PI System Architecture, Planning and Implementation Course

Version 2018
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Compiled: 19 December 2018
How to Use this Workbook

Each Main Heading describes a high-level valuable learning topic.

Your objectives are skills you can expect to learn in this segment.

New concepts are presented as level 2 headings.

Throughout the class you will be presented with questions and challenges to help you learn.

The majority of your time will be spent learning new skills via hands-on exercises, either in small groups or on your own.

Icons help you identify themes, like exercises, tools, tips, or documentation references.

User manuals, Learning workbooks, and other materials used in class can be downloaded from http://techsupport.osisoft.com. Login to an OSIsoft technical support account is required.
Software Versions Used in this Document

PI Software versions used in this course are:

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<th>Software</th>
<th>Version</th>
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<td>Data Archive</td>
<td>2018 (3.4.420.1182)</td>
</tr>
<tr>
<td>PI Interface for OPC DA</td>
<td>2.6.15.3</td>
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<tr>
<td>PI Connector for OPC UA</td>
<td>1.2.1.113</td>
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<td>PI System Management Tools</td>
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<td>1.4.16.79</td>
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<tr>
<td>PI Vision</td>
<td>2017 R2 SP1 (3.3.1.0)</td>
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PI Reference Library

Data Archive Installation and Upgrade Guide

Explains how to install, upgrade or restore a Data Archive.

Data Archive Introduction to System Management Guide

Provides information on how to manage the many aspects of a Data Archive.

Data Archive Reference Guide

The Data Archive Reference Guide provides a reference for the Data Archive command line utilities. It also discusses Data Archive database files, performance counters, and messages.

Data Archive Security Configuration Guide

This manual explains how to set up Windows Integrated Security on Data Archive servers, how and when to create PI Mappings and trusts, and how to improve Data Archive security.

It discusses built-in Data Archive Identities and provides a table of access permissions required for performing different Data Archive tasks, as well as access permissions required by specific PI products.

Data Archive System Management Guide

This book provides detailed instructions for configuring, maintaining, and troubleshooting your Data Archive. It also discusses other PI components that are relevant to Data Archive system management. These include PI Interfaces as well as client tools that can be used to manage your PI System.

Data Archive Applications User Guide

Data Archive Applications are a set of processing tools that help you get more out of your data by automating specific processes.
Terminology change

OSIsoft is revising its terminology to reflect the growth of the PI System from its original single-server architecture. In the revised terminology, **Data Archive** refers to the component that stores time-series data (formerly called PI Server), and PI Server refers to both Data Archive and Asset Framework. This document uses the revised terminology.
1. PI System Basics

1.1 Course structure

The course consists of instructor lead training with individual and group activities, coupled with student exercises. You will need to be familiar with your own corporate network topology, and the real-time data environment; including where the data originates and who can best take advantage of the dissemination of this data.

During the course, you will:

- Develop the PI System environment topology for your company,
- Install and configure a simple PI System,
- Modify this simple system to form a High Availability PI System with redundant PI Data Archives, PI Interfaces for OPC DA and PI Connectors for OPC UA.

1.2 Why PI? (What problem are you trying to solve?)

Many businesses realise there is a need to take closer control of their production processes. Instead of weekly reports rolled up monthly, CEO’s are now requesting timely situation reports so that efficiencies are introduced to ensure the profitability of the company. Selected you have been for the task of getting the key performance indicators and process data to the CEO more quickly than is currently the case. Your site will be used as a pilot and when proven, your solution will be rolled out across the enterprise.

Any solution must address the needs of all stakeholders - operators, process engineers, maintenance engineers, site management and enterprise management – as efficiently as possible. Current SCADA system operator stations are too expensive to roll out to non-operations employees.

Before going too much further you must decide exactly what type of data the stakeholders need and just where that data can be found in your organisation. All too often, planning and analysis reports are created with static and inconsistent sources of information – so-called ‘silos of information’. Data may be currently locked in spreadsheets or a customized application interface or is on the SCADA system and not easily accessible by mere mortals. You need to unlock the source of this data and present it to all, easily, and in a timely manner.

This course will lead you into an examination of your users’ data requirements and will examine the infrastructure required to meet those requirements. You will then install components of the PI System that demonstrate the way those sections interact to provide you with a model for you to use in your own environment.

