion sort, based on the return value of the function.

Example

```
Gamma> x = array("a", "b", "c");
["a" "b" "c"]
Gamma> insert(x,3,"d");
"d"
Gamma> x;
["a" "b" "c" "d"]
Gamma> insert(x,strcmp,"acme");
"acme"
Gamma> x;
```

```
["a" "acme" "b" "c" "d"]
Gamma>
```

See Also

aref, array, aset

intersection

`intersection` — constructs a list of all the elements found in both of two lists.

Synopsis

```
intersection (listA, listB)
```

Arguments

listA
A list.

listB
A list.

Returns

All elements which appear in both *listA* and *listB*.

Description

This function generates a new list which contains all of the elements that appear in both *listA* and *listB*. The elements are compared using eq. The order of the elements in the resulting list is not defined.

Example

```
Gamma> A = list(#a,#b,#c);
(a b c)
Gamma> B = list(#b,#c,#d);
(b c d)
Gamma> intersection(A,B);
(b c)
Gamma>
```

See Also

eq, equal difference union

length

`length` — counts the number of elements in a list or array.

Synopsis

```
length (list)
```

Arguments

list

A list or array.

Returns

The number of elements in the *list* or *array*. If the argument is not a list or array, returns 0.

Example

```
Gamma> length(list(#a,#b,#c,#d));
4
Gamma> length([11,13,15,17,19,21]);
6
Gamma> length(sqr(2 + 3));
0
Gamma>
```

list, listq

`list`, `listq` — create lists.

Synopsis

```
list (s_exp?...)
listq (!s_exp?...)
```

Arguments

s_exp
Any Gamma or Lisp expression.

Returns

A list containing all of the arguments.

Description

A list is represented as a sequence of objects surrounded by parentheses, as in (1 2 a [4 5]), possibly with a dot between the second-to-last and last elements in the list. A literal list can be read from a file or from the command line, but must be quoted (using a quote operator) within code to make it literal.

The `list` function creates a list from its arguments. `listq` creates a list from its arguments without evaluation.

Example

```
Gamma> list(4+5,6,"hi",#xref);
(9 6 "hi" xref)
Gamma> listq(4+5,6,"hi",#xref);
((+ 4 5) 6 "hi" 'xref)
Gamma>
```

See Also

Data Types and Predicates Lists and Arrays

list_to_array

`list_to_array` — converts a list to an array.

Synopsis

```
list_to_array (list)
```

Arguments

list
: A list to convert to an array.

Returns

The *list* converted to an array.

Description

This convenience function converts the top level of a list to an array. Sub-lists will remain unchanged unless converted separately.

Example

```
Gamma> a = list(1,2,3);
(1 2 3)
Gamma> b = list(4,5,6);
(4 5 6)
Gamma> c = list(7,8,9);
(7 8 9)
Gamma> d = list(a,b,c);
((1 2 3) (4 5 6) (7 8 9))
Gamma> e = list_to_array(d);
[(1 2 3) (4 5 6) (7 8 9)]
Gamma> array_p(e);
t
Gamma> array_p(a);
nil
Gamma>
```

See Also

array_to_list

make_array

`make_array` — creates an empty array.

Synopsis

```
make_array (n_elements)
```

Arguments

n_elements
A number of elements.

Returns

An array with the given number of elements, all `nil`.

Description

Creates an empty array for later use. This function has become obsolete as the `array` function can now create empty arrays. See `array`.

Example

```
Gamma> make_array(4);
[nil nil nil nil]
Gamma> make_array(7);
[nil nil nil nil nil nil nil]
Gamma>
```

See Also

`array`

nappend

nappend — appends one or more lists, destructively modifying them.

Synopsis

```
nappend (list...)
```

Arguments

list
: One or more lists which will be appended in order.

Returns

The first *list*, modified in place with the remaining lists appended onto it.

Description

This function appends one or more lists, destructively modifying all but the last argument. It is otherwise identical to append.

Example

```
Gamma> a = list (1, 2, 3);
(1 2 3)
Gamma> b = list (4, 5, 6);
(4 5 6)
Gamma> c = list (7, 8, 9);
(7 8 9)
Gamma> nappend (a, b, c);
(1 2 3 4 5 6 7 8 9)
Gamma> a;
(1 2 3 4 5 6 7 8 9)
Gamma> b;
(4 5 6 7 8 9)
Gamma> c;
(7 8 9)
Gamma>
```

See Also

append

nremove

`nremove` — removes list items, destructively altering the list.

Synopsis

```
nremove (s_exp, list, use_equal?)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

list
: A list.

use_equal
: If non-`nil`, use `equal` instead of eq for comparison.

Returns

The *list* with any elements which are eq (or equal if specified) to *s_exp* destructively removed.

Description

This function removes all occurrences of the *s_exp* within the given list and destructively alters the list to reduce its size by one for each occurrence. The default comparison used is eq. If the first argument is removed, then the return value will be (cdr list) with all other occurrences of *s_exp* destructively removed.

Example

```
Gamma> y = list (#a, #b, #c);
(a b c)
Gamma> nremove (#b, y);
(a c)

Gamma> x = list(1,2,3,4,5,6);
(1 2 3 4 5 6)
Gamma> nremove(3, x);
(1 2 3 4 5 6)
Gamma> nremove(3, x, t);
(1 2 4 5 6)
```

```
Gamma> y = list(1,2,3,4,1,2,3,4,1,2);
(1 2 3 4 1 2 3 4 1 2)
Gamma> nremove (1,y,t);
(2 3 4 2 3 4 2)
Gamma>
```

See Also

nreplace, remove

nreplace, nreplace_equal

`nreplace`, `nreplace_equal` — replace elements in a list.

Synopsis

```
nreplace (new_s_exp, old_s_exp, list)
nreplace_equal (new_s_exp, old_s_exp, list)
```

Arguments

new_s_exp
: The new expression to be inserted into the list.

old_s_exp
: The expression in the list to be replaced.

list
: A list.

Returns

The *list*, with all occurrences of *old_s_exp* destructively replaced by *new_s_exp*.

Description

`nreplace` traverses the *list*, replacing any element which is eq to *old_s_exp* with *new_s_exp*. `nreplace_equal` uses `equal` as its comparison function.

Example

```
Gamma> R = list (#f, nil, 5, #ftg);
(f nil 5 ftg)
Gamma> nreplace(#h, #ftg, R);
(f nil 5 h)

Gamma> x = list(1,2,3,1,6,7);
(1 2 3 1 6 7)
Gamma> nreplace(4,1,x);
(1 2 3 1 6 7)
Gamma> nreplace_equal(4,1,x);
(4 2 3 4 6 7)
Gamma> x;
(4 2 3 4 6 7)
Gamma>
```

See Also

remove, nremove

nth_car, nth_cdr

nth_car, nth_cdr — iteratively apply the car and cdr functions to a list.

Synopsis

```
nth_car (list, number)
nth_cdr (list, number)
```

Arguments

list
: Any list.

number
: The number of cars (or cdrs) to apply to the list argument. Non-integers are rounded down. Non-numbers are treated as zero.

Returns

An element of the *list*, or nil.

Description

The nth_car and nth_cdr functions iteratively apply the car and cdr functions to a list. If the list argument is not a list, or if the result of any subsequent application of car or cdr is not a list, the result is nil. If the number of applications is less than or equal to 0, the result is the original list.

Example

```
Gamma> c = list (list(list(list(4,5))));
((((4 5))))
Gamma> nth_car(c,2);
((4 5))
Gamma> nth_car(c,4);
4

Gamma> b = list (6,7,8,9,10);
(6 7 8 9 10)
Gamma> nth_cdr (b,2);
(8 9 10)
Gamma> nth_cdr(b,5);
nil
Gamma> nth_cdr(b,4);
```

```
(10)
Gamma>
```

See Also

cons, list, car, cdr

remove

`remove` — removes list items without altering the list.

Synopsis

```
remove (s_exp, list, use_equal?)
```

Arguments

s_exp

An expression to remove from the list.

list

The list from which to remove the s_exp.

use_equal

An optional argument. If `t`, `remove` uses the `equal` function for equality, otherwise it uses the more stringent eq.

Returns

The *list*, with any matching *s_exp* removed.

Description

This function non-destructively walks a list and removes elements matching the passed *s_exp* using either eq or equal.

Example

```
Gamma> A = list (#a, #b, #c, #b, #a);
(a b c b a)
Gamma> remove (#a, A);
(b c b)
Gamma> A;
(a b c b a)
Gamma> B = list(1,2,3,2,1);
(1 2 3 2 1)
Gamma> remove(2,B);
(1 2 3 2 1)
Gamma> remove(2,B,t);
(1 3 1)
Gamma>
```

See Also

`nremove`

reverse

`reverse` — reverses the order of list elements.

Synopsis

```
reverse (list)
```

Arguments

list
: A list.

Returns

A new list which whose top-level structure is the reverse of the input *list*. If the argument is not a list, returns the argument.

Description

None of the elements of the original *list* is copied. The resulting list contains elements which are eq to the corresponding elements in the original. The original *list* is not changed.

Example

```
Gamma> S = list(1,2,3);
(1 2 3)
Gamma> R = reverse (S);
(3 2 1)
Gamma> S;
(1 2 3)
Gamma> car (S);
1
Gamma> caddr(R);
1
Gamma> eq (car (S),caddr(R));
t
Gamma>
```

rplaca, rplacd

`rplaca`, `rplacd` — replace the car and cdr of a list.

Synopsis

```
rplaca (cons, s_exp)
rplacd (cons, s_exp)
```

Arguments

list
: A list element.

s_exp
: Any Gamma or Lisp expression.

Returns

The *s_exp*, or `nil` on failure.

Description

These functions destructively alter the form of a list. `rplaca` modifies the car of a list, effectively replacing the first element. `rplacd` modifies the cdr of a list, replacing the entire tail of the list. These functions have no meaning for non-lists. To entirely remove the tail of a list, replace the cdr of the list with `nil`.

Example

```
Gamma> x = list(1,2,3,4);
(1 2 3 4)
Gamma> rplaca(x,0);
0
Gamma> x;
(0 2 3 4)
Gamma> rplacd(x,list(7,8,9,10,11,12));
(7 8 9 10 11 12)
Gamma> x;
(0 7 8 9 10 11 12)
Gamma>
```

See Also

`car`, `cdr`

shorten_array

`shorten_array` — reduces or expands the size of an array.

Synopsis

```
shorten_array (array, size)
```

Arguments

array
: The array to shorten or expand.

size
: The new length for the array.

Returns

The resized array.

Description

This function reduces or expands the size of an array by cutting off any elements which extend beyond the given size, or by adding `nil`s to the end of the array until the new size is reached. This function is analogous to the C function, `realloc`.

Example

```
Gamma> a = array (1,2,3,4,5);
[1 2 3 4 5]
Gamma> shorten_array(a,3);
[1 2 3]
Gamma> shorten_array(a,9);
[1 2 3 nil nil nil nil nil nil]
Gamma>
```

See Also

`array`, `make_array`

sort

`sort` — sorts a list or array, destructively modifying the order.

Synopsis

```
sort (list_or_array, compare_function)
```

Arguments

list_or_array
: A list or an array.

compare_function
: A function on two arguments used to compare elements in the list or array.

Returns

The input *list* or *array*, sorted.

Description

This function sorts the *list* or *array* in place, destructively modifying the order of the elements. The *compare_function* must be a function on two arguments which returns: an integer value less than zero if the first argument is ordinally less than the second, zero if the two arguments are ordinally equal, and greater than zero if the first argument is ordinally greater than the second. This function uses the quicksort algorithm.

Example

```
Gamma> x = list("one","two","three","four","five");
("one" "two" "three" "four" "five")
Gamma> sort(x,strcmp);
("five" "four" "one" "three" "two")
Gamma> x;
("five" "four" "one" "three" "two")
Gamma>
```

union

union — constructs a list containing all the elements of two lists.

Synopsis

```
union (listA, listB)
```

Arguments

listA
: A list.

listB
: A list.

Returns

A new list containing all elements in *listA* plus all elements in *listB* which do not appear in *listA*.

Description

The resulting list will not contain duplicate elements from either list. This function uses eq for comparisons.

Example

```
Gamma> union (list (#j,#j,#j,#k,#l,#j),list(#k,#k,#l,#m,#n));
(j k l m n)
Gamma> union(list(1,2),list(5,1,2,7));
(1 2 5 1 2 7)
Gamma>
```

See Also

difference, intersection

Strings and Buffers

bdelete

`bdelete` — deletes a number of bytes from a buffer.

Synopsis

```
bdelete (buffer, position, length?)
```

Arguments

buffer
: A buffer.

position
: The position of the first byte to delete. A number between `0` and the length of the buffer minus `1`.

length
: An optional number of bytes to delete. The default is `1`. A negative number deletes all bytes to the end. A value of `0` does nothing.

Returns

The number contained at the specified *position* in the *buffer*, or `nil` if the *buffer* is undefined at the given *position*.

Description

This function deletes a specified number of bytes from a raw memory buffer. The buffer length does not change as a result of this function. A zero character is placed at the empty position at the end of the buffer, then the buffer is collapsed.

Example

```
Gamma> y = buffer (101, 102, 103, 104);
#{efgh}
Gamma> bdelete(y,1,2);
102
Gamma> y;
#{eh\0h}
Gamma>
```

See Also

`delete`

binsert

`binsert` — inserts a value into a buffer.

Synopsis

```
binsert (buffer, position, value)
```

Arguments

buffer
: A buffer.

position
: A number giving the zero-based position of the new element within the buffer, or a function.

value
: A number which will be cast to an 8-bit signed integer.

Returns

The *value* inserted.

Description

The binsert function inserts the *value* by moving all other values after *position* one space to the right, and removing the last value from the buffer.

If *position* is a function, it is taken to be a comparison function with two arguments. The value will be inserted using a binary insertion sort with the function as the comparison. A comparison function must return a negative number if the value is ordinally less than the buffer element, 0 if the two are equal, and a positive number if the value is ordinally greater than the buffer element.

Example

```
Gamma> x = string_to_buffer("Hellothere");
#{Hellothere}
Gamma> binsert(x,5,32);
32
Gamma> x;
#{Hello ther}
Gamma>
```

See Also

buffer

buffer

`buffer` — constructs a buffer.

Synopsis

```
buffer (contents?...)
```

Arguments

contents
: Any Gamma or Lisp expression.

Returns

A buffer containing all of the *contents*.

Description

This function constructs a buffer of all of the arguments, in the order they are given.

A buffer is printed as a sequence of characters (some consoles may not support a character for every entry) surrounded by curly brackets and preceded by a hash sign, such as: #{\n+6ALWbe}. This representation of a buffer cannot be read back in to Gamma, so a symbol must be assigned to a buffer in order to refer to or work with it.

Example

```
Gamma> bu = buffer (101, 102, 103, 104, 2 * 25, 4 / 82);
#{efgh2\0}
Gamma> shorten_buffer (bu, 2);
#{ef}
Gamma>
```

See Also

binsert, bdelete

buffer_to_string

`buffer_to_string` — converts a buffer to a string.

Synopsis

```
buffer_to_string (buffer)
```

Arguments

buffer

A buffer.

Returns

A string representing the contents of the given *buffer* up to the first zero character, or `nil` if the argument is not a buffer.

Description

This function converts the *buffer* into a string by treating each element in the buffer as a single character. The first zero character in the buffer terminates the string.

Example

```
Gamma> x = buffer(104,101,108,108,111);
#{hello}
Gamma> buffer_to_string(x);
"hello"
Gamma>
```

See Also

`buffer`

format, formatl

`format`, `format` — generates a formatted string.

Synopsis

```
format (format_string, arguments?...)
formatl (format_string, arguments?...)
```

Arguments

format_string
: A string containing format directives and literal text.

arguments
: Expressions which will be matched to format directives on a one-to-one basis.

Returns

A string.

Description

Generates a formatted string using directives similar to those used in the "C" `printf` function. Text in the *format_string* will be output literally to the formatted string. Format directives consist of a percent sign (%) followed by one or more characters. The following directives are supported:

The `format` function will convert floating point numbers to strings in locale-insensitive format (using a dot as the decimal separator). The `formatl` function will convert floating point numbers using the decimal separator in the current locale.

- **a** Any Gamma or Lisp expression. The `princ_name` (the same result as applying the string function on the expression) of a Lisp expression is written to the result string.
- **d** An integer number. A numeric expression is cast to a long integer and written to the result string. %d is equivalent to %ld.
- **f** A floating point number. A numeric expression is cast to a long floating point number and written to the result string.
- **g** A floating point number in "natural" notation. A numeric expression is cast to a long floating point number and written to the result string using the most easily read notation which will fit into the given field size, if any. If no field size is specified, use a notation which minimizes the number of characters in the result.
- **s** A character string. A string is written to the result string.

The format directive may contain control flags between the % sign and the format type character. These control flags are:

- **-** Left justify the field within a specified field size.
- **+** Numbers with a positive value will begin with a + sign. Normally only negative numbers are signed.
- **" "** (A space). Signed positive numbers will always start with a space where the sign would normally be.
- **0** A numeric field will be filled with zeros to make the number consume the entire field width.

Format directives may contain field width specifiers which consist of an optional minimal field width as an integer, optionally followed by a period and a precision specified as an integer. The precision has different meanings depending on the type of the field.

- **a** The field width option does not apply to this general case. To specify precision on a s_exp, you can convert it to a string and use the **s** format directives.
- **d** The precision specifies the minimum number of digits to appear. Leading zeros will be used to make the necessary precision.
- **f** The precision specifies the number of digits to be presented after the decimal point. If the precision is zero, the decimal point is not shown.
- **g** The precision specifies the maximum number of significant digits to appear.
- **s** The precision specifies the maximum number of characters to appear.

Example

```
Gamma> pi = 3.1415926535;
3.1415926535000000541
Gamma> format("PI is %6.3f",pi);
"PI is  3.142"
Gamma> alpha = "abcdefghijklmnopqrstuvwxyz";
"abcdefghijklmnopqrstuvwxyz"
Gamma> format("Alphabet starts: %.10s",alpha);
"Alphabet starts: abcdefghij"
Gamma> x = [1,2,3,4,5,6,7,8,9];
[1 2 3 4 5 6 7 8 9]
Gamma> format("x is: %a",x);
"x is: [1 2 3 4 5 6 7 8 9]"
Gamma> format("x is: %.6s",string(x));
"x is: [1 2 3"
Gamma>
```

make_buffer

`make_buffer` — creates a new, empty buffer.

Synopsis

```
make_buffer (n_elements)
```

Arguments

n_elements

The number of elements (bytes) in the buffer.

Returns

A new buffer.

Description

This function creates a new, empty buffer with *n_elements* number of bytes, all set to zero.

Example

```
Gamma> make_buffer(5);
#{\0\0\0\0\0}
Gamma> make_buffer(12);
#{\0\0\0\0\0\0\0\0\0\0\0\0}
Gamma>
```

See Also

buffer, buffer_to_string

open_string

open_string — allows a string to be used as a file.

Synopsis

```
open_string (string)
```

Arguments

string
A string.

Returns

A pseudo-file that contains the *string* if successful, otherwise nil.

Description

This function allows a string to be used as a pseudo-file to facilitate reading and writing to a local buffer. All read and write functions which operate on a file can operate on the result of this call. An attempt to write to the string always appends information destructively to the string. Subsequent reads on the string can retrieve this information. A string is always opened for both read and write.

Example

```
Gamma> s = open_string("Hello there.");
#<File:"String">
Gamma> read_line(s);
"Hello there."
Gamma> s = open_string("Hello there.");
#<File:"String">
Gamma> read(s);
Hello
Gamma> read(s);
there.
Gamma> read(s);
"Unexpected end of file"
Gamma>
```

See Also

close, open, read, read_char, read_double, read_float, read_line, read_long, read_short, read_until, terpri, write, writec

parse_string

`parse_string` — parses an input string.

Synopsis

```
parse_string (string, use_gamma?=nil, parse_all?=nil)
```

Arguments

string
: A character string representing either a Lisp expression or a Gamma statement.

use_gamma
: An optional argument that defaults to `nil`. If `nil`, the Lisp parser will be used, otherwise the Gamma parser will be used.

parse_all
: An optional argument that defaults to `nil`. If `nil`, only the first statement in the string will be parsed, otherwise all statements up to the end of the string will be paresed..

Returns

If *parse_all* is `nil`, return the first statement in the string in internal form. If *parse_all* is non-`nil`, return all statements in the string as a list of expressions in internal form. If an error occurs during parsing, this function will throw an error.

Description

This function parses the input string using either the Lisp parser or the Gamma parser, and returns either the first complete statement found in the string or all of the statements to the end of the string.

If only the first statement is parsed, the rest of the string is ignored, even if it is invalid. The result is returned in internal form, effectively an executable Lisp representation. Internal form can be passed directly to the `eval` function for evaluation.

If all statements are returned, they are returned in a list, even if there is only one statement in the string. The resulting list can be passed directly to `eval_list`.

Example

```
Gamma> a = parse_string("hello");
hello
Gamma> b = parse_string("(cos 5)");
(cos 5)
```

```
Gamma> c = parse_string("(+ 5 6) (/ 6 3)");
(+ 5 6)
Gamma> eval(b);
0.28366218546322624627
Gamma> eval(c);
11
Gamma>
```

Using optional arguments:

```
Gamma> parse_string("cos(5);", t);
(cos 5)
Gamma> parse_string("cos(5); sin(5);", t);
(cos 5)
Gamma> parse_string("cos(5); sin(5);", t, t);
((cos 5) (sin 5))
Gamma> parse_string ("if (x < 1) y = 1; else y = 0;", t)
(if (< x 1)
  (setq y 1)
  (setq y 0)
  )
Gamma>
```

See Also

eval, eval_string, open_string

raw_memory

`raw_memory` — tells the amount of memory in use.

Synopsis

```
raw_memory ()
```

Arguments

none

Returns

The amount of raw memory in use by the system.

Example

```
Gamma> raw_memory();
(72462 818)
Gamma> x = 41;
41
Gamma> raw_memory();
(72787 847)
Gamma> x = 55;
55
Gamma> raw_memory();
(73034 871)
Gamma> y = 10;
10
Gamma> raw_memory();
(73359 900)
Gamma>
```

shell_match

`shell_match` — compares string text to a pattern.

Synopsis

```
shell_match (text, pattern)
```

Arguments

`text`

A text string to compare against the given pattern.

`pattern`

A shell style pattern.

Returns

`t` if the *`text`* matches the *`pattern`*, otherwise `nil`.

Description

This function compares the *`text`* to the *`pattern`* using shell-style wildcard rules. The available patterns are as follows:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

Example

To get a directory listing of just *.txt files, use:

```
shell_match(directory("/etc/readme",0,nil),"*.txt");
```

```
Gamma> shell_match("hello","?el[a-m]*");
t
Gamma> shell_match("hello","hel{p,m,ga}");
nil
```

```
Gamma>
```

See Also

apropos

shorten_buffer

`shorten_buffer` — reduces the size of a buffer.

Synopsis

```
shorten_buffer (buffer, n_elements)
```

Arguments

buffer
: The buffer to shorten.

n_elements
: The number of elements that the buffer is to be reduced to.

Returns

The shortened buffer.

Description

This function reduces the size of a buffer by cutting off any elements which extend beyond the given size. This function is analogous to the C function, `realloc`.

Example

```
Gamma> b = buffer(119,120,121,122);
#{wxyz}
Gamma> shorten_buffer(b,3);
#{wxy}
Gamma>
```

See Also

`buffer`, `make_buffer`

strchr, strrchr

`strchr`, `strrchr` — search a string for an individual character.

Synopsis

```
strchr (string, char_as_string)
strrchr (string, char_as_string)
```

Arguments

string
: Any character string.

char_as_string
: A string containing the one character to be found.

Returns

The position of the *char_as_string* within the *string*, where the first character is in position zero. If the *char_as_string* is not found in the *string*, returns -1. `strchr` returns the first occurrence of the character in the string. `strrchr` returns the last occurrence of the character in the string.

Description

These functions search a string for an individual character and return the first or last occurrence of that character within the string. The characters within a string are numbered starting at zero.

Example

```
Gamma> strchr("apple","a");
0
Gamma> strchr("apple","r");
-1
Gamma> strchr("apple","p");
1
Gamma> strrchr("apple pie","p");
6
Gamma>
```

See Also

strcmp, stricmp, string_split, strlen, strrev, strstr, substr

strcmp, stricmp

`strcmp`, `stricmp` — compare strings.

Synopsis

```
strcmp (string, string)
stricmp (string, string)
```

Arguments

string

Any string.

Returns

A negative number if the first *string* is ordinally less than the second *string* according to the ASCII character set, a positive number if the first *string* is greater than the second, and zero if the two strings are exactly equal.

Description

These functions can be used as comparison functions for `sort` and `insert`. `stricmp` performs the same function as `strcmp`, but alphabetic characters are compared without regard to case. That is, "A" and "a" are considered equal by `stricmp`, but different by `strcmp`.

Example