First let’s examine what a PI System is.
1.3 What is a PI System?

Objectives

- Define the components of a PI System
- Draw a diagram of the architecture of a PI System

1.3.1 The PI System Described

The PI System collects, stores, and manages data from your plant or process. You connect your data sources to one or more Data Collection computers. In turn, the Data Collection computers get the data from your data sources and send it to the Data Archive. The Asset Framework (AF) Server is one method of accessing the Data Archive server, and there may be other PI and non-PI servers. Users request data from the AF Server or Data Archive for display in the client tools.

Generally the parts involved in a PI System are:

- Source data is collected by a PI Interface or PI Connector application hosted on the data acquisition computer.
- From the PI Interface the time series data is sent to the Data Archive server (asset data is referenced on the AF server) and stored.
- From the PI Connector the data is sent to the Data Archive with automatic PI Point creation and the data structure from data source is sent to AF.
- Data is read from the PI System (Data Archive and/or AF server) by any component of the PI Visualization Suite, such as PI ProcessBook, PI DataLink or PI Vision.
1.3.2 Architecture of a Typical PI System

The PI architecture may be very simple. Some customers have as few as one interface or connector feeding data to a Data Archive server. Everyone reads that Data Archive for their data.

More complex systems may include AF, PI Notifications, PI Analytics, PI Event Frames, browser tools, redundancy and failover.

\[ \text{PI Server} = \text{Data Archive} + \text{Asset Framework} \]
1.3.3 Architecture of PI System Architecture, Planning and Implementation Course

In this class, each student has a virtual environment consisting of five servers:

**PISRV1** – pre-installed MS SQL Server, AF and Data Archive for primary member of PI Collective will be installed.

**PISRV2** – pre-installed Data Archive for the secondary member of PI Collective, pre-installed PI ProcessBook and PI DataLink and Web Server with PI Vision

**PIINT1** – pre-installed OPC DA and OPC UA Servers, PI Interface for OPC DA and PI Connector for OPC UA will be installed.

**PIINT2** – pre-installed PI Interface for OPC DA and PI Connector for OPC UA to make a failover pair.

**PIDC** – Domain Controller. This server will not be touched during the class.
2. PI System Environment Architecture

Objectives

- Describe the PI System components
- Categorise users
- Examine data in the Data Archive and the AF Server
- Explain where each component can fit into your Enterprise
- List the pros and cons of the various client tools

In this section, you will investigate your users and the data they require, and develop an understanding of the IT network topology required to support them.

2.1 Simple PI

At its simplest, PI is a data infrastructure. A simple PI System consists of:

- the data source
- the data collector for that data source
- the Data Archive combined with its Asset Framework server
- an appropriate visualization tool on a PC or web browser.
The PI environment may be expanded to become a system similar to that represented below:

**Important**: The PI environment does not start with the system – it starts with the users and what they need from their data.
2.2 Directed Activity – Identify the Parts

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section. Your instructor will have directions.

Activity Objectives

- Describe the PI System components
- Define the purpose of each component

Approach

Using the image on the previous page, answer the following questions:

1. Why are there two Server applications in a PI Server?

2. What is the difference between smart and thin clients? Advantages or disadvantages? Use the table at the next page to write down your ideas.

3. List some of the ways data gets into the PI System.
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<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
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<td><img src="image1.png" alt="Process Book" /></td>
<td></td>
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<td>Thick</td>
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<td><img src="image3.png" alt="PI Vision" /></td>
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<td>Thin</td>
<td><img src="image3.png" alt="PI Vision" /></td>
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</table>
2.3 Back to the Data - What Do Your Users Require?

Users’ data is any data associated with the diverse equipment required in the modern business environment. This may be data such as:

- pump RPM,
- pump serial number,
- the date the pump had its impellor changed,
- running hours of the pump,
- calculated efficiency of the pump.

It can also record:

- the ping time between computers in corporate network,
- server CPU temperature,
- the memory requirements of a monitored business application.

Users may also require information about:

- equipment shutdown times,
- in-stream analysis,
- shift production limits,
- production totals,
- cost of production,
- data with time stamps in the future,

to name a few types of data.