```
Gamma> strcmp("apple", "peach");
-15
Gamma> strcmp("peach", "apple");
15
Gamma> strcmp("Apple","Apple");
0
Gamma> strcmp("Apple","Apple pie");
-32
Gamma> strcmp("Apple","apple");
-32
Gamma> stricmp("Apple","apple");
0
Gamma>
```

See Also

insert, sort, strchr, strrchr

string

`string` — constructs a string.

Synopsis

```
string (s_exp...)
```

Arguments

s_exp

Any Gamma or Lisp expression.

Returns

A string which is the concatenation of all of the arguments.

Description

This function constructs a string by concatenating the `princ` names of all of the arguments. Any argument that can be evaluated will be. No separation is provided between arguments in the resulting string.

Example

```
Gamma> string("A list: ",list(#a,#b,#c), " and a sum: ",2 + 3);
"A list: (a b c) and a sum: 5"
Gamma>
```

See Also

format

stringc

`stringc` — constructs a string in Lisp-readable form,

Synopsis

```
stringc (s_exp...)
```

Arguments

s_exp
Any number of expressions.

Returns

A string which is the concatenation of all of the arguments.

Description

This function is identical to the `string` function, except that the result is produced in a form which is guaranteed to be in Lisp-readable form. This means that special characters within strings and symbols will be escaped appropriately for the reader, and that new-line, form-feed, and tab characters are translated into their \n, \f, and \t equivalents.

Example

```
Gamma> string(#my, #symbol);
"mysymbol"
Gamma> stringc(#my, #symbol);
"mysymbol"
Gamma> stringc("A list: ",list(#a,#b,#c), " and a sum: ",2 + 3);
"\"A list: \"(a b c)\" and a sum: \"5"
Gamma>
```

See Also

`string`

string_file_buffer

`string_file_buffer` — queries a string file for its internal buffer.

Synopsis

```
string_file_buffer (string_file)
```

Arguments

`string_file`

A file which points to an in-memory string, created by a call to `open_string`.

Returns

The characters remaining to be read within the string file.

Description

This function queries a string file for its internal buffer.

Example

```
Gamma> a = open_string("my false file");
#<File:"String">
Gamma> read_n_chars(a,3);
#{my }
Gamma> string_file_buffer(a);
"false file"
Gamma>
```

See Also

`open_string`

string_split

`string_split` — breaks a string into individual words.

Synopsis

```
string_split (string, delimiters, max_words)
```

Arguments

string

Any character string.

delimiters

A character string containing delimiter characters.

max_words

The maximum number of words to separate.

Returns

A list containing at most (*max_words* + 1) elements, each of which is a string.

Description

This function breaks a string into individual words wherever it finds any one of the characters in the *delimiters* string. If *max_words* is zero or less, there is no limit to the number of words which may be generated. If *max_words* is greater than zero, then at most *max_words* words will be generated. If there are any characters remaining in the string once *max_words* words have been generated, then the remaining characters will be returned as the last element in the result list. If *delimiters* is the empty string, "", then the input string will be split at any white space.

Example

```
Gamma> string_split("This is a test","",0);
("This" "is" "a" "test")
Gamma> string_split("This is a test"," ",2);
("This" "is" "a test")
Gamma> string_split("This is a test","ie",0);
("Th" "s " "s a t" "st")
Gamma> string_split("12:05:29",":",-1);
("12" "05" "29")
Gamma>
```

See Also

`strchr`, `strrchr`, `strstr`

string_to_buffer

`string_to_buffer` — creates a buffer object from a string.

Synopsis

```
string_to_buffer (string)
```

Arguments

string
: The string to be converted to a buffer.

Returns

A buffer whose contents are those of the *string*.

Description

This function creates a buffer object from a string. The buffer and string are mapped to different memory areas, so that alterations to one do not affect the other.

Example

```
Gamma> a = "rhino";
"rhino"
Gamma> b = string_to_buffer(a);
#{rhino}
Gamma> a = "hippo";
"hippo"
Gamma> b;
#{rhino}
Gamma>
```

See Also

buffer_to_string

strcvt

`strcvt` — converts the Windows character set of a string.

Synopsis

```
strcvt (string, from?, to?)
```

Arguments

string
: The string that you need to convert.

from
: An optional argument specifying the Windows code page identifier for the local character set. If no value is entered, the default is `0`, for your system's code page identifier.

to
: An optional argument specifying the Windows code page identifier of the new character set for the string. If no value is entered, the default is `65001`, for UTF8.

Returns

The converted string.

Description

This function lets Windows users convert the local character set for a given string into a different character set. In many cases, this function is used to convert the local character set into UTF8, and can thus be run with a single *string* argument, using the defaults for the *from* and *to* arguments. A list of valid Windows code page identifiers for various character sets can be found online in the Microsoft documentation, or by searching on the term "`code page identifiers`".

In QNX or Linux this function simply returns the *string* argument.

strlen

`strlen` — counts the number of characters in a string.

Synopsis

```
strlen (string)
```

Arguments

string
: A string.

Returns

The number of characters in the *string*.

Example

```
Gamma> strlen("Hello");
5
Gamma> strlen("How about a cup of coffee?");
26
Gamma>
```

See Also

length

strncmp, strnicmp

`strncmp`, `strnicmp` — compare two strings and return a numeric result.

Synopsis

```
strncmp (string1, string2, length)
strnicmp (string1, string2, length)
```

Arguments

string1
: The first string.

string2
: The second string.

length
: The maximum length of the comparison.

Returns

An integer < 0 if *string1* is lexically less than *string2* to the given length; 0 if the two strings are equal up to the given length; and an integer > 0 if *string1* is lexically greater than *string2* up to the given length.

Description

The `strncmp` function compares two strings and returns a numeric result indicating whether the first string is lexically less than, greater than, or equal to the second string. The comparison will carry on for not more than *length* characters of the shorter string. The `strnicmp` function is the case-insensitive version of `strncmp`.

Example

```
Gamma> strncmp("hello","helicopter",4);
3
Gamma> strncmp("hello","help",3);
0
Gamma> strncmp("Hello","help", 3);
-32
Gamma> strnicmp("Hello","help", 3);
0
Gamma>
```

See Also

`strcmp`, `stricmp`

strrev

`strrev` — reverses the order of characters in a string.

Synopsis

```
strrev (string)
```

Arguments

string
    A string.

Returns

A new string which is the reverse of the given string.

Description

Automatic, full featured, palindrome creator.

Example

```
Gamma> strrev("I Palindrone I");
"I enordnilaP I"
Gamma> strrev("Madam, I'm adam");
"mada m'I ,madaM"
Gamma> strrev("123456789");
"987654321"
Gamma> strrev("poor dan is in a droop");
"poord a ni si nad roop"
Gamma>
```

See Also

strchr, strrchr

strstr

`strstr` — finds the location of a given substring.

Synopsis

```
strstr (stringA, stringB)
```

Arguments

`stringA`
: A string.

`stringB`
: A string.

Returns

The position of *`stringB`* within *`stringA`*, or -1 if *`stringA`* does not contain *`stringB`*.

Description

This function finds the first complete occurrence of *`stringB`* within *`stringA`* and returns the position of the starting character of the match within *`stringA`*. The first character in *`stringA`* is numbered zero. If no match is found, -1 is returned.

Example

```
Gamma> strstr("Acme widgets","get");
8
Gamma> strstr("Acme widgets","wide");
-1
Gamma>
```

See Also

`strchr`, `strrchr`

substr

`substr` — returns a substring for a given location.

Synopsis

```
substr (string, start_char, length)
```

Arguments

string
: A string.

start_char
: The position number of the first character of the substring.

length
: The length of the substring.

Returns

A new string which is a substring of the input *string*.

Description

This function returns a substring of the input string starting at the *start_char* position and running for *length* characters. The first character in the string is numbered zero. If *start_char* is greater than the length of the string, the function returns an empty string. If *start_char* is negative, it is indexed from the end of the string. If it is negative and greater than the length of the string, it is treated as zero—the beginning of the string.

If there are fewer characters than *length* in the string, or if *length* is -1, then the substring contains all characters from *start_char* to the end of the string.

Example

```
Gamma> substr("Acme widgets",7,3);
"dge"
Gamma> substr("Acme widgets",9,-1);
"ets"
Gamma> substr("Acme widgets",-7,4);
"widg"
Gamma> substr("Acme widgets",-30,4);
"Acme"
Gamma>
```

See Also

strchr, strrchr, string, strstr

tolower

`tolower` — converts upper case letters to lower case.

Synopsis

```
tolower (string|number)
```

Arguments

string
: Any string.

number
: Any number.

Returns

Strings with all letters converted to lower case. Numbers in integer form. Floating point numbers are truncated.

Description

This function converts any upper case letters in a string to lower case. It will also convert numbers to their base 10 integer representation.

Example

```
Gamma> tolower("Jack works for IBM.");
"jack works for ibm."
Gamma> tolower("UNICEF received $150.25.");
"unicef received $150.25."
Gamma> tolower(5.3);
5
Gamma> tolower(0b0110);
6
Gamma>
```

See Also

toupper

toupper

`toupper` — converts lower case letters to upper case.

Synopsis

```
toupper (string|number)
```

Arguments

string
: Any string.

number
: Any number.

Returns

Strings with all letters converted to upper case. Numbers in integer form. Floating point numbers are truncated.

Description

This function converts any lower case letters in a string to upper case. It will also convert numbers to their base 10 integer representation.

Example

```
Gamma> toupper("Jack works for IBM.");
"JACK WORKS FOR IBM."
Gamma> toupper("UNICEF received $150.25.");
"UNICEF RECEIVED $150.25."
Gamma> toupper(5.3);
5
Gamma> toupper(0b0110);
6
Gamma>
```

See Also

tolower

Data Type Conversion

bin

`bin` — converts numbers into binary form.

Synopsis

```
bin (number)
```

Arguments

number

Any number.

Returns

An integer number in binary format.

Description

This function casts any number to an integer, and returns it in a binary representation. Floating point numbers are truncated.

Example

```
Gamma> bin(12);
0b1100
Gamma> bin(12.9342);
0b1100
Gamma> bin(0x3b);
0b00111011
Gamma> bin(0o436);
0b000100011110
Gamma>
```

See Also

dec, hex, oct

char

char — generates an ASCII character from a number.

Synopsis

```
char (number)
```

Arguments

number

Any number. This is cast to an integer between 0 and 255. Negative numbers are treated as unsigned 2's complement integers.

Returns

A character string with one character which is the character representation of the ASCII value given as the argument.

Description

This function generates the string representation of an ASCII character value.

Example

```
Gamma> char (65);
"A"
Gamma> char (188);
"¼"
Gamma> char (350.25);
"^"
Gamma> char (-12);
"ô"
Gamma>
```

See Also

char_val

char_val

`char_val` — generates a character's numeric value.

Synopsis

```
char_val (char_as_string)
```

Arguments

char_as_string
: A string.

Returns

The ASCII (numeric) value of the first character in the argument string.

Description

Generates the ASCII (numeric) representation of the first character in a string.

Example

```
Gamma> char_val ("A");
65
Gamma> char_val ("q");
113
Gamma> char_val ("hope for all");
104
Gamma> char_val ("3");
51
Gamma> char_val ("ô");
-12
Gamma>
```

See Also

char

dec

dec — converts numbers into base-10 form.

Synopsis

```
dec (number)
```

Arguments

number

Any number.

Returns

An integer number in decimal format.

Description

This function casts any number to an integer, and returns it in decimal (base-10) representation.

Example

```
Gamma> dec(0b1100);
12
Gamma> dec(0x3b);
59
Gamma> dec(45.95);
45
Gamma> dec('A');
65
Gamma>
```

See Also

bin, hex, oct

hex

hex — converts numbers into hexadecimal form.

Synopsis

```
hex (number)
```

Arguments

number

Any number.

Returns

An integer number in hexadecimal format.

Description

This function casts any number to an integer, and returns it in a hexadecimal representation. Floating point numbers are truncated.

Example

```
Gamma> hex (12);
0xc
Gamma> hex (12.9341);
0xc
Gamma> hex (0b111011);
0x3b
Gamma> hex ('r');
0x72
Gamma>
```

See Also

bin, dec, oct

int

`int` — converts to integer form.

Synopsis

```
int (s_exp)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

An integer representation of the argument.

Description

This function converts the argument to an integer. Floating point numbers are truncated. Binaries, hexadecimals and characters convert to decimal integers. In strings, if the first character(s) are numerical, they will be converted to an integer. Otherwise, a string will return zero. All other expression types generate zero.

Example

```
Gamma> int(5.5);
5
Gamma> int(0xc);
12
Gamma> int(0b111011);
59
Gamma> int('h');
104
Gamma> int("63 hello");
63
Gamma> int("hello 63");
0
Gamma> int(random());
0
Gamma>
```

See Also

Literals

number, numberl

`number, numberl` — attempt to convert an expression to a number.

Synopsis

```
number (s_exp)
numberl (s_exp)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

A numeric representation of the *s_exp* if possible, otherwise zero.

Description

This function attempts to convert its argument to a number. Integer and floating point values remain untouched. String arguments are converted to numbers by attempting to read a number from the string starting at the first character in the string. The longest legal number at the beginning of the string is used. All other data types return zero. If possible, the result will be an integer. If the result cannot be represented as an integer, a real (floating point) number is returned.

The `number` function will convert a string in local-invariant format to a number. For example, the string `"1.2"` will convert to the number `1.2`. In locales where the decimal separator is not a dot, `number` will also attempt to perform the conversion in the current locale.

The `numberl` function (with an `l` for locale) will strictly perform the conversion in the current locale. For example, in a locale that uses comma as a decimal separator, `number("1.2")` will produce `1.2`, `numberl("1,2")` will produce `1.2`, and `numberl("1.2")` will produce `1`.

Example

```
Gamma> number(5);
5
Gamma> number("5.4m");
5.4000000000000003553
Gamma> number("m5.4");
0
```

```
Gamma> number(#a);
0
Gamma>
```

oct

`oct` — converts numbers into octal form.

Synopsis

```
oct (number)
```

Arguments

number
: Any number.

Returns

An integer number in octal format.

Description

This function casts any number to an integer, and returns it in an octal representation. Floating point numbers are truncated.

Example

```
Gamma> oct(12);
0o14
Gamma> oct(12.86223);
0o14
Gamma> oct(0x3b);
0o73
Gamma> oct(0b0101101);
0o55
Gamma>
```

See Also

bin, dec, hex

symbol

`symbol` — constructs a symbol from a string.

Synopsis

```
symbol (string)
```

Arguments

string
A string.

Returns

A symbol.

Description

This function constructs a symbol whose name is the same as the *string*, and places that symbol into the symbol table. Subsequent calls to this function with the same *string* will result in the same symbol, preserving the uniqueness of the symbol. Special characters may be included in the symbol name.

Example

```
Gamma> symbol("Strange symbol");
Strange\ symbol
Gamma> Strange\ symbol;
5
Gamma> symbol(string("item",2+3));
item5
Gamma>
```

Math

acos, asin, atan, atan2

`acos`, `asin`, `atan`, `atan2` — perform trigonometric arc functions.

Synopsis

```
acos (number)
asin (number)
atan (number)
atan2 (number, number)
```

Arguments

number
: Any integer or real number. Non-numbers are treated as zero.

Returns

The result of the arc trigonometric function in radians.

Description

These functions perform the arc trigonometric functions arc cosine, arc sine, arc tangent, and arc tangent with 2 arguments. The `atan2` function is equivalent to:

```
atan( y / x );
```

except that `atan2` is able to correctly handle x and y values of zero.

Example

```
Gamma> acos (0.5);
1.0471975511965978534
Gamma> asin (0.5);
0.52359877559829892668
Gamma> atan (2);
1.107148717794090409
Gamma> atan2 (1, 2);
0.46364760900080609352
Gamma> atan2 (1, 0);
1.570796326794896558
Gamma> atan2 (0, 2);
0
Gamma>
```

See Also

sin, cos, tan

and, not, or

and, not, or — are the same as the corresponding Logical Operators.

Synopsis

```
and (!condition[,!condition]...)
not (condition)
or (!condition[,!condition]...)
```

Arguments

condition

Any Gamma or Lisp expression.

Returns

Non-nil or nil.

Examples

```
Gamma> not(6);
nil
Gamma> not(nil);
t

Gamma> and(5<6,string("hi ","there"));
"hi there"
Gamma> and(5>6,string("hi ","there"));
nil

Gamma> x = 5;
5
Gamma> y = 6;
6
Gamma> or(x == 3, y == 0);
nil
Gamma> or(x == 3, y == 6);
t
Gamma>
```

See Also

Logical Operators

band, bnot, bor, bxor

band, bnot, bor, bxor — perform bitwise operations.

Synopsis

```
band (number, number)
bnot (number)
bor (number, number)
bxor (number, number)
```

Arguments

number

Any number. Non-numbers are treated as zero.

Returns

An integer which is the result of the particular operation.

Description

The binary operations cast their arguments to integers, and then perform bitwise operations to produce an integer result.

- **band** bitwise AND
- **bnot** bitwise NOT (inversion of all bits in a 32-bit word)
- **bor** bitwise OR
- **bxor** bitwise exclusive OR (XOR)

Example

```
Gamma> band(7,5);
5
Gamma> bnot(7);
-8
Gamma> bor(7,5);
7
Gamma> bxor(7,5);
2
Gamma>
```

See Also

Bitwise Operators

ceil

`ceil` — rounds a real number up to the next integer.

Synopsis

```
ceil (number)
```

Arguments

number
: Any number. Non-numbers are treated as zero.

Returns

The smallest integer that is greater than or equal to the *number*.

Description

This function has the effect of rounding real numbers up to the next integer. Integers are unaffected.

Example

```
Gamma> ceil(1.1);
2
Gamma> ceil(-1.1);
-1
Gamma> ceil(4);
4
Gamma>
```

See Also

`floor`, `round`

cfand, cfor

`cfand`, `cfor` — perform and and or functions with confidence factors.

Synopsis

```
cfand (!s_exp[,!s_exp]...)
cfor (!s_exp[,!s_exp]...)
```

Arguments

condition

Any Gamma or Lisp expression.

Returns

A confidence factor, an integer between 0 and 100.

Description

These functions determine the confidence factor of one or more expressions. `cfand` returns the lowest confidence factor among all of the passed *conditions*, while `cfor` returns the highest confidence factor among the *conditions*.

Example

```
Gamma> a = 3;
3
Gamma> b = 4;
4
Gamma> set_conf(a,50);
50
Gamma> set_conf(b,10);
10
Gamma> cfand(a,b);
10
Gamma> cfor(a,b);
50
Gamma>
```

See Also

conf

conf, set_conf

conf, set_conf — query and set confidence factors.

Synopsis

```
conf (s_exp)
set_conf (s_exp, number|s_exp)
```

Arguments

s_exp

Any Gamma or Lisp expression.

number|s_exp

Any number, or any expression that evaluates to a number. Non-numbers are treated as zero.

Returns

The confidence factor of the *number* or *s_exp*.

Description

All Gamma and Lisp expressions in Gamma have an associated confidence factor between 0 and 100 which may be queried using the conf function. This is typically 100, or fully confident. Exceptions arise only when the user explicitly sets the confidence to another value, or when the DataHub instance provides a confidence value to the interpreter.
The set_conf function will set the confidence of an expression to any numerical value, though legal values are between 0 and 100. Numbers less than 0 indicate indeterminate confidence. Numbers greater than 100 will produce strange results.

Example

```
Gamma> x = 3;
3
Gamma> set_conf(x, 40);
40
Gamma> conf(x);
40
Gamma>
```

cos, sin, tan

cos, sin, tan — perform trigonometric functions.

Synopsis

```
cos (number)
sin (number)
tan (number)
```

Arguments

number
Any number in radians. Non-numbers are treated as zero.

Returns

The result of the trigonometric functions cosine, sine and tangent.

Example

```
Gamma> cos(8);
-0.14550003380861353808
Gamma> sin(.8);
0.71735609089952279138
Gamma> tan(.5);
0.54630248984379048416
Gamma>
```

See Also

asin, acos, atan, atan2

div

`div` — divides, giving an integer result.

Synopsis

```
div (number, number)
```

Arguments

number

Any number.

Returns

The integer result of the division of the first argument by the second.

Description

This function is equivalent to `floor` (number/number)

Example

```
Gamma> div(12,5);
2
Gamma> div(23423,899);
26
Gamma>
```

See Also

Arithmetic Operators

exp

exp — calculates an exponent of the logarithmic base (e).

Synopsis

```
exp (number)
```

Arguments

number
Any number.

Returns

The natural logarithmic base, e, raised to the power of the *number*.

Example

```
Gamma> exp(0);
1
Gamma> exp(3);
20.085536923187667924
Gamma>
```

floor

`floor` — rounds a real number down to its integer value.

Synopsis

```
floor (number)
```

Arguments

number

Any number. Non-numbers are treated as zero.

Returns

The largest integer which is less than or equal to the *number*.

Example

```
Gamma> floor(1.2);
1
Gamma> floor(1.9);
1
Gamma> floor(-1.2);
-2
Gamma> floor(-1.9);
-2
Gamma>
```

See Also

ceil, round

log, log10, logn

`log`, `log10`, `logn` — calculate logarithms.

Synopsis

```
log (number)
log10 (number)
logn (base, number)
```

Arguments

number

Any numeric value.

base

The logarithmic base.

Returns

For `log`, the natural logarithm of the argument. For `log10`, the base 10 logarithm of the argument. For `logn`, the logarithm of the number in the given base.

Description

Non-numeric arguments are treated as zero. Illegal values for the arguments will cause an error.

Example

```
Gamma> log(2);
0.69314718055994528623
Gamma> log10(2);
0.30102999566398119802
Gamma> logn(8,2);
2.9999999999999995559
Gamma>
```

isnan

`isnan` — identifies invalid or illegal numbers.

Synopsis

```
isnan (number)
```

Arguments

number
: A floating point number.

Returns

`t` if the argument is not a number (nan), otherwise `nil`.

Description

This function tests to see whether the argument is a special floating point number that indicates the specific case of an illegal number or an infinite number. `NAN` is a floating point number that represents an invalid state, and is represented in Gamma as a constant. Please refer to Literals for more information on `NAN`.

Example

```
Gamma> isnan(sqrt(-1));
t
Gamma> isnan(sqrt(2));
nil
```

isinf

`isinf` — determines if a number is infinite.

Synopsis

```
isinf (number)
```

Arguments

number
: A floating point number.

Returns

`1` if the number is positive and infinite, `-1` if it is negative and infinite, otherwise `nil`.

Example

These examples use the constant INF, which represents an infinite number in Gamma.

```
Gamma> isinf(95);
nil
Gamma> isinf(INF);
1
Gamma> isinf(-INF);
-1
```

neg

neg — negates.

Synopsis

```
neg (number)
```

Arguments

number

Any number.

Returns

The negative of the *number*.

Example

```
Gamma> neg(5);
-5
Gamma> neg(-5);
5
Gamma>
```

pow

pow — raises a base to the power of an exponent.

Synopsis

```
pow (base, exponent)
```

Arguments

base

Any number.

exponent

Any number.

Returns

The result of raising the *base* to the given *exponent*.

Description

Calculates a base to the power of an exponent. Non-numbers are treated as zero.

Example

```
Gamma> pow(2,3);
8
Gamma> pow(12,2);
144
Gamma> pow(5.2,4.75);
2517.7690015606849556
Gamma>
```

random

`random` — generates random numbers from 0 to 1.

Synopsis

```
random ()
```

Arguments

none

Returns

A floating point random number which is greater than or equal to 0 and is less than 1.

Description

This function uses a pseudo-random number generator to generate a non-repeating sequence of numbers randomly distributed across the range of 0 <= x < 1.

The random number generator should be seeded prior to being called by using the `set_random` function. If the same seed is given to `set_random`, the same random sequence will result every time.

Example

```
#!/usr/local/bin/gamma -d

//Seed random number generator to clock setting:
set_random(clock());

//Randomly generate an integer from one to six:
function one_to_six ()
{
        floor(6 * random()) + 1;
}

//Princ the results:
x = one_to_six();
princ(x, "\n");
```

See Also

`set_random`

round

`round` — rounds a real number up or down to the nearest integer.

Synopsis

```
round (number)
```

Arguments

number
: A number.

Returns

The nearest integer to the *number*.

Description

This function rounds its argument to the nearest integer. Values of .5 are rounded up to the next highest integer.

Example

```
Gamma> round(8.73);
9
Gamma> round(2.21);
2
Gamma> round(5.5);
6
Gamma> round(5.49);
5
Gamma>
```

See Also

ceil, floor

set_random

`set_random` — starts `random` at a different initial number.

Synopsis

```
set_random (integer_seed)
```

Arguments

integer_seed
: Any integer number.

Returns

`t`

Description

This function seeds the random number generator to start the pseudo-random sequence at a different number. The same *integer_seed* will always produce the same pseudo-random sequence. `set_random` is commonly called with an unpredictable *integer_seed*, such as the result of `clock`.

Example

```
Gamma> set_random(95);
t
Gamma> random();
0.26711518364027142525
Gamma> random();
0.8748339582234621048
Gamma> random();
0.30958001874387264252
Gamma> set_random(clock());
t
Gamma> random();
0.41952831624075770378
Gamma> random();
0.99278739839792251587
Gamma> random();
0.42997436970472335815
Gamma>
```

See Also

random

sqr

sqr — finds the square of a number.

Synopsis

```
sqr (number)
```

Arguments

number
Any number.

Returns

The square of the *number*.

Example

```
Gamma> sqr(11);
121
Gamma> sqr(32.73);
1071.2528999999997268
Gamma>
```

See Also

sqrt

sqrt

`sqrt` — finds the square root of a number.

Synopsis

```
sqrt (number)
```

Arguments

number

Any number.

Returns

The square root of the *number*.

Example

```
Gamma> sqrt(9);
3
Gamma> sqrt(144);
12
Gamma> sqrt(95);
9.7467943448089631175
Gamma>
```

See Also

sqr

Input/Output

close

`close` — closes an open file.

Synopsis

```
close (file)
```

Arguments

`file`
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

`t` if the *`file`* had been open and was closed successfully, else `nil`.

Description

This function closes a previously opened file. It is not strictly necessary, as the file will be closed when the garbage collector recognizes that there are no references to the file, but it is extremely good policy. This function will close a string opened for reading and writing as well.

Example

```
Gamma> fp = open("myfile.dat","r");
#<File:"myfile.dat">
Gamma> close(fp);
t
Gamma> fp;
#<Destroyed Instance>
Gamma>
```

See Also

`fd_close`, `open`, `open_string`

fd_close

`fd_close` — closes a file identified by a file descriptor.

Synopsis

```
fd_close (fd)
```

Arguments

fd
: A file descriptor as returned from `fd_open`.

Returns

`t`, if successful, otherwise `nil`.

Description

This function closes a file identifed by a file descriptor, ie. that was opened by `fd_open`.

Example

```
Gamma> require_lisp("const/filesys");
"const/filesys"
Gamma> fp = fd_open("/fd/ttyp8",O_WRONLY);
4
Gamma> fd_write(fp,"\nHello\n");
8
Gamma> fd_close(fp);
t
Gamma> fd_close(fp);
nil
```

See Also

`close`, `fd_open`, Referencing Files

fd_data_function

`fd_data_function` — attaches a write-activated callback to a file.

Synopsis

```
fd_data_function (fd|file, code)
```

Arguments

fd|file
: A file descriptor as returned from `fd_open`, or the name of a file pointer to a file that was opened by a call to `open` or `open_string`.

code
: Any valid Gamma program, executable code block, or statement.

Returns

The return value of the executed *code*.

Description

This function acts as a callback, causing the *code* to execute whenever data is written to the file associated with the *fd* or *file* pointer.

See Also

`fd_open`, `fd_eof_function`, `fd_write`, `open`, `open_string`, `write`

fd_eof_function

`fd_eof_function` — attaches an `eof`-activated callback to a file.

Synopsis

```
fd_eof_function (fd|file, code)
```

Arguments

fd|file
: A file descriptor as returned from `fd_open`, or the name of a file pointer to a file that was opened by a call to `open` or `open_string`.

code
: Any valid Gamma program, executable code block, or statement.

Returns

The return value of the executed *code*.

Description

This function acts as a callback, causing the *code* to execute whenever the end of the file (`_eof_`) is reached during a call to `fd_read` or one of the other `read` functions. The *fd|file* argument identifies the file.

See Also

`fd_open`, `fd_data_function`, `fd_write`, `open`, `open_string`, `write`

fd_open

`fd_open` — opens a file or device and assigns it a file descriptor.

Synopsis

```
fd_open (name, mode)
```

Arguments

name
: The name of a file, as a string.

mode
: The mode for opening the file.

Returns

A non-negative integer representing the lowest numbered unused file descriptor if successful. If an error occurs, the function returns -1 and sets the errno.

Description

This function opens a file for reading and/or writing, and assigns it a file descriptor which is used as an argument by other functions such as `fd_read` and `fd_write`. The file that is opened could be a regular file, a directory, or a block or character device. Legal *mode* values are:

- **O_RDONLY** Read-only mode
- **O_WRONLY** Write-only mode
- **O_RDWR** Read-Write mode

Any combination of the following flags may be bitwise OR-ed with the open mode to modify how the file is accessed:

- **O_APPEND** Append (writes guaranteed at the end)
- **O_CREAT** Opens with file create
- **O_EXCL** Exclusive open
- **O_NOCTTY** Don't assign a controlling terminal
- **O_NONBLOCK** Non-blocking I/O
- **O_TRUNC** Open with truncation
- **O_DSYNC** Data integrity synch

- **O_SYNC** File integrity synch
- **O_TEMP** Temporary file, don't put to disk
- **O_CACHE** Cache sequential files too

If an error occurs -1 is returned and errno is set to one of the following:

- **EACCES** Search permission denied on a portion of the path prefix, or the file exists and the permissions required to open the file in the given mode so not exist.
- **EBADFSYS** The file or the path prefix to the file was found to be corrupted
- **EBUSY** The file is already open for writing.
- **EEXIST** O_CREAT and O_EXCL are set and the named file exists
- **EINTR** The function was interrupted by a signal
- **EISDIR** The named file is a directory
- **EMFILE** Too many file descriptors are currently in use by this process
- **ENAMETOOLONG** The length of the path to the file is too long.
- **ENFILE** Too many files are currently open on the system
- **ENOENT** O_CREAT is not set and the file does not exist
- **ENOSPC** The directory or file system which would create the new file cannot be extended
- **ENOTDIR** A component of the path to the file is not a directory
- **ENXIO** O_NONBLOCK is set, the file is a FIFO, O_WRONLY is set, and no process has the file open for reading
- **EROFS** The named file resides on a read-only file system.

Example

```
Gamma> require_lisp("const/filesys");
"/usr/cogent/lib/const/filesys.lsp"
Gamma> ptr = fd_open("/fd/ttyp8",O_WRONLY);
4
Gamma> fd_write(ptr,"\nhello\n");
7
```

See Also

fd_close, fd_data_function, fd_eof_function, fd_read, fd_write ser_setup, Referencing Files

fd_read

`fd_read` — reads a buffer or string from a file identified by a file descriptor.

Synopsis

```
fd_read (fd, buffer|string, length?, offset?)
```

Arguments

fd
: A file descriptor as returned from `fd_open`.

buffer|string
: A buffer or string to be read from the file.

length
: An integer specifying the length of the buffer or string.

offset
: An integer specifying the position in the file to begin reading the buffer or string.

Returns

The number of bytes actually read from the file, or -1 on failure and the errno is set.

Description

This function reads a buffer or string from the specified file.

When an error occurs, the following errnos are possible:

- **EAGAIN** The O_NONBLOCK flag is set for the *fd* and the process would be delayed in the read operation.
- **EBADF** The passed *fd* is invalid or not open for writing.
- **EFBIG** File is too big.
- **EINTR** Read was interrupted by a signal.
- **EINVAL** iovcnt was less than or equal to 0, or greater than UIO_MAXIOV.
- **EIO** Physical I/O error.

Example

```
Gamma> x = fd_open("/fd/ser1",O_RDWR);
4
```

```
Gamma> fd_read(x,"hello\n");
6
Gamma> fd_close(x);
t
```

See Also

fd_close, fd_open, fd_read, ser_setup, Referencing Files

fd_to_file

`fd_to_file` — creates a file pointer from a descriptor.

Synopsis

```
fd_to_file (fd, mode)
```

Arguments

fd

A file descriptor as returned from `fd_open`.

mode

A string indicating the mode for the file: `"r"` for read-only, `"w"` for writable, `"a"` for append.

Returns

`t`, if successful, otherwise `nil`.

Description

This function creates a file pointer from a file descriptor.

See Also

`fileno`, Referencing Files

fd_write

`fd_write` — writes a buffer or string to a file identified by a file descriptor.

Synopsis

```
fd_write (fd, buffer|string, length?, offset?)
```

Arguments

fd
: A file descriptor as returned from `fd_open`.

buffer|string
: A buffer or string to write to the file.

length
: An integer specifying the length of the buffer or string.

offset
: An integer specifying the position in the file to begin writing the buffer or string.

Returns

The number of bytes actually written to the file, or -1 on failure and the errno is set.

Description

This function writes a buffer or string to the specified file.

When an error occurs, the following errnos are possible:

- **EAGAIN** The O_NONBLOCK flag is set for the *fd* and the process would be delayed in the write operation.
- **EBADF** The passed *fd* is invalid or not open for writing.
- **EFBIG** File is too big.
- **EINTR** Write was interrupted by a signal.
- **EINVAL** iovcnt was less than or equal to 0, or greater than UIO_MAXIOV.
- **EIO** Physical I/O error.
- **ENOSPC** No free space remaining on drive.
- **EPIPE** Attempt to write to a pipe (or FIFO) that is not open for write. SIGPIPE is also sent to process.

Example

```
Gamma> x = fd_open("/fd/ser1",O_RDWR);
4
Gamma> fd_write(x,"hello\n");
6
Gamma> fd_close(x);
t
```

See Also

fd_close, fd_open, fd_read, ser_setup, Referencing Files

fileno

`fileno` — creates a file descriptor from a pointer.

Synopsis

```
fileno (file)
```

Arguments

`file`

A file pointer as returned from `open`.

Returns

`t`, if successful, otherwise `nil`.

Description

This function creates a file descriptor from a file pointer.

See Also

`fd_to_file`, Referencing Files

ioctl

`ioctl` — performs control functions on a file descriptor.

Synopsis

```
ioctl (fd, request, value)
```

Arguments

`fd`
: A file descriptor as returned from `fd_open`.

`request`
: One of the functions listed below in Description.

`value`
: A number that supplies additional information needed by the *`request`* function.

Returns

The return value of the *`request`* function.

Description

This function performs an `ioctl` call (C library `ioctl` subroutine) for the given *`fd`* file descriptor and *`request`*. The Gamma `ioctl` function currently only supports *`request`*s that take numeric arguments, ie. *`value`* must be a number. You may make operating-system specific `ioctl` calls by giving a numeric value for the *`request`* argument.

The currently supported *`request`*s are:

TCSBRK	TCXONC	TCFLSH	TIOCHPCL	TIOCEXCL	TIOXNXCL
TIOCFLUSH	TIOCDRAIN	TIOCSCTTY	TIOCMGET	TIOCMBIC	TIOCMBIS
TIOCMSET	TIOCSTART	TIOCSTOP	TIOCNOTTY	TIOCOUTQ	TIOCSPGRP
TIOCGPGRP	TIOCCDIR	TIOCSDIR	TIOCCBRK	TIOCSBRK	TIOCLGET
TIOCLSET	TIOCSETPGRP	TIOCGETPGRP	FIOCLEX	FIONCLEX	FIOGETOWN
FIOSETOWN	FIOASYNC	FIONBIO	FIONReAd	SIOCSHIWAT	SIOCGHIWAT
SIOCSLOWAT	SIOCGLOWAT	SIOCATMARK	SIOCSPGRP	SIOCGPGRP	

open

open — attempts to open a file.

Synopsis

```
open (filename, mode, use_parser?)
```

Arguments

filename
: A filename (possibly including the path), as a string.

mode
: A string indicating the mode for the file: `"r"` for read-only, `"w"` for writable, `"a"` for append. Other characters might be available, depending on the operating system. Please refer to the documentation for the operating system's `fopen` function.

use_parser
: Assume Lisp grammar regardless of the default grammar.

Returns

A file pointer, or `nil` if the request failed.

Description

This function attempts to open a file. If the file is opened for write (`"w"`), any previously existing file of the same name will be destroyed. If the file is opened for append (`"a"`) then a previously existing file will be lengthened with subsequent writes, but the data in that file will not be damaged. A file can only be opened read-only (`"r"`) if it already exists. The result of this function may be used as an argument to a variety of read and write operations.

> When Gamma opens or creates a file, it creates an abstract *file pointer*. A printed representation of the file pointer looks like this: `#<File:`*`filename`*`>`. This representation cannot be read back in to Gamma, and so a symbol must be assigned to the file pointer in order to refer to or work with a file. In common language, we refer to this symbol as the file pointer. For instance, in the examples below, we would say the symbol `fp` is the file pointer. (See also Referencing Files.)

If *use_parser* is non-`nil`, then a call to read will parse the file according to its default grammar. If *use_parser* is `nil`, then a call to read will parse the file as if it were a Lisp expression. A file must be opened in Lisp format in order to use calls to `read_char`, `read_double`, `read_float`, `read_line`, `read_long`, `read_short` and `read_until`.

Examples

An input file contains the following:

```
      (setq y 5)
```

Calling open will produce:

```
Gamma> fp = open ("myopenfile.dat", "r", nil);
#<File:"myopenfile.dat">
Gamma> princ(read_line(fp), "\n");
(setq y 5)
t
Gamma> fp = open ("myopenfile.dat", "r", nil);
#<File:"myopenfile.dat">
Gamma> eval (read(fp));
5
Gamma> fp = open ("myopenfile.dat", "r", t);
#<File:"myopenfile.dat">
Gamma> princ(read_line(fp), "\n");
(setq y 5)
t
Gamma> fp = open ("myopenfile.dat", "r", t);
#<File:"myopenfile.dat">
Gamma> eval (read(fp));
Error: ./generate.slg: line 1: Malformed expression within ()
Error: ./generate.slg: line 1: Unexpected end of file
Macro read left extra stuff on the LISP stack: 8098478, 8098470
nil
nil
Gamma>
```

The following example opens and reads a file, if it exists. If not, it prints and error message.

```
if ( (fp=open("myfile","r")) != nil )
{
  local line;
  while((line = read_line(fp)) != _eof_)
    {
      princ(line, "\n");
    }
  close(fp);
}
else
{
 princ("Error : unable to open myfile for read\n");
}
```

See Also

close, fd_open, open_string, read, read_char, read_double, read_float, read_line, read_long, read_short, read_until, seek, tell, terpri, write, writec

pipe

pipe — creates a pipe.

Synopsis

```
pipe ()
```

Arguments

none

Returns

A list of the read pipe and the write pipe, each as a file pointer.

Description

This function creates an un-named pipe.

Example

```
Gamma> pipe1 = pipe();
(#<File:"read_pipe"> #<File:"write_pipe">)
Gamma> pread = car(pipe1);
#<File:"read_pipe">
Gamma> pwrite = cadr(pipe1);
#<File:"write_pipe">
Gamma> write (pwrite, "This is a test");
t
Gamma> read (pread);
"This is a test"
Gamma>
```

princ, print, pretty_princ, pretty_print

princ, print, pretty_princ, pretty_print — write to the standard output file.

Synopsis

```
princ (s_exp...)
print (s_exp...)
pretty_princ (s_exp...)
pretty_print (s_exp...)
```

Arguments

s_exp
: Any Gamma or Lisp expression.

Returns

t

Description

These functions write to the standard output file, typically the screen. The princ and pretty_princ functions produce formatted output, which means that special characters are not escaped, and double quotes are not printed around character strings. Output generated by princ cannot be read by the Lisp reader.

print and pretty_print produce Lisp-readable output. The result of reading a printed expression using a call to read will generate an equal expression.

pretty_princ and pretty_print generate carriage returns and spaces with the intention of formatting the output to make long or complex Lisp expressions easier for a person to read.

Examples

```
Gamma> x = "hello";
"hello"
Gamma> print (x,"\n");
"hello""\n"t
Gamma> princ (x,"\n");
hello
t
Gamma> >
```

```
Gamma> class C {a; b; c;}
(defclass C nil [][a b c])
Gamma> princ (C);
(defclass C nil [][a b c])t
Gamma> pretty_princ (C);
(defclass C nil
[]
[a b c])t
Gamma>

Gamma> L = list (1,2,3,4,5,list(1,2,3,4,5,list(1,2,3
list(1,2,3,4,5,list(1,2,3,4,5,list(1,2,3,4,5,list(1,2
,list(1,2,3,4,5,list(1,2,3,4,5))))))))));
(1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4
4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5)))))
Gamma> princ (L);
(1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4
4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5)))))
Gamma> pretty_princ (L);

(1 2 3 4 5
   (1 2 3 4 5
      (1 2 3 4 5
         (1 2 3 4 5
            (1 2 3 4 5
               (1 2 3 4 5
                  (1 2 3 4 5 (1 2 3 4 5 (1 2 3 4 5 (
))))))))))t
Gamma>
```

See Also

write, writec, pretty_write

pty, ptytio

`pty`, `ptytio` — run programs in a pseudo-tty.

Synopsis

```
pty (program, arguments...? = nil)
ptytio (termios, program, arguments...? = nil)
```

Arguments

program
: A string containing the name of the program to be executed.

arguments
: A string containing any command-line arguments for the program.

termios
: A `termios` structure.

Returns

A list of:

```
(process_id file_for_stdin file_for_stdout file_for_stderr pty_name)
```

Where:

process_id
: The process ID of the program called.

file_for_stdin
: A pointer to the file used for STDIN.

file_for_stdout
: A pointer to the file used for STDOUT.

file_for_stderr
: A pointer to the file used for STDERR.

pty_name
: The path and filename of this pseudo-tty, as a string.

Description

These functions run programs in a pseudo-tty. A Gamma program can read from either program's standard output by issuing a `read` or `read_line` call on *`file_for_stdout`*. The process can be reaped using `wait`.

The ptytio function is the same as pty, but the first argument is a termios structure. This is useful if particular terminal characteristics are required on the pty. The termios structure is only available through the gammatios.so dynamic library.

Example

This example calls pty on the following test program, called testpty.g:

```
#!/usr/cogent/bin/gamma
princ("Test output.\n");
princ(cadr(argv),"\n");
```

Here we call pty in interactive mode, and then read the output:

```
Gamma> ptylist = pty("testpty.g", "Argument");
(4760 #<File:"testpty.g-stdin"> #<File:"testpty.g-stdout">
    #<File:"testpty.g-stderr"> "/dev/ptyp0")
Gamma> read_line(caddr(ptylist));
"This software is free for non-commercial use, and no valid
commercial license"
Gamma> read_line(caddr(ptylist));
"is installed.  For more information, please contact info@cogent.ca."
Gamma> read_line(caddr(ptylist));
"Test output."
Gamma> read_line(caddr(ptylist));
"Argument"
Gamma>
```

read

`read` — reads a Lisp expression from a file.

Synopsis

```
read (file)
```

Arguments

`file`
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

The next Lisp expression in the file, or `_eof_`.

Description

This function reads one Lisp expression from the given *`file`*. The file must have been opened before this call with the open or `open_string` functions. White space and newline characters are ignored during a read. If the end of file is reached during the `read` call, the message "Unexpected end of file" is returned. `read` does not evaluate the expressions it reads.

Example

The file "myreadfile.dat" contains the following:

```
(a b (c d e))
"A message"  (+ 2 3)
```

Successive calls to `read` will produce:

```
Gamma> fp = open ("myreadfile.dat", "r");
#<File:"myreadfile.dat">
Gamma> read (fp);
(a b (c d e))
Gamma> read (fp);
"A message"
Gamma> read (fp);
(+ 2 3)
Gamma> read (fp);
"Unexpected end of file"
```

```
Gamma>
```

See Also

read_char, read_double, read_float, read_line, read_long, read_short, read_until

read_char, read_double, read_float, read_long, read_short

`read_char`, `read_double`, `read_float`, `read_long`, `read_short` — read the next character, double, float, long or short value in binary representation from the input file.

Synopsis

```
read_char (file)
read_double (file)
read_float (file)
read_long (file)
read_short (file)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

read_char returns the decimal representation of a string of length 1 containing a single character, or -1 indicating end of file.

read_double, read_float return a floating point value, or nan indicating end of file.

read_long, read_short return an integer value, or -1 indicating end of file.

Description

These functions read the next character, double, float, long or short value in binary representation from the input file, regardless of Lisp expression syntax. This allows a programmer to read binary files constructed by other programs.

Example

The file "myfile.dat" contains the following:

```
ajz
```

Successive calls to `read_char` will produce:

```
Gamma> ft = open ("myreadcfile.dat","r");
#<File:"myreadcfile.dat">
Gamma> read_char(ft);
97
```

```
Gamma> read_char(ft);
106
Gamma> read_char(ft);
122
Gamma> read_char(ft);
-1 Gamma>
```

See Also

read, read_line, read_until

read_eval_file

`read_eval_file` — reads a file, evaluating and counting expressions.

Synopsis

```
read_eval_file (file)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

The number of expressions that were read and evaluated.

Description

This function reads from the current location in the file to the end, evaluating its contents as Lisp expressions and counting them.

Example

The file "myevalfile.dat" contains the following:

```
(+ 3 4) 3 + 2;
```

```
Gamma> ft = open ("myevalfile.dat", "r");
#<File:"myevalfile.dat">
Gamma> read_eval_file(ft);
4
Gamma> close(ft);
t
Gamma>
```

See Also

require, load, open

read_line

`read_line` — reads a single line of text.

Synopsis

```
read_line (file)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

All characters in the file up to the first newline character, as a string. If the end of file is reached, returns "Unexpected end of file".

Description

This function reads a single line of text from the given file, up to the first newline character, regardless of Lisp syntax. This allows a programmer to deal with text files constructed by other programs.

Example

An input file contains the following:

```
      Lists can be
      expressed as (a b c).
```

Successive calls to `read_line` will produce:

```
Gamma> ft = open ("myreadlfile.dat", "r");
#<File:"myreadlfile.dat">
Gamma> read_line(ft);
"Lists can be"
Gamma> read_line(ft);
"expressed as (a b c)."
Gamma> read_line(ft);
"Unexpected end of file"
Gamma>
```

See Also

read, read_char, read_double, read_float, read_long, read_short, read_until

read_n_chars

`read_n_chars` — reads and stores characters.

Synopsis

```
read_n_chars (file, nchars)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

nchars
: The number of characters to read.

Returns

A buffer containing the characters read. The length of the return buffer is equal to the number of characters actually read. This function returns `nil` if no characters could be read.

Description

This function reads the given number of characters from the file, without any form of translation, and builds a new buffer object in which to store them. If this function reaches the end of the file before all characters are read, then the buffer will be shorter than the requested number of characters.

Example

An input file contains the following:

```
To be or not to be, that is the question.
```

Successive calls to `read_n_chars` will produce:

```
Gamma> ft = open ("myreadnfile.dat", "r");
#<File:"myreadnfile.dat">
Gamma> read_n_chars(ft,15);
#{To be or not to}
Gamma> read_n_chars(ft,18);
#{ be, that is the q}
Gamma> read_n_chars(ft,18);
#{uestion.}
```

```
Gamma> read_n_chars(ft,18);
nil
Gamma>
```

See Also

read_char

read_until

`read_until` — reads characters, constructing a string as it goes.

Synopsis

```
read_until (file, delimiters)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

delimiters
: A string of delimiter characters. "" indicates white space.

Returns

All characters in the file up to the first occurrence of any of *delimiter* characters, or "Unexpected end of file".

Description

This function reads characters from the input file one at a time until it reaches any of the *delimiter* characters, constructing a string as it goes. Successive calls continue from the point of the previous `read_until`. If the end of file is reached, the function returns "Unexpected end of file".

Example

An input file contains the following:

```
      Lists can be
      expressed as (a b c).
```

Successive calls to `read_until` will produce:

```
Gamma> ft = open ("myreadlfile.dat","r");
#<File:"myreadlfile.dat">
Gamma> read_until(ft, "(");
"Lists can be\nexpressed as "
Gamma> read_until(ft,"x");
"a b c)."
Gamma> read_until(ft,"y");
"Unexpected end of file"
```

```
Gamma>
```

See Also

read, read_char, read_double, read_float, read_line, read_long, read_short

seek

seek — sets the file position for reading or writing.

Synopsis

```
seek (file, offset, where)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

offset
: An integer specifying the number of characters into the file, starting from *where*.

where
: A starting point, indicated by a number:

- **0** Beginning of the file.
- **1** Current position in the file.
- **2** End of the file.

Returns

t if successful, nil if unsuccessful.

Description

This function lets you specify a position in a file to start reading or writing.

Example

The file "myseekfile" contains the following:

```
Now is the time for all good men and women
to come to the aid of their world.
```

```
Gamma> msk = open("myseekfile.dat", "r",nil);
#<File:"myseekfile.dat">
Gamma> seek(msk, 5, 0);
t
Gamma> read_line(msk);
"s the time for all good men and women"
Gamma> seek(msk, 2, 1);
t
```

```
Gamma> read_line(msk);
" come to the aid of their world."
Gamma> seek(msk, -15, 2);
t
Gamma> read_line(msk);
"of their world."
Gamma> seek(msk, -3, 0);
nil
Gamma>
```

See Also

open, open_string, read, read_char, read_double, read_float, read_line, read_long, read_short, read_until, tell

ser_setup

`ser_setup` — sets parameters for a serial port device.

Synopsis

```
ser_setup (devno, baud, bits/char, parity, stopbits, min, time)
```

Arguments

devno
: A file ID as returned from a call to `fd_open`.

baud
: A legal baud rate.

bits/char
: Bits per character (6, 7 or 8).

parity
: "none", "even", "odd", "mark" or "space"

stopbits
: Stop bits (0, 1 or 2).

min
: Default minimum number of characters for a read.

time
: Default inter-character timeout for a read.

Returns

`t` on success or `nil` on failure.

Description

This function sets the most common parameters for a serial port device, as opened by a call to `fd_open`. The function is currently only available in QNX 4.

Example

```
Gamma> id = fd_open("/dev/ser1",O_RDWR);
4
Gamma> ser_setup(id,9600,8,"none",1,1,0);
t
```

See Also

fd_close, fd_open

tell

`tell` — indicates file position.

Synopsis

```
tell (file)
```

Arguments

file

A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

Current file position, as an integer.

Description

This function returns the current file position as an integer representing the number of characters from the beginning of the file.

Example

```
Gamma> msk = open("myseekfile.dat", "r",nil);
#<File:"myseekfile.dat">
Gamma> read_until(msk,"f");
"Now is the time "
Gamma> tell(msk);
17
Gamma> seek(msk, 18, 1);
t
Gamma> tell(msk);
35
Gamma> msk = open("myseekfile3.dat", "w",nil);
#<File:"myseekfile3.dat">
Gamma> write(msk,"hello");
t
Gamma> tell(msk);
7
Gamma> msk = open("myseekfile3.dat", "a",nil);
#<File:"myseekfile3.dat">
Gamma> write(msk,"goodbye");
```

```
t
Gamma> tell(msk);
16
Gamma>
```

See Also

open, open_string, read, read_char, read_double, read_float, read_line, read_long, read_short, read_until, seek

terpri

`terpri` — prints a newline to an open file.

Synopsis

```
terpri (file?)
```

Arguments

`file`

A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

`t` if successful, otherwise `nil`.

Description

This function writes a newline to the open *`file`*. Any existing contents written to a file before it was opened will be deleted when the file is opened and written to.

Example

This example writes a file with the following contents, including the newline:

```
      (chars (1 2 3))
      (chars (4 5 6))
```

```
Gamma> fw = open("mytpfile.dat", "w");
#<File:"mytpfile.dat">
Gamma> write(fw,list(#chars,list(1,2,3)));
t
Gamma> terpri(fw);
t
Gamma> write(fw,list(#chars,list(4,5,6)));
t
Gamma> close(fw);
t
Gamma> fr = open("mytpfile.dat", "r", nil);
#<File:"mytpfile.dat">
Gamma> read_line(fr);
"(chars (1 2 3))"
```

```
Gamma> read_line(fr);
"(chars (4 5 6))"
Gamma> terpri();

t
Gamma>
```

unread_char

`unread_char` — attempts to replace a character to a file for subsequent reading.

Synopsis

```
unread_char (file, character)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

character
: A single character.

Returns

`t` if the *character* could be replaced on the *file*, otherwise `nil`.

Description

This function attempts to place the given *character* back onto the *file* so that it can be read again by subsequent calls to any of the `read` family of functions. Only one character may be replaced onto a file between calls to `read`. At least one `read` call must have been made prior to calling this function.

Example

An input file contains the following:

```
ABCDE
```

A call to `unread_char` within a succession of calls to `read_char` will produce:

```
Gamma> fr = open("myunreadfile.dat", "r", t);
#<File:"myunreadfile.dat">
Gamma> read_char(fr);
65
Gamma> read_char(fr);
66
Gamma> unread_char(fr,'A');
t
Gamma> read_char(fr);
65
```

```
Gamma> read_char(fr);
67
Gamma> read_char(fr);
68
Gamma>
```

See Also

read

write, writec, pretty_write, pretty_writec

`write`, `writec`, `pretty_write`, `pretty_writec` — write an expression to a file.

Synopsis

```
write (file, s_exp...)
writec (file, s_exp...)
pretty_write (file, s_exp...)
pretty_writec (file, s_exp...)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

s_exp
: Any Gamma or Lisp expression.

Returns

`t` on success, otherwise `nil`.

Description

Writes the given expressions to the file using the same format as `print`. See `print` for more information.

`writec` produces the same format as `princ`; `pretty_write` produces the same format as `pretty_print`; and `pretty_writec` produces the same format as `pretty_printc`. Any contents written to the file before it was opened will be deleted when any of these `write` functions are used.

Example

```
Gamma> fw = open("mywritefile.dat", "w");
#<File:"mywritefile.dat">
Gamma> write(fw,"This is on \n one line.");
t
Gamma> writec(fw,"This finishes on \n another line.");
t
Gamma> close(fw);
t
Gamma> fr = open("mywritefile.dat", "r", nil);
```

```
#<File:"mywritefile.dat">
Gamma> read_line(fr);
"\"This is on \n one line.\"This finishes on "
Gamma> read_line(fr);
" another line."
Gamma>
```

See Also

print

write_n_chars

write_n_chars — writes characters from a buffer to a file.

Synopsis

```
write_n_chars (file, buffer, nchars)
```

Arguments

file
: A file pointer to the open destination file for the characters.

buffer
: The buffer that is the source of the characters.

nchars
: The number of characters to write.

Returns

The number of characters successfully written to the file.

Description

This function reads a given number of characters from a buffer and writes them to an open file.

Example

The following example writes the characters 'e', 'f', and 'g' to a file.

```
Gamma> fw = open("mywritencharsfile.dat", "w");
#<File:"mywritencharsfile.dat">
Gamma> buf = buffer (101, 102, 103, 104);
#{efgh}
Gamma> write_n_chars (fw, buf, 3);
3
Gamma>
```

See Also

write, writec, pretty_write

File System

absolute_path

`absolute_path` — returns the absolute path of the given file.

Synopsis

```
absolute_path (filename)
```

Arguments

`filename`
The name of a disk file.

Returns

The absolute path of the file.

Description

This function returns the absolute path of the given file, with extraneous ../ constructs removed, and with the full QNX 4 node number added. The filename can be relative or absolute, on any node on the network.

Example

```
Gamma> absolute_path(".profile");
"//1/home/andrewt/.profile"
```

access

`access` — checks a file for various permissions.

Synopsis

```
access (filename, mode)
```

Arguments

filename
: The name of a file on disk.

mode
: The file mode to be tested. The legal modes are discussed below.

Returns

Zero is returned if the access *mode* is valid, otherwise -1 is returned and the errno is set.

Description

This function checks a file for the following permissions. Two or more permissions in bitwise OR combinations can be checked at one time.

- **R_OK** Test for read permission.
- **W_OK** Test for write permission.
- **X_OK** Test for execute permission.
- **F_OK** Test for existence of file.

The library "const/Filesys.lsp" must be required to use the constants listed above.

Example

```
Gamma> require_lisp("const/Filesys");
"/usr/cogent/lib/const/Filesys.lsp"
Gamma> system("touch /tmp/access_test");
0
Gamma> system("chmod a=rx /tmp/access_test");
0
Gamma> access("/tmp/access_test", R_OK|X_OK);
0
Gamma> access("/tmp/access_test", W_OK);
-1
```

```
Gamma>
```

See Also

is_busy, is_file, is_readable, is_writable, errno

basename

`basename` — gives the base of a filename.

Synopsis

```
basename (filename, suffix?)
```

Arguments

filename
: A file name as a string, as defined by the operating system.

suffix
: Any ending part of the filename to exclude.

Returns

The base of the filename. If a suffix is specified, the base of the filename without the suffix.

Example

```
Gamma> x = basename("/usr/george/lib/misc/myfile.dat");
"myfile.dat"
Gamma> y = basename("misc/myfile.dat", ".dat");
"myfile"
Gamma>
```

See Also

dirname root_path

cd

cd — changes the working directory.

Synopsis

```
cd (path)
```

Arguments

path

A character string which defines a directory path in the current operating system.

Returns

t if the operation is successful, otherwise nil.

Description

This function changes the current working directory for subsequent file system operations.

Example

```
Gamma> cd ("/usr/local/bin");
t
```

chars_waiting

`chars_waiting` — checks for characters waiting to be read on a file.

Synopsis

```
chars_waiting (file)
```

Arguments

file
: A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

The number of characters waiting on the open file.

Description

This function determines whether there are any characters waiting to be read on the given file. The file may be a string file (created by `open_string`), in which case the number of characters which have not yet been treated by a `read` or similar call will be returned.

If `chars_waiting` is to be called on a file after it has been partially read, the file must be unbuffered first with `unbuffer_file`. Otherwise characters will be read in buffer by buffer and held locally in groups of 1024. This will cause `chars_waiting` to return unexpected results.

Example

```
Gamma> ft = open("mytestfile.dat", "r");
#<File:"mytestfile.dat">
Gamma> unbuffer_file(ft);
#<File:"mytestfile.dat">
Gamma> chars_waiting(ft);
9
Gamma> char(read_char(ft));
"A"
Gamma> chars_waiting(ft);
8
Gamma> read_line(ft);
"BCDEFGHI"
Gamma>
```

```
Gamma> x = open_string("hello");
#<File:"String">
Gamma> chars_waiting(x);
5
Gamma> char(read_char(x));
"h"
Gamma> chars_waiting(x);
4
Gamma>
```

See Also

open, open_string, unbuffer_file

directory

`directory` — returns the contents of a directory.

Synopsis

```
directory (path, filetypes, fullpaths)
```

Arguments

path
: A path to a directory as defined by the operating system.

filetypes
: A number in the range 0 to 2:

- **0** Find all files and directories.
- **1** Find all files.
- **2** Find all directories.

fullpaths
: If non-`nil`, show the full pathname of the file by prepending the *path* to all filenames.

Returns

A list containing all of the requested directory entries as strings.

Example

```
Gamma> directory("/usr",0,nil);
("local" "lib" "bin" "readme")
Gamma> sort(directory("/usr",2,t),strcmp);
("/usr/bin" "/usr/lib" "/usr/local")
```

dirname

`dirname` — returns the directory path of a file.

Synopsis

```
dirname (filename)
```

Arguments

`filename`

A file name as a string, including its directory path, as defined by the operating system.

Returns

The directory path of the *`filename`*, or if no path is entered, the *`filename`*.

Description

This function reads the *`filename`* and directory path as a string, returning the directory path as a string.

Example

```
Gamma> x = dirname("/usr/george/lib/misc/myfile.dat");
"/usr/george/lib/misc"
Gamma> y = dirname("misc/myfile.dat");
"misc"
Gamma> z = dirname("myfile.dat");
"myfile.dat"
Gamma>
```

See Also

`basename`, `root_path`

drain

`drain` — modifies end-of-file detection.

Synopsis

```
drain (file, drain_p)
```

Arguments

file
: An open file.

drain_p
: A flag. If non-`nil`, sets the file to drain.

Returns

The previous state of the drain flag for this file.

Description

This function sets a flag on the file state such that if the *drain_p* flag is on, the first time that a read on that file finds no characters waiting, the read will return immediately with "Unexpected end of file". This is intended for use in situations where the operating system may never actually generate an end of file indication, but where it is known that no more input will be available once a read would block. This function does not affect `dev_read`.

For best results, the file should be unbuffered first with `unbuffer_file`. Otherwise characters will be read in buffer by buffer and held locally in groups of 1024. This could cause a `read` function to return "Unexpected end of file" even when there are still characters waiting to be read.

Example

```
Gamma> fp = open("mydrainfile.dat","r",nil);
#<File:"mydrainfile.dat">
Gamma> unbuffer_file(fp);
#<File:"mydrainfile.dat">
Gamma> drain(fp,t);
nil
Gamma> read_line(fp);
"This is my drain file."
Gamma> read_line(fp);
"Unexpected end of file"
```

```
Gamma>
```

file_date

`file_date` — gives the file modification date.

Synopsis

```
file_date (filename)
```

Arguments

filename
A filename as defined by the operating system.

Returns

The modification date of the file as an integer if the file exists and is readable, else `nil`.

Example

```
Gamma> fd =(file_date("myfile.dat"));
936977583
Gamma> date_of(fd);
"Fri Sep 10 11:33:03 1999"
Gamma> file_date("nonexistent.file");
nil
Gamma> file_date("unreadable.file");
nil
Gamma>
```

See Also

`clock`, `date_of`

file_size

`file_size` — gives the file size.

Synopsis

```
file_size (filename)
```

Arguments

filename
: A file name as a string, as defined by the operating system.

Returns

The size of the file in bytes if the file exists and is readable, else `nil`.

Example

```
Gamma> file_size("myfile.dat");
1467
Gamma> file_size("non_existing.file");
nil
Gamma> file_size("unreadable.file");
nil
Gamma>
```

flush

`flush` — flushes any pending output on a file or string.

Synopsis

```
flush (file)
```

Arguments

file

A file pointer to a previously opened file. This may be either a file in the file system, or a string opened for read and write.

Returns

`t`

Description

This function flushes any pending output on the file or string. This has the effect of printing output on the screen or updating a file on disk in the case of a file. `flush` has no effect on strings. `flush` is called automatically by `close`.

Example

```
Gamma> fp=open("myflushfile.dat","w",nil);
#<File:"myflushfile.dat">
Gamma> write(fp, "I am written.");
t
Gamma> fp=open("myflushfile.dat","r",nil);
#<File:"myflushfile.dat">
Gamma> read_line(fp);
"Unexpected end of file"

Gamma> fp=open("myflushfile.dat","w",nil);
#<File:"myflushfile.dat">
Gamma> write(fp, "I am written.");
t
Gamma> flush(fp);
t
Gamma> fp=open("myflushfile.dat","r",nil);
#<File:"myflushfile.dat">
Gamma> read_line(fp);
```

```
"\"I am written.\""
Gamma>
```

See Also

open, open_string

getcwd

`getcwd` — gets the current working directory.

Synopsis

```
getcwd ()
```

Arguments

none

Returns

The current working directory as a string.

Example

```
Gamma> getcwd();
"/home/robert/w/devel/lisp"
Gamma>
```

is_busy

`is_busy` — determines if a file is busy.

Synopsis

```
is_busy (path)
```

Arguments

`path`
: A character string defining a file path and file name in this file system.

Returns

`t` if the named file exists and is busy, otherwise `nil`.

Description

This function is supported only by certain operating system and hardware combinations that mark files as busy when they are opened for write by another task. You can check this using the **ls -l** shell command. If it shows a busy file with a 'B' or 'b' as the first bit in the bitmask, this function should be supported.

Example

```
Gamma> is_busy("/tmp/busyfile");
t
```

See Also

`is_writable`

is_dir

is_dir — determines if a file is a directory.

Synopsis

```
is_dir (path)
```

Arguments

path
A character string defining a relative or absolute file path in this file system.

Returns

t if the named file exists and is a directory, otherwise nil.

Description

This function checks if a file is a directory. Relative file paths are relative to the current working directory.

Example

```
Gamma> is_dir("/home/robert/w/devel/lisp");
t
Gamma> is_dir("../../doc");
t
Gamma> is_dir("doc");
nil
Gamma>
```

See Also

is_file

is_file

is_file — determines if a file exists.

Synopsis

```
is_file (path)
```

Arguments

path
A character string defining a file path and file name in this file system.

Returns

t if the named file exists and is a regular file, otherwise nil.

Example

```
Gamma> is_file("/usr/doc/FAQ/txt/FAQ");
t
Gamma>
```

See Also

is_dir

is_readable

is_readable — determines if a file is readable.

Synopsis

```
is_readable (path)
```

Arguments

path
A character string defining a file path and file name in this file system.

Returns

t if the named file exists and is readable, otherwise nil. Existing files might not be readable because of settings on the files bitmask.

Example

```
Gamma> is_readable("/usr/doc/FAQ/txt/FAQ");
t
Gamma>
```

See Also

is_writable, is_busy

is_writable

`is_writable` — determines if a file is writable.

Synopsis

```
is_writable (path)
```

Arguments

path
: A character string defining a file path and file name in this file system.

Returns

`t` if the named file exists and is writable, otherwise `nil`.

Example

```
Gamma> is_writable("/usr/doc/FAQ/txt/FAQ");
nil
Gamma> is_writable("/home/robert/w/devel/lisp/mytestfile.dat");
t
Gamma>
```

See Also

`is_readable`

mkdir

`mkdir` — creates a new sub-directory.

Synopsis

```
mkdir (dirname, mode)
```

Arguments

dirname
The name of the directory to create.

mode
The access permissions of the new directory, joined in sequence. If there are more than one, they are OR'ed by the | character in text format, or written consecutively in octal format. (See below.)

Returns

Zero if successful, otherwise non-zero, and the errno will be set.

Description

This function creates a new sub-directory whose path-name is *dirname*. The file permissions for the new sub-directory are determined from the *mode* argument. Valid modes are summarized here.

Table 12. User/owner permission modes

Text format	Octal format	Meaning
S_IRWXU	0o7	Read, write, execute/search
S_IRUSR	0o4	Read permission
S_IWUSR	0o2	Write permission
S_IXUSR	0o1	Execute/search permission

Table 13. Group permission modes

Text format	Octal format	Meaning
S_IRWXG	0o7	Read, write, execute/search
S_IRGRP	0o4	Read permission
S_IWGRP	0o2	Write permission
S_IXGRP	0o1	Execute/search permission

Table 14. Other permission modes

Text format	Octal format	Meaning
S_IRWXO	0o7	Read, write, execute/search
S_IROTH	0o4	Read permission
S_IWOTH	0o2	Write permission
S_IXOTH	0o1	Execute/search permission

Miscellaneous permissions.

- **S_IREAD** Same as S_IRUSR
- **S_IWRITE** Same as S_IWUSR
- **S_IEXEC** Same as S_IXUSR

These flags are bitwise OR-ed together to get the desired mode.

Error constants for this function:

- **EACCES** Search permission for some component of the path denied.
- **EEXIST** The named file exists.
- **EMLINK** Maximum sub-dirs. reached.
- **ENAMETOOLONG** The name of the path or the new directory is too long.
- **ENOENT** The specified path does not exist.
- **ENOSPC** No space left on the file system.
- **ENOSYS** This function is not supported for this path.
- **ENOTDIR** A component of the passed path is not a directory.
- **EROFS** Tried to create a directory on a read-only file system.

Example

```
Gamma> require_lisp("const/Filesys");
"/usr/cogent/lib/const/Filesys.lsp"
Gamma> mkdir("/tmp/mydir", S_IRWXU|S_IRGRP|S_IXGRP|S_IROTH|S_IXOTH);
0
Gamma> mkdir("/tmp/mydir2", 0o755);
0
Gamma>
```

See Also

unlink

path_node

`path_node` — gives the node number of a path in a QNX 2 path definition.

Synopsis

```
path_node (path)
```

Arguments

path

Any legal QNX 2 path.

Returns

The node number portion of the *path* in a QNX 2 path definition. If the path does not contain an explicit node portion, the function returns `nil`.

Description

This function is for version 2 of the QNX operating system only.

Example

```
Gamma> path_node("[2]3:/user");
2
Gamma> path_node("3:/user");
0
```

rename

`rename` — renames a file.

Synopsis

```
rename (filename, new_name)
```

Arguments

filename
: The name of a file on disk.

new_name
: The new name for the file.

Returns

`t` if the file could be renamed, otherwise `nil`.

Description

This function makes an operating system call rename a file on disk. The exact behavior of this function depends on the renaming facility for the operating system.

Example

```
Gamma> rename("myfile.dat","x/myrenamedfile.dat");
t
Gamma> rename("x/myrenamedfile.dat","myfile.dat");
t
Gamma>
```

root_path

root_path — strips the final file or directory name from a path.

Synopsis

```
root_path (path)
```

Arguments

path

A file path name, as a string.

Returns

The portion of the *path* with the file name and any trailing directory separators removed.

Description

This function strips the final file or directory name from the *path* to produce its parent. Any trailing directory separators are also removed. If the *path* represents the root of the file system then it is unmodified.

Example

```
Gamma> x = "/usr/doc/FAQ";
"/usr/doc/FAQ"
Gamma> x = root_path(x);
"/usr/doc"
Gamma> x = root_path(x);
"/usr"
Gamma> x = root_path(x);
"/"
Gamma> x = root_path(x);
"/"
Gamma>
```

See Also

basename, dirname

tmpfile

`tmpfile` — generates temporary output file names.

Synopsis

```
tmpfile (file_prefix?)
```

Arguments

`file_prefix`
A optional string specifying the beginning of a file name.

Returns

A string representing a file name which is guaranteed not to exist at the time that the function was called.

Description

This function is used to generate a temporary output file name. The *`file_prefix`* can specify any part of a file path. If the *`file_prefix`* is `nil`, then "`/tmp/lisp_t`" will be used. Typically the resulting file name will be the result of appending a number to the file prefix.

Example

```
Gamma> tmpfile();
"/tmp/lisp_t1"
Gamma> tmpfile("/tmp/atempfile");
"/tmp/atempfile2"
Gamma> tmpfile("/tmp/atempfile");
"/tmp/atempfile3"
Gamma> tmpfile("/tmp/atempfile");
"/tmp/atempfile4"
Gamma> tmpfile("anotherfile");
"anotherfile5"
Gamma>
```

unbuffer_file

`unbuffer_file` — causes a file to be treated as unbuffered on both input and output.

Synopsis

```
unbuffer_file (file)
```

Arguments

file
: A file pointer to a previously opened file. This may only be a file in the file system, and not a string opened for read and write.

Returns

The unbuffered file object on success, or `nil` on failure.

Description

This function causes a file to be treated as unbuffered on both input and output. The normal buffering mode of a file depends on whether it is in the file system, or to a character device such as a terminal or console.

When the file is unbuffered, all input and output to that file will occur immediately, without going through internal buffers. In general, an unbuffered file is much less efficient for file I/O. Unbuffering is temporary, as the file will revert to a buffered state when it is closed or reopened.

Example

```
Gamma> fu = open("mytestfile.dat","r",nil);
#<File:"mytestfile.dat">
Gamma> unbuffer_file(fu);
#<File:"mytestfile.dat">
Gamma>
```

unlink

`unlink` — deletes a file.

Synopsis

```
unlink (filename)
```

Arguments

filename
A string representing a valid file name.

Returns

`t` if the file could be deleted, otherwise `nil`.

Description

This functioin deletes a file in the file system. It will fail if the given file does not exist, or the calling process does not have sufficient privilege to delete the file. Wild cards are not expanded in the file name.

Example

```
Gamma> fu = open("todeletefile.dat","r");
#<File:"todeletefile.dat">
Gamma> unlink("todeletefile.dat");
t
Gamma> unlink("todeletefile.dat");
nil
Gamma>
```

See Also

`open`

OS APIs

atexit

`atexit` — evaluates code before exiting a program.

Synopsis

```
atexit (code)
```

Arguments

code
: Code to be evaluated.

Returns

The result of evaluating *code*.

Description

This function gives a program an opportunity to evaluate specified code before it exits. The *code* should be protected from evaluation using the quote operator #.

Example

Running this program...

```
#!/usr/cogent/bin/gamma

// Program name: exiting.g
// Demonstrates the atexit() function.

atexit(#princ("Exiting now.\n"));
princ("Started running...\n");
princ("Still running.\n");
exit_program(7);
princ("You missed this part.\n");
```

...gives these results:

```
[sh]$ exiting.g
Started running...
Still running.
Exiting now.
[sh]$
```

block_signal, unblock_signal

block_signal, unblock_signal — delimit signal blocking.

Synopsis

```
block_signal (signo)
unblock_signal (signo)
```

Arguments

signo
: The integer signal number as defined by the operating system. Symbols such as SIGINT are defined to provide an operating-system independent method for specifying this number. (see signal)

Returns

t

Description

block_signal causes a particular signal to be blocked until a call to unblock_signal is made. If the signal actually occurred while it was blocked, it will occur immediately when unblock_signal is called. Multiple occurrences of the signal while it was blocked will cause the signal to be reported multiple times when unblock_signal is called on most operating systems. Code that blocks signals should be surrounded by a call to unwind_protect.

Example

```
Gamma> block_signal(14);
t
Gamma> kill(getpid(),14);
t
Gamma> unblock_signal(14);
Alarm clock
```

```
Gamma> block_signal (SIGINT);
t
Gamma> critical_function();
<function return>
Gamma> unblock_signal (SIGINT);
t
```

See Also

block_timers, unblock_timers

errno

errno — detects and numbers errors.

Synopsis

```
errno ();
```

Arguments

none

Returns

The system error number.

Description

When a function fails it returns a value and optionally sets the system error number. The errno function can be used to check the current error number. To check error numbers against constant error code in your program remember to include the file with: require_lisp ("Errno.lsp");.

Calling the errno function in interactive mode does not return a valid number since you are retrieving the errno of the C function printf of the error to the screen (which will usually be 0).

Example

In this example, we first define a function to remove a file. Then we call that function on a non-existing file to generate an error. Finally, we check the returned error code to get the error message.

```
function remove_file(file)
{
   unlink(file);
   errno();
}

Gamma> ret_val = remove_file("/tmp/xyz");
2
Gamma> strerror(2);
"No such file or directory"
Gamma>
```

See Also

error, strerror

exec

exec — executes a program.

Synopsis

```
exec (program, arguments?...)
```

Arguments

program
: The name of a program to execute, as a string.

arguments
: The arguments to the program, each as a string.

Returns

Does not return if successful, or -1 if an error occurs.

Description

This function is a binding for the C function execvp, which causes the interpreter to terminate immediately, and to run the named program in its place. The "p" in the execvp function indicates that a search is made for the named executable in the current path, as defined by the PATH shell variable. Unlike the C execvp function, the first argument in Gamma's exec function does not repeat the program name—it is automatically inserted for you.

Example

```
Gamma> exec("/bin/ls","-l","/usr/bin");
-rwxr-xr-x    1 root     root        98844 Aug  7  2000 a2p*
-rwxr-xr-x    1 root     root         4080 Jul 19  2000 access*
-rwxr-xr-x    1 root     root        10256 Jul 12  2000 aclocal*
...
```

See Also

fork, wait

exit_program

`exit_program` — terminates the interpreter.

Synopsis

```
exit_program (return_value)
```

Arguments

return_value
An integer value to be returned to the operating system when the program exits.

Returns

This function does not return.

Description

Terminate the interpreter immediately and return the provided integer value to the operating system as an exit code.

Example

Running this program...

```
#!/usr/cogent/bin/gamma

//Program: exiting.g

atexit(#princ("Exiting now.\n"));
princ("Started running...\n");
princ("Still running.\n");
exit_program(7);
princ("You missed this part.\n");
```

...gives these results:

```
[]$ gamma exiting.g
Started running...
Still running.
Exiting now.
[]$
```

```
Exit showing abnormal termination of -1 (255) to the operating system.
```

```
exit_program(-1);

/>echo $?
255
/>
```

fork

`fork` — duplicates a process.

Synopsis

```
fork ()
```

Arguments

none

Returns

A positive task id that identifies the child process, and 0 that identifies the parent process to the child; or -1 if an error occurred. The errno is set if an error occurs.

Description

The `fork` function creates a new process identical to the calling (parent) process except for a unique process ID. The child process has a different parent process ID and its own copy of the parent file descriptors. The child process does not inherit outstanding signals.

Example

The following example illustrates using the `fork` function with `if` syntax. This is a useful way of separating the two, identical processes produced from `fork`. The first block of code applies to the parent process, while the second block applies to the child.

```
#!/usr/cogent/bin/gamma

if ((childID = fork()) > 0)
{
  princ("P> My ID is: ", getpid(),"\n");
  princ("P> My child's ID is: ", childID, "\n");
  signal(SIGCHLD, #princ("P> Signal received that my child -- ",
                         childID, " -- has died.\n"));
  princ("P> Waiting for my child.\n");
  w = wait(childID);
  princ("P> wait() returned this: ", w, "\n");
}
else
{
  sleep(2);
```

```
  if (childID == -1)
    error("C> An error occurred.\n");
  else
    {
      princ("C> I am the child process.\nC> My process ID is: ",
            getpid(), "\n");
      sleep(2);
      princ("C> Time to exit.\n");
      exit_program(3);
    }
}
```

Will produce these results:

```
P> My ID is: 1225
P> My child's ID is: 1226
P> Waiting for my child.
```

(after 2 seconds)

```
C> I am the child process.
C> My process ID is: 1226
```

(after 2 more seconds)

```
C> Time to exit.
P> Signal received that my child -- 1226 -- has died.
P> wait() returned this: (1226 3 nil nil)
```

See Also

exec, wait

getenv

getenv — retrieves the value of an environment variable.

Synopsis

```
getenv (envar)
```

Arguments

envar

A string.

Returns

A string containing the value of the given environment variable, or nil if the environment variable is not defined.

Description

This function retrieves the value of an environment variable from the current process's environment. The environment variable must have been set or defined previously by a call to setenv.

Example

```
Gamma> setenv("high", "40");
t
Gamma> getenv("high");
"40"
Gamma> low = 20;
20
Gamma> getenv("low");
nil
Gamma>
```

See Also

setenv

gethostname

`gethostname` — gets the computer's host name.

Synopsis

```
gethostname ()
```

Arguments

none

Returns

The host name of this computer, as a string.

Example

```
Gamma> gethostname();
"rex"
Gamma>
```

getnid

`getnid` — returns the local node number.

Synopsis

```
getnid ()
```

Arguments

none

Returns

The node number

Example

```
Gamma> getnid();
2
```

See Also

getpid

getpid

`getpid` — returns the program ID.

Synopsis

```
getpid ()
```

Arguments

none

Returns

The program ID of the current session of the interpreter.

Example

```
Gamma> getpid();
8081
Gamma>
```

See Also

`getnid`

getsockopt, setsockopt

getsockopt, setsockopt — get and set a socket option.

Synopsis

```
getsockopt (socket, option)
setsockopt (socket, option, value1, value2? = nil)
```

Arguments

socket
: The file descriptor of a socket.

option
: The option being queried. Supported options and their possible values are listed below.

value
: The value to set the socket option to. There may be one or two values, depending on the option. If a socket option requires two values, both must be specified.

Returns

getsockopt returns the socket option value(s) on success, as shown below, or nil on failure. When the option has two values, they are returned as a list.

setsockopt returns 0 on success, otherwise -1.

Description

These functions get and set a socket option, using the socket's file descriptor. The supported socket options are given below.

SO_SNDTIMEO, SO_RCVTIMEO, SO_SNDLOWAT and SO_RCVLOWAT are not supported by all operating systems.

Option	Possible Values	Comments
SO_BROADCAST	0 for off, non-zero for on.	Allows for broadcasting datagrams from the socket.
SO_DEBUG	0 for off, non-zero for on.	Records debugging information.
SO_DONTROUTE	0 for off, non-zero for on.	Sends messages directly to the network interface instead of using normal message routing.

Option	Possible Values	Comments
SO_ERROR	A number.	Resets the error status (for getsockopt only).
SO_KEEPALIVE	0 for off, non-zero for on.	Transmits messages periodically on a connected socket. No response means the connection is broken.
SO_LINGER	Two values: on_or_off and linger_time, where on_or_off is 0 for off, non-zero for on. If on, a value for linger_time is required.	Keeps the socket open after a close() call, to deliver untransmitted messages. If on_or_off is non-zero, the socket will block for the duration of the linger_time or until all messages have been sent.
TCP_NODELAY	0 for enable, non-zero for disable.	Disables the Nagle algorithm for sending data.
SO_OOBINLINE	0 for off, non-zero for on.	Puts out-of-band data in the normal input queue.
SO_REUSEADDR	0 for off, non-zero for on.	Permits the reuse of local addresses for this socket.
SO_RCVBUF	A number.	The size of the input buffer.
SO_RCVLOWAT	A number.	Sets the minimum count for input operations.
SO_RCVTIMEO	Two values: seconds and nanoseconds.	Sets a timeout value for input.
SO_SNDBUF	A number.	The size of the output buffer.
SO_SNDLOWAT	A number.	Sets the minimum count for output operations.
SO_SNDTIMEO	Two values: seconds and nanoseconds.	Sets a timeout value for output.
SO_TYPE	A number.	The type of socket (for getsockopt only).

Example

```
Gamma> skt = tcp_connect("localhost", 22);
8
Gamma> getsockopt(skt, SO_KEEPALIVE);
0
Gamma> setsockopt(skt, SO_KEEPALIVE, 1);
0
Gamma> getsockopt(skt, SO_KEEPALIVE);
1
Gamma> getsockopt(skt, SO_DEBUG);
0
```

```
Gamma> setsockopt(skt, SO_DEBUG, 1);
-1
Gamma> getsockopt(skt, SO_DEBUG);
0
Gamma>
```

kill

`kill` — sends a signal to a process.

Synopsis

```
kill (pid, signo)
```

Arguments

pid

The process id number.

signo

The signal number, normally one of the built-in signal values.

Returns

`t`

Description

This process functions similarly to the `kill` shell command. Signals and their descriptions can be found in `signal`.

Example

Process 1:

```
Gamma> getpid();
8299
Gamma>
```

Process 2:

```
Gamma> kill(8299,9);
t
Gamma>
```

Process 1:

```
Gamma> Killed
```

Process 3:

```
Gamma> getpid();
9041
Gamma> kill (9041,14);
Alarm clock
```

See Also

signal

nanosleep

`nanosleep` — pauses the interpreter for seconds and nanoseconds.

Synopsis

```
nanosleep (seconds,nanosecs)
```

Arguments

seconds
The number of seconds to pause.

nanosecs
The number of nanoseconds to pause.

Returns

`t` after the time has elapsed.

Description

This function will pause the interpreter for the total time of seconds + nanoseconds

Example

```
Gamma> time(1,nanosleep( 0, 999999999 ));
1.0009529590606689453
//this example is done with the ticksize at 0.5 ms.
```

See Also

`sleep`

setenv

`setenv` — sets an environment variable for the current process.

Synopsis

```
setenv (envar, value)
```

Arguments

envar
: The name of the environment variable to set.

value
: The string value for this environment variable.

Returns

`t` on success, or `nil` on failure.

Description

This function sets an environment variable for the current process. Both arguments are strings. The value of an environment variable can be acquired using the function `getenv`.

Example

```
Gamma> setenv("high", "40");
t
Gamma> getenv("high");
"40"
Gamma> low = 20;
20
Gamma> getenv("low");
nil
Gamma>
```

See Also

`getenv`

shm_open

`shm_open` — opens shared memory objects.

Synopsis

```
shm_open (share_name, open_flags, create_mode, size?)
```

Arguments

share_name
: The name of the shared memory object.

open_flags
: Open control flags.

create_mode
: Creation mode.

size
: The size of the shared object in bytes.

Returns

A handle to the shared memory object, or `nil` on failure.

Description

This function is a wrapper for the C function `shm_open`. It is currently only available in QNX 4.

The name of the shared memory object is usually a name found under the /dev/shmem directory. Direct shared memory access to devices is acheived through a `shm_open` call to the existing `Physical` shared memory.

If you are accessing the existing `Physical` shared memory region (`/dev/shmem/Physical`) DO NOT use the *size* argument, as you may inadvertantly resize this shared memory. The *size* argument is added as a convenience, and can be used to specify the size of a newly created object.

Valid open-flags are OR-ed combinations of:

- **O_RDONLY** Open for read-only
- **O_RDWR** Open for read and write access
- **O_CREAT** creates a new shared memory segment with access privledges governed by the *create_mode* parameter

- **O_EXCL** Exclusive mode. If O_EXCL and O_CREAT are set then shm_open will fail if the shared memory segment exists.
- **O_TRUNC** If the shared memory object exists, and it is successfully opened O_RDWR, the object is truncated to zero length and the mode and owner are unchanged.

The creation mode is usually an octal number in the range 0o000 - 0o777 defining the access privledges for the shared memory object. Require the 'const/filesys' file to load constants to make this arg easier

Possible errno values are:

- **EACCESS** Permission to create the shared memory object denied
- **EEXIST** O_CREAT and O_EXCL are set and the named shared memory object already exists
- **EINTR** The function call was interrupted by a signal
- **EMFILE** Too many file descriptors in use by this process
- **ENAMETOOLONG** The lengthof the name arg is too long
- **ENFILE** Too many shared memory objects are currently open in the system
- **ENOENT** O_CREAT is not set and the named shared memory object does not exist, or O_CREAT is set and either the name prefix does not exist or the name arg is an empty string
- **ENOSPC** Not enough space for the creation of the new shared memory object
- **ENOSYS** This function is not supported by this implementation.

Example

```
//This code maps the first 1000 bytes from video
//memory (0xA0000) into a buffer named buf.

require_lisp("const/filesys");
require_lisp("const/mman");
fd = shm_open("Physical",O_RDONLY, 0o777);
buf = mmap(1000, PROT_READ , MAP_SHARED, fd, 0xA0000);
```

See Also

shm_unlink

shm_unlink

shm_unlink — removes shared memory objects.

Synopsis

```
shm_unlink (share_name)
```

Arguments

share_name
: The name of the shared object to delete.

Returns

t on success, or nil on failure, with errno set.

Description

This function is currently only available in QNX 4. It attempts to remove the shared object, *share_name*. If more than one process or link into the shared memory area exists the shared object will not be removed.

Possible values of errno are:

- **EACCESS** Permission to unlink the object is denied
- **ENAMETOOLONG** The length of the name of the object is too long
- **ENOENT** The named shared memory object does not exist.
- **ENOSYS** This function is not supported by this implementation.

Example

```
Gamma> shm_unlink("card_mem");
t
Gamma>
```

See Also

shm_open

signal

`signal` — defines an expression to be evaluated at an OS generated signal.

Synopsis

```
signal (signal, action[, action]...)
```

Arguments

`signal`
: A signal number. Normally one of the built-in signal values.

`action`
: Any Gamma or Lisp expression.

Returns

`t`

Description

This function defines an expression to be evaluated whenever the operating system generates signal number signal to this process. A signal handler may be of any complexity, though it is advisable to keep signal handlers as simple as possible. All signals and timers are blocked for the duration of the signal handler. In addition, the signal handler runs in a separate, smaller heap. If the signal handler is large, this could result in memory inefficiency. Signal handlers are typically used to ensure that the Gamma application does not exit when a signal occurs.

Table 15. Signals

Signal	Description
`SIGABRT`	Abort signal from the `abort()` C function.
`SIGALRM`	A timer has occurred. This signal is reserved in most operating system implementations of Gamma for use with the `after`, `at` and `every` functions. This signal is not available in Linux because it is used by the timer processing internally to Gamma. In QNX, it is the timer signal from the `alarm()` C function.
`SIGBUS`	Bus error.
`SIGCHLD`	Child died. Generated when a child process of the current process has died.
`SIGCONT`	Continue. Causes the task to restart after a SIGSTP.
`SIGFPE`	Floating point exception. Generated by an illegal mathematical function call (such as division by zero).

Signal	Description
SIGHUP	Hangup. Typically generated when a terminal session disconnects.
SIGILL	Illegal instruction. This is an internal error.
SIGINT	Keyboard interrupt. Generated by **CTRL-C**.
SIGIO	I/O processing is required. This signal is generated when a socket or file descriptor has incoming data which must be processed.
SIGIOT	IOT trap. A synonym for SIGABRT.
SIGKILL	Killed. Kills the process with extreme prejudice. This signal cannot be caught.
SIGPIPE	Broken pipe. This occurs when a TCP/IP socket or a pipe to an inferior process is broken.
SIGPOLL	A pollable event. Synonym of SIGIO.
SIGPWR	Power failure. This is generated by a power monitor program to indicate that a power loss is imminent.
SIGQUIT	Quit.
SIGSEGV	Segmentation fault. This signal is generated by an attempt to access illegal memory. If this signal occurs, it represents a fault in the LISP interpreter and should be reported along with the corresponding memory address of the fault.
SIGSTOP	Stop execution immediately. This is used by the operating system to implement multi-tasking. This signal cannot be caught.
SIGSYS	Bad argument to a system routine. This happens very rarely.
SIGTERM	Terminated. This is generated by other programs which wish to terminate the job.
SIGTRAP	Trace/breakpoint trap.
SIGTSTP	Terminal stop. This signal is generated when the user attempts to stop a process (in operating systems which support job control).
SIGTTIN	Terminal input is available.
SIGTTOU	Terminal output is required.
SIGURG	Urgent. An urgent condition has occurred.
SIGUSR1	User-defined signal 1.
SIGUSR2	User-defined signal 2.
SIGWINCH	Window change. This is used to indicate that a change has been made to the size or position of the window in which the process is running.

Example

```
Gamma> getpid();
10341
Gamma> signal(SIGUSR1,#princ("Got the signal.\n"));
t
Gamma> kill(10341,SIGUSR1);
Got the signal.
t
Gamma>
```

See Also

after, at, every

sleep, usleep

sleep, usleep — suspend execution.

Synopsis

```
sleep (seconds)
usleep (microseconds)
```

Arguments

seconds

The integer number of seconds to sleep.

microseconds

The integer number of microseconds to sleep.

Returns

t

Description

These functions suspend execution for the given number of seconds or microseconds, after which time the task continues. Signals and timers will still be processed during this time.

This function is ignored in Windows, as it would cause all scripts to hang, but is maintained for compatibility. Instead, you can use a .TimerAfter timer, like this:

```
.TimerAfter (3, `some_code);
```

For example, to call the "myMethod" method with no arguments:

```
.TimerAfter(3, `(@self).myMethod());
```

Or, for example, to print "end":

```
.TimerAfter(3, `princ("end\n"));
```

Example

```
Gamma> sleep (3);

(after 3 seconds...)
```

```
t
Gamma> usleep (500000);

(after 1/2 second...)

t
Gamma>
```

See Also

nanosleep

strerror

`strerror` — retrieves an error message.

Synopsis

```
strerror (errno)
```

Arguments

errno
: The error number as returned by `errno`.

Returns

An error message as a string.

Description

This function looks up error messages associated with error numbers.

Example

In this example, we first define a function to remove a file. Then we call that function on a non-existing file to generate an error. Finally, we check the returned error code to get the error message.

```
function remove_file(file)
{
   unlink(file);
   errno();
}

Gamma> ret_val = remove_file("/tmp/xyz");
2
Gamma> strerror(2);
"No such file or directory"
Gamma>
```

See Also

errno

system

`system` — treats its argument as a system command.

Synopsis

```
system (command_line)
```

Arguments

command_line
: A string.

Returns

A numerical return code as generated by the operating system.

Description

This function treats its argument as a command to be run in the native operating system. This function will wait until the command completes before returning with the command's exit status. In UNIX and QNX 4, the command may be run in the background by using an *&* symbol after the *command_line* argument.

Example

```
Gamma> system("ps");
 PID TTY          TIME CMD
7856 pts/4    00:00:00 bash
8335 pts/4    00:00:00 Gamma
8336 pts/4    00:00:00 ps
0
Gamma> system("ls *ty*");
li_type.c  li_type.o  privity.c  pty.lsp
0
Gamma> system("mysubtask &");
0
```

tcp_accept

tcp_accept — forks a new TCP socket on the server side to accept a new connection.

Synopsis

```
tcp_accept (socket)
```

Arguments

socket
: A descriptor for a listening socket, as returned by a call to tcp_listen.

Returns

A file descriptor for a new, connected socket.

Description

This function allows a passive, listening socket to accept a connection, by spawning a new socket that maintains the connection. It is essentially the same as the C accept function, but returns a socket descriptor instead of an address.

Example

```
         CLIENT SIDE:                              SERVER SIDE:

                                           Gamma> tcp_listen(51715);
                                           5
                                           Gamma> tcp_accept(51715);

Gamma> tcp_connect("localhost", 51715);    6
5

Gamma> fd_write(5, "Hi there");            Gamma> fd_read(6, "Hi there");
8                                          8
```

See Also

tcp_connect, tcp_listen

tcp_connect

`tcp_connect` — creates a client-side TCP socket connection.

Synopsis

```
tcp_connect (host, port)
```

Arguments

host
: The IP address of the host machine.

port
: The port to connect to.

Returns

A file descriptor for a new, connected socket.

Description

This function creates a connected socket. This can be accessed with Gamma `fd_*` functions such as `fd_write` and `fd_read`.

Example

See the example for `tcp_accept`.

See Also

`tcp_accept`, `tcp_listen`

tcp_listen

tcp_listen — creates a server-side TCP socket connection.

Synopsis

```
tcp_listen (port, backlog?)
```

Arguments

port
: The port to connect to.

backlog
: The IP address of the host machine.

Returns

A file descriptor for a new, connected socket.

Description

This function creates a connected socket. This can be accessed with Gamma `fd_*` functions such as `fd_write` and `fd_read`.

Example

See the example for `tcp_accept`.

See Also

`tcp_accept`, `tcp_connect`

wait

`wait` — waits for process exit status.

Synopsis

```
wait (taskid?, options?)
```

Arguments

taskid
: A process ID number. A value of `0` indicates any process.

options
: Wait option `WNOHANG` or `WUNTRACED`.

Returns

One of three possibilities:

- A list of four items:
  1. The process ID.
  2. The process exit status (`WEXITSTATUS`), or `nil`.
  3. A termination signal (`WTERMSIG`) if the process exited due to a signal, or `nil`.
  4. A stopped signal (`WSTOPSIG`) if the process stopped due to a signal, or `nil`.
- `t` if the `WNOHANG` option had been set and there was a child with a status change.
- `nil` if there was a failure due to error.

Description

This function combines and simplifies the C functions `wait` and `waitpid` in a single function. If *taskid* is provided, then the function acts as `waitpid`, and will not return until the given child task has died.

The `WNOHANG` option allows the calling process to continue if the status of specified child process is not immediately available. The `WUNTRACED` option allows the calling process to return if the child process has stopped and its status has not been reported. Both of these can be specified using the `OR` (`||`) operator.

Example

Process 1:

```
Gamma> child = fork();
```

```
9089
Gamma> 0
Gamma> if (child > 0) wait(); else exit_program(5);
```

Process 2:

```
Gamma> kill(9089,14);
t
Gamma>
```

Process 1:

```
(9089 nil 14 nil)
Gamma>
```

See Also

fork, exec

Dynamic Loading

AutoLoad

`AutoLoad` — allows for run-time symbol lookup.

Synopsis

```
AutoLoad ("pattern", `action)
```

Arguments

pattern
: A shell style pattern.

action
: An action to be taken when the *pattern* is matched.

Returns

The `_auto_load_alist_`, which is a list of all currently stored `AutoLoad` rules. Each rule is itself formatted as a list. This is the `_auto_load_alist_` syntax:

```
((pattern action_func action_arg ...) ...)
```

The members of each rule list are as follows:

pattern
: The `AutoLoad` *pattern* parameter.

action_func
: The function specified in the `AutoLoad` *action* parameter.

action_arg
: The function argument(s) specified in the `AutoLoad` *action* parameter.

For example, the `AutoLoad` rules in `AutoLoadLib.g` (at the time of this writing) would be returned as follows:

```
(("P[Tthg]*" DllLoad "libgammaph.so") ("gl[A-Z]*" DllLoad "libgammagl.so")
 ("GLUT_*" DllLoad "libgammagl.so") ("GLU_*" DllLoad "libgammagl.so")
 ("GL_*" DllLoad "libgammagl.so") ("ASCII_*" DllLoad "libgammamgl.so")
 ("KB_*" DllLoad "libgammamgl.so") ("GM_*" DllLoad "libgammamgl.so")
 ("EVT_*" DllLoad "libgammamgl.so") ("[mM][gG][lL]*" DllLoad "libgammamgl.so")
 ("[gG]tk*" DllLoad "gammagtk.so"))
```

Description

This function gives Gamma a way to look up symbols during run-time. If Gamma comes across an undefined symbol while executing a program, and if the symbol matches the *pattern*, then Gamma executes the *action*. Normally the *action* is either a direct definition of the symbol, or an attempt to load a DLL that defines the symbol, using DllLoad, for example.

The available *pattern*s are as follows:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

This function is not part of the base Gamma executable. It is provided by a Gamma library AutoLoadLib.g which can be accessed using the Gamma require function like this:

```
require ("/usr/cogent/require/AutoLoadLib.g");
```

Example

- In this example, we use the ClearAutoLoad function to clear the AutoLoad list just to make the steps easier to follow.
- Once a library is loaded or a symbol is defined, Gamma no longer sends a "Looking for *symbol*" message.
- Notice how although NoAutoLoad and ClearAutoLoad remove a pattern from future consideration, any symbols defined or any libraries loaded before they were called remain valid.

```
Gamma> require ("/usr/cogent/require/AutoLoadLib.g");
t
Gamma> ClearAutoLoad();
nil
Gamma> AutoLoad ("[gG]tk*", `DllLoad ("gammagtk.so"));
(("[gG]tk*" DllLoad "gammagtk.so"))
Gamma> gtk_arg_new;
Looking for gtk_arg_new
(defun gtk_arg_new (arg_type) ...)
Gamma> gtk_main;
(defun gtk_main () ...)
Gamma> testvar;
Looking for testvar
Symbol is undefined: testvar
```

```
debug 1> (Ctrl - D)
Gamma> AutoLoad("testvar", `testvar = 5);
(("testvar" setq testvar 5) ("[gG]tk*" DllLoad "gammagtk.so"))
Gamma> testvar;
Looking for testvar
5
Gamma> NoAutoLoad("testvar");
(("[gG]tk*" DllLoad "gammagtk.so"))
Gamma> testvar;
5
Gamma> ClearAutoLoad();
nil
Gamma> gtk_main;
(defun gtk_main () ...)
Gamma> gtk_false;
(defun gtk_false () ...)
Gamma>
```

See Also

ClearAutoLoad, NoAutoLoad, DllLoad

autoload_undefined_symbol

autoload_undefined_symbol — checks undefined symbols for AutoLoad.

Synopsis

```
autoload_undefined_symbol (!sym)
```

Arguments

sym
: A symbol.

Returns

nil on success, else error.

Description

This function is generally used internally by the AutoLoadLib.g program. It is the default function that is called when an undefined symbol is encountered at run-time, if the AutoLoad.g library has been required into the program. This is normally done by startup.g, which is automatically loaded by the Gamma executable at startup.

Example

In this example, the first symbol (test1) is checked by autoload_undefined_symbol from within the AutoLoadLib.g program. We know this because the message "Looking for *symbol*" indicates that Gamma had to use AutoLoadLib.g to get the definition of the symbol. For the second symbol (test2), we make the autoload_undefined_symbol call ourselves, and the "Looking for *symbol*" doesn't appear. This indicates that Gamma knew the value of the symbol and didn't have to use AutoLoadLib.g to look it up.

```
Gamma> AutoLoad("test1", `test1 = 9);
(("test1" setq test1 9) ("P[Tthg]*" DllLoad "libgammaph.so")...)
Gamma> test1;
Looking for test1
9
Gamma> AutoLoad("test2", `test2 = 8);
(("test2" setq test2 8) ("test1" setq test1 9)
                        ("P[Tthg]*" DllLoad "libgammaph.so")...)
Gamma> autoload_undefined_symbol(test2);
nil
Gamma> test2;
8
```

```
Gamma>
```

See Also

AutoLoad

AutoMapFunction

`AutoMapFunction` — maps a C function to a Gamma function.

Synopsis

```
AutoMapFunction (name, rettype, args)
```

Arguments

name
: The name of a C function.

rettype
: Not yet documented.

args
: Not yet documented.

Returns

Not yet documented.

Description

This function checks to see if the C function *name* exists in (is linked into) the Gamma executable. If so, it then maps it to a Gamma function according to the *rettype* and *args*. The details this function have not yet been documented.

See Also

AutoLoad

ClearAutoLoad

`ClearAutoLoad` — removes all `AutoLoad` rules.

Synopsis

```
ClearAutoLoad ()
```

Arguments

None.

Returns

`nil`.

Description

This function removes all `AutoLoad` rules by setting the `_auto_load_alist_` to `nil`.

This function is not part of the base Gamma executable. It is provided by a Gamma library `AutoLoadLib.g` which can be accessed using the Gamma `require` function like this:

```
require ("/usr/cogent/require/AutoLoadLib.g");
```

Example

See the example for AutoLoad.

See Also

`AutoLoad`, `NoAutoLoad`

dlclose

`dlclose` — closes an open dynamic library.

Synopsis

```
dlclose (handle)
```

Arguments

handle
: The "handle" returned by `dlopen`.

Returns

0 when successful, else -1.

Description

This function is a wrapper for the `dlclose` shell command. Each call decrements the link count in the dl library created by `dlopen`. When this count reaches zero and no other loaded libraries use symbols in it, the library is unloaded.

If the library exports a routine named `_fini`, that will be called just before the library is unloaded.

Example

```
Gamma> dlopen("libform.so",RTLD_NOW|RTLD_GLOBAL);
134940024
Gamma> a = dlopen("libform.so",RTLD_NOW|RTLD_GLOBAL);
134940024
Gamma> dlclose(a);
0
Gamma> dlclose(a);
0
Gamma> dlclose(a);
-1
Gamma>
```

See Also

`dlopen`

dlerror

`dlerror` — reports errors in dl functions.

Synopsis

```
dlerror ()
```

Arguments

none

Returns

An error message, or 0 if no error has occurred since it was last called.

Description

This function returns an error message for the most recent error in `dlopen` or `dlclose`. If several errors have occured since the last call to `dlerror`, only the first will return an error message.

Example

```
Gamma> dlopen("nolibraryhere",RTLD_LAZY);
0
Gamma> dlopen("norhere",RTLD_LAZY);
0
Gamma> dlerror();
"norhere: cannot open shared object file: No such file or directory"
Gamma> dlerror();
nil
Gamma>
```

See Also

`dlopen`, `dlclose`

dlfunc

`dlfunc` — reserved for future use.

Synopsis

```
dlfunc (handle symname rettype args)
```

Arguments

Returns

Description

Example

```
```

See Also

DllLoad

`DllLoad` — loads dynamic libraries.

Synopsis

```
DllLoad ("filename", verbose? = nil)
```

Arguments

filename
: The name of the dynamic library to be loaded.

verbose
: When set to `t`, shows the paths of load attempts.

Returns

An integer "handle" on success, or an error message.

Description

This function loads a DLL if the system supports it (Linux, QNX 6, and MS-Windows). The first search path for the DLL is taken to be `./`, next is `/usr/cogent/dll/`, and finally the system DLL search path, if any.

Example

Without using the optional *verbose* parameter:

```
Gamma> DllLoad("gammagtk.so");
135024608
Gamma>
```

Using the optional *verbose* parameter:

```
Gamma> DllLoad("gammagtk.so", t);
DllLoad: attempting to load: ./gammagtk.so
DllLoad: attempting to load: /usr/cogent/dll/gammagtk.so
135024608
Gamma>
```

See Also

`AutoLoad`

dlmethod

`dlmethod` — reserved for future use.

Synopsis

```
dlmethod (handle class methodname symname rettype args)
```

Arguments

Returns

Description

Example

```
```

See Also

NoAutoLoad

NoAutoLoad — removes selected AutoLoad rules.

Synopsis

```
NoAutoLoad ("pattern")
```

Arguments

pattern

A shell style pattern.

Returns

The _auto_load_alist_ (a list of all currently stored AutoLoad rules) with the rules corresponding to the *pattern* removed.

Description

This function removes from future consideration any AutoLoad rules that correspond to the *pattern*.

The available *pattern*s are as follows:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

This function is not part of the base Gamma executable. It is provided by a Gamma library AutoLoadLib.g which can be accessed using the Gamma require function like this:

```
require ("/usr/cogent/require/AutoLoadLib.g");
```

Example

See the example for AutoLoad.

See Also

AutoLoad, ClearAutoLoad

dlopen

`dlopen` — loads a dynamic library from a file.

Synopsis

```
dlopen (filename flags)
```

Arguments

filename

The name of the file to open, as a string. If no absolute path is given, the file is searched for in the user's `LD_LIBRARY` path, the `/etc/ld.so.cache` list of libraries, and the `/usr/lib/` directory.

flags

Must be either `RTLD_LAZY` or `RTLD_NOW`, optionally OR'ed with `RTLD_GLOBAL`.

- **`RTLD_LAZY`** causes undefined symbols to be resolved as the dynamic library code executes.
- **`RTLD_NOW`** forces undefined symbols to be resolved before `dlopen` returns, otherwise `dlopen` fails.
- **`RTLD_GLOBAL`** makes any external symbols defined in the library available to subsequently loaded libraries.

Returns

An integer "handle" if successful, else 0.

Description

This function is a wrapper for the `dlopen` shell command. It loads a dynamic library from the file and returns a "handle", which is an integer uniquely associated with the file for this application. The same handle is returned each time the same library is opened, and the dl library counts the number of links created for each handle.

If the library exports a routine named `_init`, that will be executed before `dlopen` returns.

Example

```
Gamma> dlopen("libform.so",RTLD_LAZY|RTLD_GLOBAL);
134936808
Gamma> dlopen("libconsole.so",RTLD_NOW);
0
Gamma> dlopen("libconsole.so",RTLD_LAZY);
```

```
134935848
Gamma> dlopen("libconsole.so",RTLD_LAZY);
134935848
```

See Also

dlclose

Profiling and Debugging

allocated_cells

allocated_cells — gives the number of allocated and free cells.

Synopsis

```
allocated_cells ()
```

Arguments

none

Returns

A list containing the number of allocated cells and the number of free cells currently held by the memory management system.

Description

The memory management system allocates cells as required to continue execution, limited only by operating system memory. Once cells have been allocated, they are placed on the heap by the garbage collector and re-used. New cells are only allocated from the operating system if the garbage collector is unable to fulfill a request for more memory from the running Gamma or Lisp program. This function returns the number of cells which are currently in use, and the number of free cells remaining on the heap. The sum of these numbers is the total number of cells allocated by the interpreter.

Example

This example shows 380 cells in use and 1620 cells free on the heap, for a total of 2000 cells available.

```
Gamma> allocated_cells();
(380 1620 0 0 0 0 0 0)
Gamma>
```

See Also

free_cells, gc

eval_count

eval_count — counts evaluations made since a program started.

Synopsis

```
eval_count ()
```

Arguments

none

Returns

A list of three values. First is the number of times any symbol has been evaluated. Second is the number of times any function has been evaluated. Third is the number of times any other Gamma expression has been evaluated.

Description

This function counts the number of evaluations of symbols, functions, and other Gamma expressions. All of these are counted from the time the program started.

Example

```
Gamma> gc();
1
Gamma> eval_count();
(0 2 0)
Gamma> a = 5;
5
Gamma> eval_count();
(0 4 1)
Gamma> a;
5
Gamma> eval_count();
(1 5 1)
Gamma>
```

free_cells

`free_cells` — returns the number of available memory cells.

Synopsis

```
free_cells ()
```

Arguments

none

Returns

The number of free memory cells available on the memory heap.

Example

```
Gamma> free_cells();
1620
Gamma>
```

See Also

allocated_cells

function_calls

`function_calls` — tells how often a function was called during profiling.

Synopsis

```
function_calls (function)
```

Arguments

function
A function.

Returns

The number of times this function has been called while profiling was active.

Description

This function queries the system to determine the number of times that a function was called while profiling was active (using the profile function).

Example

```
Gamma> profile(t);
t
for(i=0;i<10;i++)
{
 princ("i:",i,"\n");
}
>> i:0
>> i:1
>> i:2
>> i:3
>> i:4
>> i:5
>> i:6
>> i:7
>> i:8
>> i:9
Gamma> i;
9
Gamma> profile(nil);
t
```

```
Gamma> function_calls(princ);
10
```

See Also

profile, function_runtime

function_runtime

`function_runtime` — gives the time a function has run during profiling.

Synopsis

```
function_runtime (function)
```

Arguments

function
: A function.

Returns

The total number of seconds that the *function* has run.

Description

This function returns the number of seconds (as a floating point number) that a function has run during all complete invocations of the function while profiling has been active. The number of seconds is measured using the QNX 4 tick clock, and thus represents elapsed time rather than CPU time, with a granularity of one tick (typically 10ms). Invocations of the function which have not completed at the time of the call to `function_runtime` are not included in the calculation.

Example

```
Gamma> function_runtime(cdr);
0.05341
```

See Also

`function_calls`, `profile`

gc

gc — runs the garbage collector.

Synopsis

```
gc ()
```

Arguments

none

Returns

The number of cells freed by the garbage collector.

Description

Causes the garbage collector to run if possible. The garbage collector will not run during a timer or signal handler, but it will flag the need for garbage collection, causing the garbage collector to run immediately after the timer or signal handler exits.

Example

```
Gamma> gc();
68
Gamma> gc();
17
Gamma> fp = open("myfile.dat", "r", nil);
#<File:"myfile.dat">
Gamma> close(fp);
t
Gamma> gc();
67
Gamma> gc();
17
Gamma>
```

See Also

allocated_cells, free_cells

gc_blocksize

gc_blocksize — for internal use only.

Synopsis

```
gc_blocksize (ncells)
```

gc_enable

gc_enable — for internal use only.

Synopsis

```
gc_enable (enable_p)
```

gc_newblock

gc_newblock — for internal use only.

Synopsis

```
gc_newblock ()
```

gc_trace

gc_trace — controls the tracing of garbage collection.

Synopsis

```
gc_trace (on_flag)
```

Arguments

on_flag
: If non-nil, turn on garbage collector tracing, else turn it off.

Returns

The new status of garbage collector tracing.

Description

This function turns on (on-flag is non-nil) or off (on-flag is nil) the tracing of garbage collection. When garbage collection tracing is on, statistics are collected concerning the number of allocated cells, number of collection calls, and the elapsed time spent within the garbage collector. These statistics can be accessed using a call to allocated-cells.

Example

```
Gamma> gc_trace (t);
nil
```

See Also

allocated_cells

profile

profile — collects statistics on function usage and run time.

Synopsis

```
profile (on_p, tick_nanosecs?)
```

Arguments

on_p
: If non-nil, start profiling, else stop profiling.

tick_nanosecs
: Reset the QNX 4 tick size to this many nanoseconds before beginning to profile.

Returns

The previous state of profiling.

Description

This function starts (or stops) collecting statistics on the usage and run time of all functions in the system. The profile mechanism uses an interrupt on the QNX 4 tick clock, and so must run with root permissions. If the optional *tick_nanosecs* argument is provided, this function will reset the tick size. Otherwise, it will profile using the current tick size. The smaller the tick size, the more precise is the profile result.

Example

The following program gives the output shown below.

```
#!/usr/cogent/bin/gamma

require_lisp("Profile.lsp");

e_list = list();
j = 0;

function print_reverse()
{
  with i in cdr(argv) do
    {
      e_list = cons(i, e_list);
```

```
      j++;
    }
  princ("The numbers in reverse order are:\n", e_list, "\n");
}

function main()
{
  profile(t);
  print_reverse();
  profile(nil);

  profiled_functions();
  princ("Function calls: ", function_calls(cons),"\n");
  princ("Function runtime: ", function_runtime(cons),"\n");
}
```

Entered on command line:

```
[sh]$ ex_profile.g 1 2 3 4 5
```

Output:

```
The numbers in reverse order are:
(5 4 3 2 1)
                 Function     Calls  Total Time
                      +++         5  4e-06
                      cdr         1  0
                     cons         5  2e-06
                      for         1  2.3e-05
                  profile         1  1e-06
                     setq         5  3e-06
                    princ         1  0.006502
            print_reverse         1  0.006534
                    progn         6  0.006546
Function calls: 5
Function runtime: 1.9999999999999999095e-06
```

See Also

function_calls, function_runtime

set_autotrace

`set_autotrace` — is reserved for future use.

Synopsis

```
set_autotrace (state, functions...)
```

Arguments

state

functions

Returns

Description

Example

```
```

See Also

set_breakpoint

`set_breakpoint` — is reserved for future use.

Synopsis

```
set_breakpoint (state, functions...)
```

Arguments

state

functions

Returns

Description

Example

```
```

See Also

time

`time` — gives command execution times.

Synopsis

```
time (iterations, !command)
```

Arguments

iterations
: The number of times to execute the command.

command
: Any Gamma or Lisp command.

Returns

The number of seconds consumed performing the *command* for the given number of *iterations*.

Description

This function performs the *command* for the given number of *iterations* and returns the clock time consumed. This does not break down the time into user and system time. Times on successive calls to this function will differ slightly due to operating system requirements, garbage collection and active timers.

Example

```
Gamma> time(10, list(1,2,3));
3.2972253393381834O3e_05
Gamma>
```

trace, notrace

`trace`, `notrace` — turn tracing on or off.

Synopsis

```
trace (!code?)
notrace (!code?)
```

Arguments

code
: If provided, limits the scope to this code.

Returns

With no argument, `t`, or with a *code* argument, the result of evaluating code.

Description

These functions turn tracing (execution tracking to standard output) on or off, either at the global level, or for the duration of the evaluation of *code*, if provided.

Example

```
#!/usr/local/bin/gamma -d

/* here is an example of a troublesome function and its
   return being debugged with the aid of trace() and
   notrace() functions.
*/

a = 0;
b = 1;
trace();
function trouble_function(x,y) {y/x;}
results = trouble_function(a,b);
notrace();
princ(results, "\n");
```

Gamma generates the following:

```
(defun trouble_function (x y) (/ y x))
--> trouble_function
```

```
(trouble_function a b)
  (/ y x)
  --> inf
--> inf
(setq results (trouble_function a b))
--> inf
(notrace)
inf
```

Miscellaneous

apropos

`apropos` — finds all defined symbols in the current interpreter environment.

Synopsis

```
apropos (pattern, predicate?)
```

Arguments

pattern
: A character string which specifies a search pattern

predicate
: A function taking one argument which will return either `nil` or non-`nil`.

Returns

A list of all symbols defined in the system which match the given *pattern*, and if the *predicate* is supplied, whose values are true under that predicate.

Description

This function searches the names of all defined symbols in the currently running interpreter environment. The *pattern* can contain the following special characters:

- ***** matches any number of characters, including zero.
- **[*c*]** matches a single character which is a member of the set contained within the square brackets.
- **[^*c*]** matches any single character which is not a member of the set contained within the square brackets.
- **?** matches a single character.
- **{*xx*,*yy*}** matches either of the simple strings contained within the braces.
- ***c*** (a backslash followed by a character) - matches that character.

The *predicate* is any function which accepts a single argument. If the *predicate* evaluates to non-`nil` when given the value of a symbol, and if the symbol matches the pattern, then the symbol will be reported by apropos. If the *predicate* is not supplied, then all symbols which match the *pattern* will be reported. The *pattern* is case-sensitive.

Example

```
Gamma> apropos("s*", function_p);
```

```
(setq strchr string symbol)
Gamma> apropos("?[sli]{igc,er}*");
(SIGCHLD SIGCONT dlerror)
```

create_state, enter_state, exit_state

create_state, enter_state, exit_state — are part of the SCADALisp exception-driven state machine mechanism.

Synopsis

```
create_state (state_function, symbol?...)
enter_state (state_machine, state)
exit_state (state_machine, state)
```

Arguments

state_function
: The function to call upon entering this state.

symbol
: One or more symbols which will act as triggers to cause this state to be re-evaluated.

state_machine
: A state machine created through a call to (new StateMachine)

state
: A state created through a call to (create-state...)

Returns

create_state: The new state definition.

enter_state: A status value.

exit_state: A status value.

Description

These functions are part of the exception-driven state machine mechanism built into SCADALisp. This mechanism is not fully supported, and will not be documented for this release. The reader may find the library file StateMachine.lsp helpful in determining how to use state machines. In general, this function should not be called directly from user code, as it is designed to provide support for the StateMachine library functions.

Example

```
none
```

gensym

gensym — generates a unique symbol.

Synopsis

```
gensym (prefix_string?)
```

Arguments

prefix_string
A character string which will be used as the prefix for the newly generated symbol.

Returns

A unique symbol.

Description

This function generates a symbol which does not currently exist by attaching a unique number to the end of the *prefix_string*. If the *prefix_string* is nil, use a default prefix.

Example

```
Gamma> gensym("tag");
tag1
Gamma> gensym();
tmp_sym2
Gamma> tag3 = 1;
1
Gamma> gensym("tag");
tag4
Gamma>
```

modules

`modules` — is obsolete, and returns nothing of value.

Synopsis

```
modules ()
```

Arguments

none

nil

Returns

A string.

Description

This function is obsolete, and returns nothing of value.

stack

`stack` — lists all functions called so far.

Synopsis

```
stack ()
```

Arguments

none

Returns

A list of all of the functions called up to this point in the execution of the Gamma program.

Description

A function that calls `stack` is presented in order, with the most recently called function at the end of the function list. `stack` can be useful for debugging programs by requesting a stack trace when an error occurs.

Example

The following program:

```
#!/usr/cogent/bin/gamma

function hms_to_sec(hms)
{
    hms = list_to_array(string_split(hms, ":", -1));
    (number(hms[0]) * 60 + number(hms[1])) * 60 + number(hms[2]);
    stk = stack();
}

tocheck = list(12,5,13);
hms_to_sec("tocheck");
princ(stk,"\n");
```

Yields these results:

```
((hms_to_sec tocheck) (progn (setq hms (list_to_array (string_split hms
 : (neg 1)))) (+ (* (+ (* (number (aref hms 0)) 60) (number (aref hms 1)
)) 60) (number (aref hms 2))) (setq stk #0=(stack))) #0#)
```

See Also

print_stack

IPC

add_hook

add_hook — hooks a function to an event.

Synopsis

```
add_hook (hook_sym, function_sym)
```

Arguments

hook_sym
: One of several symbols used to identify the hook, as listed below.

function_sym
: The function that is to run when the event occurs.

Returns

The hooked function (*function_sym*) that was added.

Description

This function sets up a hook, which is a function that is called when a particular event takes place. The arguments to the function identified by the *function_sym* are determined by the particular event. A hook function must be defined with the correct number of arguments, or else with optional or variable length arguments. The currently available hooks and the respective events that trigger their functions are as follows:

- `taskstarted_hook`: triggered whenever a task starts.
- `taskdied_hook`: triggered whenever a task dies.
- `exception_hook`: triggered whenever an exception for any point is emitted by a DataHub instance.
- `echo_hook`: triggered whenever an echo for any point is emitted by a DataHub instance.
- `gc_hook`: triggered whenever the garbage collector runs.
- The following are related to tracing code executions, but haven't been fully documented.

  ```
  trace_symbol_hook
  trace_entry_hook
  trace_exit_hook
  breakpoint_hook
  ```

One common use of this function is to add the internal `taskstarted` or `taskdied` functions, with the `taskstarted_hook` or `taskdied_hook`. Whenever a task that is registered with **nserve** starts or dies, **nserve** sends a message to all Gamma applications running IPC. Any of these applications that has added the `taskstarted_hook` or `taskdied_hook` then runs their corresponding *`function_sym`* function.

Example

This example program requires **qserve** and **nserve** to be running. It gives the output shown below:

```
#!/usr/cogent/bin/gamma

//Program: ex_addrunhooks.g

function main ()
{
  init_ipc ("x","x");

  add_hook (#taskstarted_hook, #hook_started);
  add_hook (#taskdied_hook, #hook_died);

  run_hooks (#taskstarted_hook, "testing start");
  run_hooks (#taskdied_hook, "testing died");

  while(t)
    next_event();
}

function hook_started (!a?...=nil)
{
  princ ("Hooked task started: ", a, "\n");
}

function hook_died (!a?...=nil)
{
  princ ("Hooked task died: ", a, "\n");
}
```

Output from `ex_addrunhooks.g` at startup:

```
Hooked task started: (testing start)
Hooked task died: (testing died)
```

Starting a new Gamma task named `mytask`...

```
Gamma> init_ipc("mytask", "myqueue");
t
Gamma>
```

...elicits this output from `ex_addrunhooks.g`:

```
Hooked task started: (mytask default myqueue 0 0 1874 0)
```

Checking process status with **nsnames**:

```
[home/robert]$ nsnames
Name   Domain  Queue    NID PID
mytask default myqueue  0   1874
x      default x        0   1873
```

Terminating `mytask` elicits this output from `ex_addrunhooks.g`:

```
Hooked task died: (mytask default myqueue 0 0 1874 0)
```

See Also

`run_hooks`, `remove_hook`, `init_ipc`

close_task

close_task — closes a task opened by locate_task.

Synopsis

```
close_task (task)
```

Arguments

task

A task descriptor as assigned to a locate_task call.

Returns

t if the task could be closed, else nil.

Description

When a task is opened (located) for interprocess communication, a communication link may be established. This link must be cleaned up if it is to be re-used. There is no hard limit to the number of tasks which may be open with QNX 4 message passing, but TCP/IP exerts an operating system-dependent limit on the number of simultaneously open tasks. Tasks will automatically be closed by the garbage collector when they are no longer referenced.

Example

```
Gamma> task = locate_task("Task 1",nil);
#<Task:9684>
Gamma> close_task(task);
t
Gamma>
```

See Also

locate_task

_destroy_task

`_destroy_task` — should never be used.

Synopsis

This function should not be used under any circumstances.

init_async_ipc

init_async_ipc — requests queue information from a task.

Synopsis

```
init_async_ipc (other_task)
```

Arguments

other_task
: A task descriptor as assigned to a locate_task call.

Returns

Non-nil on success, or nil on failure.

Description

This function initializes the interprocess communication system to allow this task to make calls to register_point, register_existing_point, send_async and send_string_async. It requests queue information from the given task. A deadlock situation could occur if two tasks attempt to initialize asynchronous communication with one another at the same time. The queue server task, **qserve**, must be running for this call to succeed.

Example

```
Gamma> init_ipc("mytask","mytask_q");
t
Gamma> task = locate_task("server", t);
#<Task: 32271>
Gamma> init_async_ipc(task);
t
```

See Also

init_ipc, locate_task, register_point, send_async, send_string_async

init_ipc

init_ipc — sets up necessary data structures for IPC.

Synopsis

```
init_ipc (my_name, my_queue_name?, domain?)
```

Arguments

my_name
: A name for this task, as a string. It is only used internally.

my_queue_name
: Optional queue name for this task, as a string. This is necessary for asynchronous communication, and it must be unique on the system.

domain
: Optional domain name for this task.

Returns

t on success, otherwise nil.

Description

Sets up all of the data structures needed prior to attempting any interprocess communication from this task. Messages can be neither sent nor received before this call is made. All DataHub functions use IPC. If the value of *my_queue_name* is nil, no queue name is assigned and no asynchronous IPC is possible.

Example

```
Gamma> init_ipc("myname","myqueue");
t
Gamma>
```

See Also

isend, next_event, next_event_nb, read_point, read_existing_point, register_point, send, send_async, send_string, send_string_async, write_point, write_existing_point

isend

isend — sends a synchronous message and doesn't wait for the result.

Synopsis

```
isend (task, s_exp)
```

Arguments

task
A task descriptor as assigned to a `locate_task` call.

s_exp
Any Gamma or Lisp expression.

Returns

`t` if the message was sent successfully, otherwise `nil`.

Description

This function sends a message via synchronous interprocess communication, but does not wait for the result. The receiving task must respond immediately, prior to actually evaluating the message that was sent. The result code can only show whether the message was sent successfully. This is a compromise between synchronous and asynchronous messaging techniques.

Example

```
Gamma> init_ipc("mytask","myqueue");
t
Gamma> task = locate_task("other_task",nil);
<task id>
Gamma> isend(task,#list(do_something));
t
```

See Also

`locate_task`, `send`, `send_async`

locate_task

`locate_task` — finds and connects to tasks by name.

Synopsis

```
locate_task (task_name, async_reqd)
```

Arguments

task_name
: The name of the task to locate. The other task must have declared this name through `init_ipc` or `name_attach`.

async_reqd
: `t` if `locate_task` should automatically call `init_async_ipc` for this task.

Returns

A task if successful, otherwise `nil`.

Description

This function makes a call to the name locator task for the current operating system. If it finds the named task it makes an IPC connection (in TCP/IP) or creates a virtual circuit (in QNX 4) to that task. If *async_reqd* is `t`, then `init_async_ipc` is also called.

When Gamma locates a task, it returns a printed representation of it, which looks like this: #<Task:10120>. This representation cannot be read back into Gamma, so a symbol is usually assigned when calling `locate_task` to facilitate refering to or working with a task. We refer to this symbol as the task descriptor. For instance, in the example below, the symbol `tsk` is the task descriptor.

Example

The two tasks are initiated with `init_ipc` before calling `locate_task`.

Task 1:

```
Gamma> init_ipc("first","Q1");
t
Gamma> getpid();
```

```
9231
Gamma> tsk = locate_task("second",nil);
#<Task:9092>
Gamma> send (tsk, #princ("Are you there?\n"));
t
Gamma>
```

Task 2:

```
Gamma> init_ipc("second","Q2");
t
Gamma> getpid();
9092
Gamma> next_event
Are you there?
t
Gamma>
```

See Also

locate_task_id

locate_task_id

`locate_task_id` — finds and connects to tasks by task ID and network node.

Synopsis

```
locate_task_id (task_id, node_id, channel_id, async_reqd)
```

Arguments

task_id
: The task ID for this task (as a number).

node_id
: The network node number for this task.

channel_id
: The task ID for this task. This is required for QNX 6, ignored in QNX 4 and Linux.

async_reqd
: `t` if `locate_task` should automatically call `init_async_ipc` for this task.

Returns

A task if successful, otherwise `nil`.

Description

This function makes a TCP/IP connection or QNX 4 virtual circuit to the named task based on the *task_id* and the *node* number on which the task is running. If *async_reqd* is `t`, then `init_async_ipc` is also called. If the *node* number is zero, the current node is used.

Example

Task 1:

```
Gamma> init_ipc("Task 1","14");
t
Gamma> getpid();
9271
Gamma>
```

Task 2:

```
Gamma> init_ipc("Task 2","25");
t
```

```
Gamma> locate_task_id(9271,1,nil);
#<Task:9271>
Gamma>
```

See Also

locate_task

name_attach

`name_attach` — attaches a name to a task.

Synopsis

```
name_attach (task_name)
```

Arguments

task_name
: The name to attach to this task.

Returns

`t` if the name was successfully attached, otherwise `nil`.

Description

This function sends a message to the QNX 4 name locator task (`nameloc`) to attach a name on this node. If the name locator is not running or the name has already been attached by another task, the call will fail.

Example

```
// attach my name
Gamma> name_attach("firstname");
t
// attach an alternate name
Gamma> name_attach("pseudonym");
t
// attempt to attach my name again
Gamma> name_attach("firstname");
nil
```

nserve_query

`nserve_query` — puts information from **nserve** into an array.

Synopsis

```
nserve_query ()
```

Arguments

none

Returns

An array of instances of the class `TaskInfo`, or `nil` on failure.

Description

This function retrieves all the information available in the Cascade NameServer (**qserve**), and puts it into an array. Each item in the array is an instance of the `TaskInfo` class, as returned from the function `task_info`. Please refer to the documentation of that function for more details.

This function requires that `init_ipc` be called first.

Example

```
Gamma> init_ipc("a", "aq");
t
Gamma> pretty_princ(nserve_query(), "\n");
[{TaskInfo (channel_id . 0) (domain . toolsdemo) (name . /dh/toolsdemo)
           (node_id . 0) (node_name . 0) (pid . 5394)
           (queue_name . /dh/toolsde) (queue_size . 0)}
 {TaskInfo (channel_id . 0) (domain . toolsdemo) (name . control)
           (node_id . 0) (node_name . 0) (pid . 16995)
           (queue_name . controlq) (queue_size . 0)}
 {TaskInfo (channel_id . 0) (domain . toolsdemo) (name . emul)
           (node_id . 0) (node_name . 0) (pid . 16998)
           (queue_name . emulq) (queue_size . 0)}
 {TaskInfo (channel_id . 0) (domain . default) (name . a)
           (node_id . 0) (node_name . 0) (pid . 16999)
           (queue_name . aq) (queue_size . 0)}]
t
```

```
Gamma>
```

See Also

task_info

remove_hook

`remove_hook` — removes a hooked function.

Synopsis

```
remove_hook (hook_sym, function_sym)
```

Arguments

hook_sym
: One of several symbols used to identify a hook, as listed below.

function_sym
: The function that is to be removed.

Returns

The hooked function (*function_sym*) that was removed.

Description

This function removes a hook that was previously set up with add_hook. The currently available hooks are:

```
taskstarted_hook
taskdied_hook
exception_hook
echo_hook
gc_hook
trace_symbol_hook
trace_entry_hook
trace_exit_hook
breakpoint_hook
```

Example

Modifying the example in add_hook by adding one line:

```
...

add_hook (#taskstarted_hook, #hook_started);
add_hook (#taskdied_hook, #hook_died);

run_hooks (#taskstarted_hook, "testing start");
run_hooks (#taskdied_hook, "testing died");
```

```
/* Remove the hook */
remove_hook (#taskstarted_hook, #hook_started);

while(t)
...
```

would remove the `taskstarted_hook`.

See Also

`add_hook`, `run_hooks`, `init_ipc`

run_hooks

`run_hooks` — runs a hooked function.

Synopsis

```
run_hooks (hook_sym, args...?)
```

Arguments

hook_sym

One of several symbols used to identify a hook, as listed below.

args

The arguments of the function that is to run when the event occurs.

Returns

`t` on success or `nil` on failure.

Description

This function runs a hook that was previously set up with `add_hook`. The currently available hooks are:

```
taskstarted_hook
taskdied_hook
exception_hook
echo_hook
gc_hook
trace_symbol_hook
trace_entry_hook
trace_exit_hook
breakpoint_hook
```

Example

Please refer to the example in `add_hook`.

See Also

`remove_hook`, `init_ipc`

send

send — transmits expressions for evaluation.

Synopsis

```
send (task, s_exp)
```

Arguments

task
: A task descriptor as assigned to a `locate_task` call.

s_exp
: Any Gamma or Lisp expression.

Returns

A result depending on the receiving task, which could include:

- `t` if the message was delivered successfully.
- `nil` if the message could not be delivered.
- An expression in the form: (error "error message") if there was an error. See `error`.

Description

This function constructs an ASCII string representing the *s_exp* and transmits it via synchronous interprocess communication to the receiving *task*. The *task* processes the message and returns a result based on that processing. If the *task* is another Gamma process, the message will be interpreted as a Gamma expression and evaluated. The return value will be the result of that evaluation.

Example

Task 1:

```
Gamma> init_ipc ("a","a");
t
Gamma> tsk = locate_task("b",nil);
#<Task:9751>
Gamma> send(tsk, #princ("hello\n"));
hello
t
Gamma> send_async(tsk, #princ(cos(5), "\n"));
t
```

```
Gamma> send(tsk, #princ("goodbye\n"));
t
Gamma>
```

Task 2:

```
Gamma> init_ipc ("b","b");
t
Gamma> while(t) next_event();
hello
0.28366218546322624627
goodbye
```

See Also

isend, locate_task, send_async, send_string, send_string_async

send_async

send_async — transmits expressions asynchronously.

Synopsis

```
send_async (task, s_exp)
```

Arguments

task
: A task descriptor as assigned to a locate_task call.

s_exp
: Any Gamma or Lisp expression.

Returns

t if the message was successfully delivered, otherwise nil.

Description

This function constructs a string representation of the given expression and delivers it via asynchronous interprocess communication to the receiving task. If the message could not be delivered, send_async returns nil. There is no indication of the status of the receiving task as a result of processing the message.

Example

Task 1:

```
Gamma> init_ipc ("a","a");
t
Gamma> tsk = locate_task("b",t);
#<Task:9751>
Gamma> send_async(tsk, #princ("hello, b\n"));
t
Gamma> send_async(tsk, #princ(cos(5), "\n"));
t
Gamma>
```

Task 2:

```
Gamma> init_ipc ("b","b");
t
```

```
Gamma> while(t) next_event();
hello, b
0.28366218546322624627
```

See Also

isend, locate_task, send, send_string, send_string_async

send_string

send_string — transmits strings for evaluation.

Synopsis

```
send_string (task, string)
```

Arguments

task
A task descriptor as assigned to a locate_task call.

string
Any string.

Returns

A result depending on the receiving *task*.

Description

This function transmits the *string* via synchronous interprocess communication to a non-DataHub receiving *task*. The *task* processes the message and returns a result based on that processing. If the *task* is a Gamma process, the message will be interpreted as a Lisp expression and evaluated. The return value will be the result of that evaluation. If an error occurs during the evaluation, an expression of the form: (error "error message") will be returned. If the message could not be delivered, nil is returned.

Example

```
Gamma> a = 5;
5
Gamma> b = 6;
5
Gamma> send_string(task,string("(+",a," ",b,")"));
11
```

See Also

isend, locate_task, send, send_async, send_string_async

send_string_async

send_string_async — transmits a string asynchronously.

Synopsis

```
send_string_async (task, string)
```

Arguments

task
: A task descriptor as assigned to a locate_task call.

string
: A string.

Returns

t if the message was successfully delivered, otherwise nil.

Description

This function delivers the *string* via asynchronous interprocess communication to a non-DataHub receiving *task*. If the message could not be delivered, send_string_async returns nil. There is no indication of the status of the receiving *task* as a result of processing the message.

Example

Task 1:

```
Gamma> init_ipc ("a","a");
t
Gamma> tsk = locate_task("b",t);
#<Task:9751>
Gamma> send_string_async(tsk, "2 + 2");
t
Gamma> send_string_async(tsk,string(list(#a,#b,#c)));
t
Gamma>
```

Task 2:

```
Gamma> init_ipc ("b","b");
t
```

```
Gamma> while(t) next_event();
```

See Also

isend, locate_task, send, send_async, send_string

taskdied, taskstarted

taskdied, taskstarted — internal functions that call another function when a task starts or stops.

Synopsis

```
taskdied (task_name, qname, domain, node, task_id)
taskstarted (task_name, qname, domain, node, task_id)
```

Arguments

task_name
: The name of the task which started or stopped.

node
: The node on which the task started or stopped.

task_id
: The process ID for the task.

qname
: The name of the task's queue, if any.

domain
: The DataHub domain for this task.

Returns

User-defined.

Description

These functions are internal to Gamma. They call `run_hooks (#taskstarted_hook, args...)` and `run_hooks (#taskdied_hook, args...)` respectively. They are called whenever a task registered with the Cascade NameServer (**nserve**) starts or stops. You can set up hooks to use these functions through the add_hook function.

> These functions were originally available to programmers, and have been internalized to allow for the greater flexibility of the `add_hook` and `run_hook` functions. However, if you have existing code that you don't want to change, you can define your own versions of `taskdied` and `taskstarted` that shadow the built-in functions and do what they always used to do. Your old code will not break, but it will hide the hook version of the `taskdied` and `taskstarted` functions.
>
> On the other hand, you could get both with something like this:

```
builtin_taskdied = taskdied;
builtin_taskstarted = taskstarted;

function main ()
{
    init_ipc ("x","x");

    add_hook (#taskdied_hook, #hook_taskdied);
    add_hook (#taskstarted_hook, #hook_taskstarted);

    while(t)
        next_event();
}

function taskdied (!a?...=nil)
{
    princ ("task died: ", a, "\n");
    funcall (builtin_taskdied, a);
}

function taskstarted (!a?...=nil)
{
    princ ("task started: ", a, "\n");
    funcall (builtin_taskstarted, a);
}

function hook_taskdied (!a?...=nil)
{
    princ ("hook task died: ", a, "\n");
}

function hook_taskstarted (!a?...=nil)
{
    princ ("hook task started: ", a, "\n");
}
```

task_info

`task_info` — gets information from a task descriptor.

Synopsis

```
task_info (tsk)
```

Arguments

tsk
: A task descriptor, as returned by the `locate_task` function.

Returns

An instance of the class `TaskInfo`, or `nil` on failure.

Description

This function returns an instance of Gamma's `TaskInfo` class. The instance variables of this class correspond to information contained in the task descriptor, as follows:

channel_id
: The channel ID number, which is used in QNX 6 but not in QNX 4 or Linux.

domain
: The name of the DataHub domain for the *tsk*.

name
: The name of the *tsk*, as recorded in the Cascade NameServer. This attribute is not contained in a task descriptor, and thus is always returned as `nil` from this function.

node_id
: The node ID number.

node_name
: The `node_id` expressed as a string.

pid
: The process ID number.

queue_name
: The name of the Cascade QueueServer queue, as registered with the Cascade NameServer.

queue_size
: The size of the Cascade QueueServer queue.

Example

```
Gamma> init_ipc("a", "aq");
t
Gamma> tsk = locate_task("/dh/toolsdemo", nil);
#>Task:5394<
Gamma> task_info(tsk);
{TaskInfo (channel_id . 0) (domain . "toolsdemo") (name)
    (node_id . 0) (node_name . "0") (pid . 5394)
    (queue_name . "/dh/toolsde") (queue_size . 0)}
Gamma>
```

See Also

nserve_query

Events and Callbacks

add_set_function

`add_set_function` — sets an expression to be evaluated when a given symbol changes value.

Synopsis

```
add_set_function (symbol, s_exp)
```

Arguments

symbol
: A symbol.

s_exp
: Any Gamma or Lisp expression.

Returns

t

Description

This function binds an expression to be evaluated whenever the value of the *symbol* changes. This expression is available globally, so if the value of the *symbol* changes during a change in scope, the expression will be evaluated. All changes in that sub-scope will trigger new evaluations of the expression. This can be used to automatically maintain consistency between the program and a DataHub instance, or to implement forward chaining in calculation rules. The expression will not be evaluated if the new value is eq to the previous value.

When a set expression (the *s_exp*) is being evaluated the special variables `this`, `value` and `previous` are all bound:

- **`this`** The symbol whose value has changed.
- **`value`** The current value of this as a result of the change.
- **`previous`** The value of this immediately prior to the change.

Example

```
Gamma> b = 5;
5
Gamma> add_set_function(#b,#princ("changed\n"));
(princ "changed\n")
Gamma> b = 4;
```

```
changed
4
Gamma>
```

The following code automatically sounds an alarm whenever a `computed_tank_level` rises above 10000 and silences the alarm whenever it drops below 10000. The DataHub instance is automatically updated to maintain the same value as the Gamma task.

```
function send_to_datahub  (point)
{
 write_point(point, value);
}

function check_alarm (value)
{
 if (value == 1)
  sound_alarm();
 else
  silence_alarm();

 send_to_datahub(this);
}

function check_tank_level (depth)
{
 if (depth > 10000)
  high_alarm = 1;
 else
  high_alarm = 0;

 send_to_datahub(this);
}

add_set_function(#high_alarm, #check_alarm(high_alarm));
add_set_function(#computed_tank_level,#check_tank_level(computed_tank_level));
```

See Also

`when_set_fns`, `remove_set_function`

flush_events

`flush_events` — handles all pending events, then exits.

Synopsis

```
flush_events ()
```

Arguments

none

Returns

The result of executing all pending events, then exits.

Description

This function ensures that an appropriate event-handling function is called to handle all pending events from: a window system (where applicable), other tasks (interprocess communication messages), timers, or signals. Upon completion, `flush_events` causes the program to exit.

Example

```
Gamma> flush_events();

(the result of any pending events)

[/user/cogent/bin]$
```

See Also

next_event

next_event, next_event_nb

next_event, next_event_nb — wait for an event and call the event handling function.

Synopsis

```
next_event ()
next_event_nb ()
```

Arguments

none

Returns

The result of executing the next event. If no event was processed, next_event_nb will return undefined, and next_event will not return.

Description

next_event blocks, waiting for an event from: a window system (where applicable), another task (an interprocess communication message), a timer, or a signal. An event handling function is automatically called if one has been defined for the event. The result of next_event is the result returned from the event handler, or nil if no event handler had been defined.

next_event_nb behaves exactly like next_event, except that next_event_nb (nb stands for non-blocking) returns immediately with undefined if no event is waiting to be processed.

Example

1. Here is the simplest use of next_event, causing Gamma to wait for and process the next event.

```
Gamma> while(t) next_event();
```

2. This program does basically the same thing, creating a main loop for program event processing, but it features error protection as well.

```
while (t)
{
 try
 {
```

```
  next_event();
 }
 catch
 {
  princ("last error: ", _last_error_," calling stack: ",
   stack(),"\n");
 }
}
```

remove_set_function

`remove_set_function` — removes a set function from a symbol.

Synopsis

```
remove_set_function (symbol, s_exp)
```

Arguments

symbol
: The symbol from which to remove the expression.

s_exp
: An expression set for the *symbol*, such as that added by *add_set_function*.

Returns

The expression, in Lisp syntax, which was removed, or `nil` if none was removed.

Description

This function removes a set expression from the *symbol*. The *s_exp* is compared to all of the current expression set for the *symbol* using the comparison function eq.

Example

```
Gamma> b = 5;
5
Gamma>  add_set_function(#b,#princ("changed\n"));
(princ "changed\n")
Gamma> b = 4;
changed
4
Gamma> remove_set_function(#b,#princ("changed\n"));
(princ "changed\n")
Gamma> b = 3;
3
Gamma>
```

See Also

`add_set_function`, `when_set_fns`

when_set_fns

when_set_fns — returns all functions set for a symbol.

Synopsis

```
when_set_fns (symbol)
```

Arguments

symbol
A symbol.

Returns

The expressions, in Lisp syntax, that have been set to be evaluated whenever the *symbol*'s value changes.

Example

```
Gamma> b = 5;
5
Gamma> add_set_function(#b,#princ("Changed.\n"));
(princ "Changed.\n")
Gamma> add_set_function(#b,#princ("Update now.\n"));
(princ "Update now.\n")
Gamma> b = 4;
Update now.
Changed.
4
Gamma> when_set_fns(#b);
((princ "Update now.\n") (princ "Changed.\n"))
Gamma>
```

See Also

add_set_function, remove_set_function

Time, Date, and Timers

after

`after` — a timer that initiates an action after a period of time.

Synopsis

```
after (seconds, action...)
```

Arguments

`seconds`
: A number of seconds, which may be fractional.

`action`
: One or more statements to be executed. This argument is evaluated, so literal statements must be quoted.

Returns

An integer timer number which may be used as the argument to `cancel`.

Description

This function specifies an action to be performed after a given period of time in seconds has elapsed. The number of *`seconds`* may be specified to arbitrary precision, but will be limited in fact by the timer resolution of the operating system. In most cases this is practically limited to 20 milliseconds (0.05 seconds).

The timer functions `after`, `every` and `at` all cause an action to occur at the specified time, regardless of what is happening at that time, except if the timer expires during garbage collection. In this case, the timer will be serviced as soon as the garbage collection finishes.

For Gamma to notice a timer, you must make a call to `next_event`.

Example

```
Gamma> after(30, #princ("Time's up!\n"));
1
Gamma> next_event();

(30 seconds pass)

Time's up!
nil
```

```
Gamma>
```

See Also

`at`, `every`, `cancel`, `_timers_` in Predefined Symbosl

at

`at` — a timer that initiates an action at a given time, or regularly.

Synopsis

```
at (day, month, year, hour, minute, second, actions...)
```

Arguments

day
: Restriction on the day of the month (1-31), or `nil` for none.

month
: Restriction on the month of the year (1-12), or `nil` for none.

year
: Restriction on the year (1994-2026), or `nil` for none.

hour
: Restriction on the hour of the day (0-23), or `nil` for none.

minute
: Restriction on the minute in the hour (0-59), or `nil` for none.

second
: Restriction on the second in the minute (0-59), or `nil` for none.

actions
: The actions to perform when the specified time arrives.

Returns

An integer number which may be used as the argument to `cancel`.

Description

This function specifies an action to be performed at a given time, or to occur regularly at certain times of the *minute*, *hour*, *day*, *month* or *year*. A restriction on a particular attribute of the time will cause `at` to fire only if that restriction is true.

A restriction may be any number in the legal range of that attribute, or a list of numbers in that range. Illegal values for the time will be normalized. For example, a time specified as July 0, 1994 00:00:00 will be treated as June 30, 1994 00:00:00. If `nil` is specified for any attribute of the time, this implies no restriction and `at` will fire cyclically at every legal value for that attribute.

For Gamma to notice a timer, you must make a call to `next_event`. To notice repeating timers, the call to `next_event` can be used with a call to `while(t)`.

Example

```
//To print "hello" at 12:00 noon on June 2, 1994:
at(2,6,1994,12,0,0,#princ("hello\n"));

//To print "hello" at 12:00 noon on the first day
//of every month in 1994:
at(1,nil,1994,12,0,0,#princ("hello\n"));

//To print "hello" every half minute at 30 seconds
//and on the minute on the 1st and 15th of every month
//except July and August, for any year:
at(list(1,15), list(1,2,3,4,5,6,9,10,11,12),list(0,30), #(princ "hello\n"));

//To print "hello" every 10 seconds during the hour
//of 3:00pm every December 21st.
at(21,12,nil,15,nil,list(0,10,20,30,40,50), #princ("hello\n"));
```

See Also

`after`, `every`, `_timers_` in Predefined Symbosl

block_timers, unblock_timers

block_timers, unblock_timers — block and unblock timer firing.

Synopsis

```
block_timers ()
unblock_timers ()
```

Arguments

none

Returns

t

Description

Timers are potentially handled by a different mechanism from operating system signals. It may be desirable to block all timers from firing for the duration of an operation, which may not be possible using the block_signal mechanism. If a timer fires while timers are blocked, the timer function will be called as soon as timers are unblocked. This will not delay subsequent timers.

For example, if a timer is intended to fire every 5 seconds at 5, 10, ... seconds after the minute and the 5-second timer is blocked until second 7, the next timer in the sequence will still fire at 10 seconds. If the 5-second timer were blocked until second 27, then the 5, 10, 15, 20 and 25-second timers would *all* fire at second 27 and the next timer would fire at second 30. Code which blocks timers should be surrounded by a call to unwind_protect.

Example

```
Gamma> block_timers();
t
Gamma> protected_function();
<function return>
Gamma> unblock_timers();
t
```

See Also

block_signal, unblock_signal, after, at, every, _timers_ in Predefined Symbosl

cancel

`cancel` — removes a timer from the set of pending timers.

Synopsis

```
cancel (timer_number)
```

Arguments

timer_number
: An integer number returned from a call to `after`, `at` or `every`.

Returns

The complete timer definition for the canceled timer, or `nil` if no timer was canceled.

Description

Removes a timer from the set of pending timers based on its unique timer ID as returned by the function which created the timer. If no timer could be found with the corresponding timer number, nothing happens.

Example

To set a timer to repeat every 5 seconds, then stop it:

```
Gamma> every(5, #princ("hello\n"));
1
Gamma> cancel(1);
[945884155 683256506 5 ((princ "hello\n")) 1]
Gamma>
```

See Also

`_timers_` in Predefined Symbols

clock, nanoclock

clock, nanoclock — get the OS time.

Synopsis

```
clock ()
nanoclock ()
```

Arguments

none

Returns

The current clock value in seconds from the operating system as a long integer. nanoclock includes the nanoseconds as well.

Description

This function gets the operating system clock setting in seconds. The time is usually expressed as the number of seconds from midnight January 1, 1970 on UNIX systems, though it may differ across implementations.

Example

```
Gamma> clock();
999810273
Gamma> nanoclock();
999810273.66378700733
Gamma>
```

See Also

date, date_of

date

`date` — gets the OS date and time; translates seconds into dates.

Synopsis

```
date (seconds?, is_utc?)
```

Arguments

seconds

A number of seconds, such as returned from a call to `clock`.

is_utc

A value of `t` puts the date in Coordinated Universal Time (formerly known as Greenwich Mean Time, GMT).

Returns

The date as a character string.

Description

This function returns a character string which represents the current date and time in human-readable form. This form depends on the operating system, but will look like "Sat Mar 21 15:58:27 2000" on most UNIX systems. The *seconds* parameter returns the date that corresponds to the number of seconds since Jan 1, 1970, Coordinated Universal Time.

Example

```
Gamma> date();
"Fri Mar 31 09:18:27 2000"
Gamma> date(987654321);
"Thu Apr 19 00:25:21 2001"
Gamma> date(987654321,t);
"Thu Apr 19 04:25:21 2001"
Gamma> date(0,t);
"Thu Jan  1 00:00:00 1970"
Gamma>
```

See Also

`clock`

date_of

date_of — is obsolete, see date

Synopsis

```
date_of (seconds)
```

Arguments

seconds

A system time as a long integer, which may be obtained from the clock function.

Returns

The date as a character string.

Description

This function has been superseded by date. It returns a character string which represents the given date and time in human-readable form. This form depends on the operating system, but will look like "Fri Feb 16 21:50:32 1973" on most UNIX systems.

Example

```
Gamma> date_of(987654321);
"Thu Apr 19 00:25:21 2001"
```

See Also

clock, date

every

`every` — a timer that initiates an action every number of seconds.

Synopsis

```
every (seconds, action...)
```

Arguments

seconds
: The number of seconds. This may be fractional. Realistically the operating system will not be able to keep up with numbers below about 0.05. This will differ from machine to machine.

action
: The actions to perform continuously every given number of seconds.

Returns

An integer number which may be used as the argument to `cancel`.

Description

This function specifies an action to be performed every time the number of *seconds* elapses. The return value is a unique timer number which may be used to cancel the *action* prior to the time expiring by calling `cancel`. The number of seconds may be specified to arbitrary precision, but will be limited in fact by the timer resolution of the operating system. In most cases this is practically limited to 20 milliseconds (0.05 seconds).

The timer functions `after`, `every` and `at` all cause the action to occur at the specified time, regardless of what is happening at that time, except if the timer expires during garbage collection. In this case, the timer will be serviced as soon as the garbage collection finishes.

For Gamma to notice a timer, you must make a call to `next_event`. To notice repeating timers, the call to `next_event` can be used with a call to `while(t)`.

Example

Print hello every 5 seconds.

```
Gamma> every(5, #princ("Hello\n"));
1
Gamma> while(t) next_event();
```

```
Hello
Hello
Hello
...
```

See Also

after, at, _timers_ in Predefined Symbosl

gmtime

`gmtime` — transforms Unix time to UTC time and date in ASCII format.

Synopsis

```
gmtime (time_t)
```

Arguments

time_t
: The time, usually expressed as the number of seconds from midnight January 1, 1970 on UNIX systems, though it may differ across implementations.

Returns

A instance of the class `tm`, whose members are as follows:

.sec
: The number of seconds after the minute (`0` - `59`).

.min
: The number of minutes after the hour (`0` - `59`).

.hour
: The number of hours past midnight (`0` - `23`).

.mday
: The day of the month (`1` - `31`).

.mon
: The number of months since January (`0` - `11`)

.year
: The number of years since 1900.

.wday
: The number of days since Sunday (`0` - `6`).

.yday
: The number of days since January 1 (`0` - `365`)

.isdst
: `1` if daylight saving time is in effect, `0` if not, and a negative number ifthe information is not available.

Example

```
Gamma> pretty_princ ("UTC breakout:\t", gmtime (1149261975.5000002), "\n");
```

```
UTC breakout: {tm (hour . 15) (isdst . 0) (mday . 2) (min . 26)
    (mon . 5) (sec . 15) (wday . 5) (yday . 152) (year . 106)}
t
Gamma>
```

See Also

gmtime, mktime

Iso8601ToUnixTime

`Iso8601ToUnixTime` — converts from ISO 8601 time to Unix time.

Synopsis

```
Iso8601ToUnixTime  (isostring)
```

Arguments

isostring
: A string in ISO 8601 date/time format.

Returns

A floating point number as a UTC UNIX timestamp.

Description

This function takes a string in ISO 8601 date format and returns a floating point number as a UNIX time. UNIX time is the number of seconds since January 1, 1970 00:00:00 UTC. This function preserves accuracy to 1 millisecond. The input string must be in a valid ISO 8601. The UTC format is described in UnixTimeToIso8601.

ISO 8601 time zone specifiers are accepted. For example:

- UTC time: `2020-05-23T12:45:23.692Z`
- Explicit time zone: `2020-05-23T08:45:23.692-04:00`

Example

```
—> Iso8601ToUnixTime("2020-05-23T08:45:23.692-04:00")
1590237923.6919999123
—> Iso8601ToUnixTime("2020-05-23T12:45:23.692Z")
1590237923.6919999123
```

localtime

`localtime` — transforms Unix time to local time and date in ASCII format.

Synopsis

```
localtime (time_t)
```

Arguments

time_t
: The time, usually expressed as the number of seconds from midnight January 1, 1970 on UNIX systems, though it may differ across implementations.

Returns

An instance of the class `tm`, whose members are as follows:

.sec
: The number of seconds after the minute (`0` - `59`).

.min
: The number of minutes after the hour (`0` - `59`).

.hour
: The number of hours past midnight (`0` - `23`).

.mday
: The day of the month (`1` - `31`).

.mon
: The number of months since January (`0` - `11`)

.year
: The number of years since 1900.

.wday
: The number of days since Sunday (`0` - `6`).

.yday
: The number of days since January 1 (`0` - `365`)

.isdst
: `1` if daylight saving time is in effect, `0` if not, and a negative number ifthe information is not available.

Example

```
Gamma> pretty_princ ("Local breakout:\t", localtime (1149261975.5000002), "\n");
```

```
Local breakout: {tm (hour . 11) (isdst . 1) (mday . 2) (min . 26)
    (mon . 5) (sec . 15) (wday . 5) (yday . 152) (year . 106)}
t
Gamma>
```

See Also

gmtime, mktime

mktime

mktime — converts the ASCII date and time data in a tm class to Unix time.

Synopsis

```
mktime (time_t)
```

Arguments

tm

A tm class, as created by localtime or gmtime

Returns

The time, usually expressed as the number of seconds from midnight January 1, 1970 on UNIX systems, though it may differ across implementations.

Example

```
Gamma> princ ("Local breakout to Unix:\t", mktime (localtime(1149261975.5000002)),
Local breakout to Unix: 1149261975
t
Gamma>
```

See Also

gmtime, localtime

timer_is_proxy

`timer_is_proxy` — controls timer handling in Gamma.

Synopsis

```
timer_is_proxy (t_or_nil);
```

Arguments

t_or_nil
: An expression that evaluates to `t` or `nil`.

Returns

The passed argument (`t` or `nil`).

Description

This function controls how timers are fundamentally handled within Gamma. By default, timers are handled by the processing of proxies which allows Gamma to delay the timer, if necessary, if a critical system process is occurring.

Calling `timer_is_proxy` with `nil` makes all timers operate by using signals. In the QNX 4 operating system SIGUSER1 (SIGALRM?) is used, and the attach code is run as a handled signal.

Running timers via signals has some very dramatic consequences. When running in this mode ALL TIMER CODE MUST BE SIGNAL SAFE.

Example

```
Gamma> timer_is_proxy (nil);
nil
Gamma> timer_is_proxy (t);
t
Gamma>
```

See Also

`every`, `at`, `after`, `block_timers`, `nunblock_timers`, `cancel`

UnixTimeToIso8601

`UnixTimeToIso8601` — converts from Unix time to ISO 8601.

Synopsis

```
UnixTimeToIso8601 (unixtime)
```

Arguments

unixtime
A floating point number as a UTC UNIX timestamp.

Returns

An ISO 8601 formatted date string.

Description

This function takes a floating point UNIX time and returns an ISO 8601 formatted date string. This string will be in the form *YYYY*-*MM*-*DD*T*HH*:*mm*:*ss*.*fff*Z where:

YYYY is the 4-digit year.
MM is the 2-digit month, from 1 to 12.
DD is the 2-digit day within the month, from 1 to 31.
T is the literal letter T.
HH is the 2-digit hour within the day, from 0 to 23.
mm is the 2-digit minute within the hour, from 0 to 59.
ss is the 2-digit second within the minute, from 0 to 59.
fff is the 3-digit millisecond within the second, from 0 to 999.
Z is the literal letter Z, indicating UTC time.

This function will always produce a UTC string. The input *unixtime* must be in UTC.

Example

```
–> UnixTimeToIso8601(1590237923.6919999123);
"2020-05-23T12:45:23.692Z"
```

Cogent DataHub

add_exception_function, add_echo_function

`add_exception_function`, `add_echo_function` — assign functions for exceptions or echoes on a point.

Synopsis

```
add_exception_function (symbol, s_exp);
add_echo_function (symbol, s_exp);
```

Arguments

symbol
A point name, as a symbol.

s_exp
Any Gamma or Lisp expression.

Returns

`t`

Description

When a Gamma or Lisp program is run in conjunction with a DataHub instance, process points may change at any time, causing point change events to occur. A point change event is referred to as an exception. It is possible to bind any Gamma or Lisp expression to a symbol to be evaluated when an exception occurs. If a program can both write a point on the DataHub instance and react to exceptions on that point, it is possible that the DataHub instance will "echo" a point written by the program itself. If this is not handled, an infinite loop between the program and the DataHub instance could occur. The DataHub instance tags point echoes so that a different function can be called in the program when that echo arrives back at its origin. Only the originating task will see a point exception as an echo. All other tasks will see a normal exception.

When an exception handler (the *s_exp* argument) is being evaluated the special variables `this`, `value` and `previous` are all bound:

- **`this`** The symbol which received the exception.
- **`value`** The current value of `this` as a result of the exception.
- **`previous`** The value of `this` immediately prior to the exception.

Example

```
Gamma> add_exception_function(#temp, #princ("temp change\n"));
```

```
(princ "temp change\n")
Gamma> add_echo_function(#temp,nil);
nil
Gamma> next_event();
temp change
(t)
Gamma> read_point(#temp);
30
Gamma> write_point(#temp,25);
t
Gamma> next_event();
(nil)
Gamma>
```

See Also

register_point, when_echo_fns, when_exception_fns, remove_echo_function, remove_exception_function

lock_point

`lock_point` — locks or unlocks points.

Synopsis

```
lock_point (symbol, locked)
```

Arguments

symbol
: A point name, as a symbol.

locked
: `t` to set a lock, `nil` to release a lock.

Returns

`t` if the function is successful, otherwise `nil`.

Description

This function locks or unlocks a point in a DataHub instance. The current security level must be greater than or equal to the security level on the point.

Example

```
Gamma> init_ipc("locker","lq");
t
Gamma> write_point(#a,5);
t
Gamma> lock_point(#a,t);
t
Gamma> write_point(#a,300);
nil
Gamma> lock_point(#a,nil);
t
Gamma> write_point(#a,300);
t
Gamma>
```

See Also

`set_security`, `point_locked`

point_locked

point_locked — indicates if a point is locked.

Synopsis

```
point_locked (symbol)
```

Arguments

symbol
A point name, as a symbol.

Returns

t if locked, or nil if not locked.

Example

```
Gamma> lock_point(#f,t);
t
Gamma> next_event();
nil
Gamma> point_locked(#f);
t
Gamma> lock_point(#f,nil);
t
Gamma> next_event();
nil
Gamma> point_locked(#f);
nil
Gamma>
```

See Also

lock_point

point_nanoseconds

point_nanoseconds — gives the nanoseconds from point_seconds that a point value changed.

Synopsis

```
point_nanoseconds (symbol)
```

Arguments

symbol
A point name, as a symbol.

Returns

A number of nanoseconds.

Description

This function returns the number of nanoseconds after point_seconds that a given point's value changed.

Example

```
Gamma> clock();
938631678
Gamma> write_point(#l,44);
t
Gamma> next_event();
nil
Gamma> point_seconds(#l);
938631693
Gamma> point_nanoseconds(#l);
735100000
Gamma>
```

See Also

point_seconds

point_seconds

point_seconds — gives the time the point value changed.

Synopsis

```
point_seconds (symbol)
```

Arguments

symbol
: A point name, as a symbol.

Returns

A time in seconds.

Description

This function returns the time in seconds when a given point's value changed.

Example

```
Gamma> clock();
938631678
Gamma> write_point(#l,44);
t
Gamma> next_event();
nil
Gamma> point_seconds(#l);
938631693
Gamma>
```

See Also

point_nanoseconds

point_security

point_security — gives the security level of a point.

Synopsis

```
point_security (symbol)
```

Arguments

symbol
A point name, as a symbol.

Returns

The security level.

Example

```
Gamma> set_security(5);
0
Gamma> secure_point(#f,3);
t
Gamma> point_security(#f);
3
Gamma>
```

See Also

secure_point, set_security,

read_existing_point, read_point

read_existing_point, read_point — retrieve points.

Synopsis

```
read_existing_point (symbol)
read_point (symbol)
```

Arguments

symbol
A point name, as a symbol.

Returns

The value of a point in the DataHub instance. If the point is unavailable then nil is returned. For read_existing_point, if the point does not exist than nil is returned. For read_point, if the point does not exist then the point is created and a default value is returned.

Description

These functions makes a call to the DataHub instance to retrieve the point whose name is the same as the *symbol*. If the point does not exist in the DataHub instance, read_existing_point returns nil and does not create the point. read_point will create a point in the DataHub instance if necessary, whose value and confidence are both zero. If the point name is pre-qualified with a domain name and a colon (:), this function will search that domain's data rather than the DataHub instance for the default domain.

Example

This example uses data points entered in the write_point reference entry example.

```
Gamma> init_ipc("reader","rq");
t
Gamma> read_point(#my);
600
Gamma> read_point(#dog);
130
Gamma> read_point(#has);
140
Gamma> read_point(#fleas);
150
Gamma> read_existing_point(#cat);
```

```
nil
Gamma> read_point(#cat);
0
Gamma>
```

See Also

register_point, write_point

register_all_points

`register_all_points` — registers an application to receive exceptions for all points.

Synopsis

```
register_all_points (domain?, newflag?)
```

Arguments

domain
: The DataHub domain in which to register.

newflag
: A flag determining whether to automatically register all future points from the DataHub instance.

Returns

`t` on success, or `nil` on failure.

Description

This function registers the current application to receive exceptions from the DataHub instance for all points in the given domain. Once this function has been called, any changes to the value of any point in the DataHub instance will be transmitted to the input queue of the application. These changes are events, and as such must be processed by calling `next_event` or `next_event_nb` before the application will recognize the new value of the point.

If the domain is `nil`, then the current default domain (set by `set_domain`) will be used. If the domain is named, even if it is the default domain, then the DataHub instance will transmit all points as fully qualified names, in the domain:name format. If the *newflag* is given and is non-`nil`, then any points which are created on the DataHub instance after this call is made will be automatically registered. If *newflag* is `nil` or not provided, then the DataHub instance will not automatically register points which were created since this call.

Example

```
Gamma> register_all_points(nil,t);
t
Gamma> write_point(#b,22);
t
Gamma> next_event();
```

```
nil
Gamma> b;
22
Gamma> register_all_points("plant",t);
t
Gamma>
```

See Also

register_point

register_exception

`register_exception` — not yet documented.

Synopsis

```
register_exception (symbol, s_exp, execute_p?)
```

Arguments

symbol

s_exp

execute_p

Returns

Description

Example

```
```

See Also

register_point, register_existing_point

`register_point`, `register_existing_point` — register an application to receive exceptions for a single point.

Synopsis

```
register_point (symbol)
register_existing_point (symbol)
```

Arguments

symbol
: A point name, as a symbol.

Returns

The current value of the point in the DataHub instance. If the point does not exist, `register_point` will create the point in the DataHub instance and return a default value. However `register_existing_point` will return `nil` if the point does not exist.

Description

These functions register an application to receive changes in the value of a point whenever they occur. The current value of the point is returned as a result of the registration. Once this function has been called, any changes to the value of the point in the DataHub instance will be transmitted to the input queue of the application. These changes are events, and as such must be processed by calling `next_event` or `next_event_nb` before the application will recognize the new value of the point.

A function may be attached to the value change event using the `when_exception` and `when_echo` functions. Regardless of whether an event is attached to the point, the interpreter will update the value of the symbol whose name is the same as the point name. This means that once a point has been registered its value will always be current in the global scope of the interpreter. If the point name is pre-qualified with a domain name and a colon (:), this function will search that domain's data rather than the DataHub instance for the default domain.

Example

```
Gamma> register_point(#f);
26
Gamma> write_point(#f,85);
t
Gamma> f;
```

```
26
Gamma> next_event();
nil
Gamma> f;
85
Gamma> register_existing_point(#newpoint);
nil
Gamma> register_point("newpoint");
0
Gamma> register_point("acme:newpoint");
0
```

See Also

init_ipc, next_event, next_event_nb, when_echo, when_exception

remove_echo_function

`remove_echo_function` — removes an echo function from a symbol.

Synopsis

```
remove_echo_function (symbol, echo_fn)
```

Arguments

symbol
: The point name, as a symbol, from which to remove the echo function.

echo_fn
: The echo function body.

Returns

The echo function which was removed, or `nil` if no function was removed.

Description

This function removes an echo function (DataHub echo handler) from the *symbol*. The *echo_fn* is compared to all of the current echo functions for the *symbol* using the comparison function eq.

Example

```
Gamma> add_echo_function(#temp,#princ("echo\n"));
(princ "echo\n")
Gamma> write_point(#temp,28);
t
Gamma> next_event();
echo
(t t)
Gamma> remove_echo_function(#temp,#princ("echo\n"));
(princ "echo\n")
Gamma> write_point(#temp,32);
t
Gamma> next_event();
(t)
Gamma>
```

See Also

`add_echo_function`

remove_exception_function

`remove_exception_function` — removes an exception function from a symbol.

Synopsis

```
remove_exception_function (symbol, exc_fn)
```

Arguments

symbol
: The point name, as a symbol, from which to remove the exception function.

exc_fn
: The exception function body.

Returns

The exception function which was removed, or `nil` if no function was removed.

Description

This function removes an exception function (DataHub exception handler) from the *symbol*. The *exc_fn* is compared to all of the current exception functions for the *symbol* using the comparison function eq.

Example

```
Gamma> add_exception_function(#temp, #princ("temp change\n"));
(princ "temp change\n")
Gamma> next_event();
temp change
(t)
Gamma> temp;
40
Gamma> remove_exception_function(#temp, #princ("temp change\n"));
(princ "temp change\n")
Gamma>  next_event();
nil
Gamma> temp;
35
Gamma>
```

See Also

add_exception_function

secure_point

`secure_point` — alters the security level on a point.

Synopsis

```
secure_point (symbol, security)
```

Arguments

symbol
: The point to alter, as a symbol.

security
: The new security level for this point.

Returns

`t` on success, or `nil` if an error occurred.

Description

This function alters the security level on a point in the DataHub instance. If the current process security level is lower than the named point (*symbol*), then the function returns `nil`, otherwise it returns `t`. The initial security level for a process is `0`.

Example

```
Gamma> init_ipc("spt","spq");
t
Gamma> secure_point(#d,5);
nil
Gamma> set_security(9);
0
Gamma> secure_point(#d,5);
t
Gamma> secure_point(#d,12);
nil
Gamma> set_security(15);
9
Gamma> secure_point(#d,12);
t
Gamma>
```

See Also

point_security, set_security

set_domain

`set_domain` — sets the default domain for future calls.

Synopsis

```
set_domain (domain_name)
```

Arguments

domain_name
A string.

Returns

The *domain_name* argument.

Description

This function sets the default DataHub domain for all future calls to `read_point`, `read_existing_point`, `register_point`, `register_existing_point`, `write_point` and `write_existing_point`. The default domain can be overridden by explicitly placing the domain name at the beginning of the point name, separated by a colon (:). For example, a variable named `tank_level` in the default domain would have to be named `acme:tank_level` in the "acme" domain.

There is a possibility of aliasing points. If the default domain is "acme" then the point `tank_level` and the point `acme:tank_level` refer to the same DataHub point. If both of these names are used in a Gamma program then one of them will not behave correctly. It is the responsibility of the programmer to ensure that there is no aliasing in the assigned names, either by always explicitly naming a point's domain or by programming carefully.

Example

```
Gamma> set_domain("acme");
t
Gamma> read_point(#tank_level);
12.5
Gamma> set_domain("steamplant");
t
Gamma> read_point("tank_level");
4.35
Gamma> read_point("acme:tank_level");
12.5
```

See Also

read_point, read_existing_point, register_point, write_point, write_existing_point

set_security

`set_security` — changes the security level for the current process.

Synopsis

```
set_security (security_level)
```

Arguments

security_level
The new security level for this process.

Returns

The previous security level for this process.

Description

This function changes the security level for the current process to the given value. There is no restriction on the security level argument. A low-security process can alter its own security level to be higher.

If it is necessary to have a process's security level to be unalterable, then the `set_security` function can be re-bound after the security level is originally set (see second example). The only use of security level is in conjunction with the DataHub instance.

Example

```
Gamma> init_ipc("spt","spq");
t
Gamma> secure_point(#d,5);
nil
Gamma> set_security(9);
0
Gamma> secure_point(#d,5);
t
Gamma> secure_point(#d,12);
nil
Gamma> set_security(15);
9
Gamma> secure_point(#d,12);
t
Gamma>
```

The example below sets the current process's security to 5, and then re-binds `set_security` so that the program can no longer alter its security. The `list` function is used in the re-binding, as it will accept any number of arguments without error, and will have no side-effects.

```
Gamma> set_security(5);
0
Gamma> set_security = list;
(defun list (&optional &rest s_exp...) ...)
Gamma> set_security(9);
(9)
Gamma> secure_point(#g,10);
nil
Gamma> secure_point(#g,6);
nil
Gamma> secure_point(#g,4);
t
Gamma>
```

See Also

`point_security`, `secure_point`

unregister_point

`unregister_point` — stops echo and exception message sending.

Synopsis

```
unregister_point (symbol)
```

Arguments

symbol
: The point to unregister.

Returns

`t` on success, or `nil` on failure.

Description

This function causes the DataHub instance to immediately stop sending echo and exception messages for the named point. It is possible that exceptions and echos which are queued to the task will arrive after this function is called, but the DataHub instance will not generate any new messages.

Example

```
Gamma> register_all_points(nil,t);
t
Gamma> b;
55
Gamma> unregister_point(#b);
t
Gamma> write_point(#b,33);
t
Gamma> write_point(#c,77);
t
Gamma> next_event();
nil
Gamma> b;
55
Gamma> c;
77
Gamma>
```

See Also

register_point, register_all_points

when_echo_fns, when_exception_fns

`when_echo_fns`, `when_exception_fns` — indicate the functions for echos or exceptions on a point.

Synopsis

```
when_echo_fns (symbol)
when_exception_fns (symbol)
```

Arguments

symbol
A point name, as a symbol.

Returns

A list of expressions to be evaluated when an echo or exception occurs on the *symbol*.

Example

```
Gamma> add_echo_function(#temp,#princ("echo\n"));
(princ "echo\n")
Gamma> add_echo_function(#temp,#temp/2);
(/ temp 2)
Gamma> when_echo_fns(#temp);
((/ temp 2) (princ "echo\n") t)
Gamma> write_point(#temp,22);
t
Gamma> next_event();
echo
(11 t t)
Gamma>
```

See Also

add_echo_function, add_exception_function, remove_echo_function, remove_exception_function

write_existing_point, write_point

write_existing_point, write_point — write point values.

Synopsis

```
write_existing_point (symbol, value, seconds?, nanoseconds?)
write_point (symbol, value, seconds?, nanoseconds?)
```

Arguments

symbol
A point name, as a symbol.

value
Any numeric or string expression.

seconds
Number of seconds since Jan 1st, 1970.

nanoseconds
Number of nanoseconds within the second.

Returns

t on success or nil on failure.

Description

These functions write a point value to the DataHub program. If the point does not exist in a DataHub instance, write_point will create the point and set its value. write_existing_point will return nil if the point does not exist.

Example

```
Gamma> init_ipc("writer","wq");
t
Gamma> write_existing_point("my",150);
nil
Gamma> write_point(#my,120);
t
Gamma> write_point(#dog,130,450000000);
t
Gamma> write_point("has",140);
t
Gamma> write_point("fleas",150,1210947,2134444);
```

```
t
Gamma> write_existing_point("my",600);
t
Gamma>
```

These points can be viewed in the DataHub instance (sorted in alphabetical order) using the **dhview** command at the shell prompt:

```
#     Point Name            Conf Value
1     dog                   100  130
2     fleas                 100  150
3     has                   100  140
4     my                    100  600
```

See Also

read_point, read_existing_point, register_point