The data are grossly categorized as:

- real-time data,
- derived (calculated) data,
- grouped (relational) data, or
- future data

Because of the differences in the rate of change of data, it is appropriate to store the data in different ways.

- Real time & future data is best stored in a database that allows for fast storage, fast retrieval and automatic compression such as the PI time series Data Archives.
• Slow changing or static data may be better stored in relational databases structures, or the asset centric elements found in the Asset Framework (AF) database.

• Calculated data may be stored in the PI Server or derived as required in the AF database with AF Analytics.

Numeric data stored in the Data Archive may be compressed to compact the historian, and to facilitate data retrieval. All data stored in the historian is kept in files called archives. When the CEO requests data, the structure of the archives facilitates the rapid retrieval of that data.

On the other hand, data in the AF can be

• stored in the associated relational database,

• derived as required from attributes and elements (AF Analytics), or

• passed through from the data archive historian.
2.4 Group Exercise – Know Your Users, Their Data.

This group exercise is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Activity Objectives
To understand who your users are and their data requirements.

Approach
As a group, create a list of the types (e.g. CEO, engineer, operator, IT network engineer, etc.) of user that will need PI.
For each of these groups produce a list of the types of data they need. As a hint you may use this Data Aggregation Hierarchy diagram
Classify whether this data as real-time or not.
2.5 Directed Activity – Categorize Your Users

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section. Your instructor will have directions.

Activity Objectives

Users are a diverse group of individuals with differing requirements from the same set of data. There are operations’ managers, engineering managers, CEOs, engineers, chemists, operators and accountants, who all require data from the various databases within the organisation. These people may exist in different places to each other necessitating a multiplicity of methods of communicating data around the network.

Approach

Your instructor will ask you to list potential users of PI Data, and where they “live” in the Enterprise. Who will want to see ‘live’ data?

Write your answers here:
2.6 Combining Different Types of Data

The AF server provides several functions that are useful for building applications upon PI data and other data. The most significant is asset centric and allows users to organize and structure PI data, as well as other, non-real time data according to objects with which the users are familiar. These can be physical objects in their production processes like pumps, transformers, grinding mills, or network hardware. These asset elements are flexible and allows hierarchical modes. AF asset elements can span Data Archives, allowing users to organize and search for PI information across multiple PI systems.

The element is a user-oriented object that contains attributes, which reference

- Time-series data from Data Archive,
- configuration data,
- data from dissimilar systems.

Other features of AF that allow users to leverage PI data include

- object-level security,
- searches,
- access to data from systems other than PI,
- the ability to scale to 100 million element attributes or more.

AF also provides an underlying infrastructure for OSIsoft products such as:

- PI Notifications,
- PI Vision,
- PI OLEDB Enterprise,
- PI Asset Analytics,
- PI Web API.

You do not have to configure your entire AF installation at once. Start with a manageable area, such as same type of equipment, or part of a process, and expand the “model” over time.

When planning an AF installation, consider the following questions:

- How will you map your company’s assets to AF elements?
- What attributes are required for each element?
- Are these attributes PI data, constants, or calculations?
- Will you use templates to speed up definition of these elements?
- How will the asset hierarchy be structured?
- Do you need data from other databases as well as real-time (PI) data?
- What security is required?
The PI System Explorer (PSE) is a tool used to see AF data. It connects to one AF database at a time. In general, OSIsoft recommends the use of one AF database for your entire asset framework. However, depending on your application, you may need multiple databases:

- Within a single company, different departments may prefer their own unique databases to handle their needs.
- A company with a database that handles current operations may have a second database for testing purposes. Modifications implemented in the future are made and tested on a testing database before transferring the structure to the production database.

AF requires a Microsoft SQL Server instance available at the time of installation. AF supports SQL Server Express editions, which can be installed on a shared computer, together with AF and/or PI Server software, or on a remote computer. SQL Express comes with a free license. Scalability limitations make it more suitable for small to medium-size installations.

With PI Connectors, the structure on the data source is replicated to the AF automatically.

Consult the AF Installation and Upgrade Guide for details.

Since PI Server 2018 unified installer, AF server is **NO longer** a required prerequisite for Data Archive server installation.
2.7 Data Sources

Data sources can be any measuring device generating data. They can be almost anything and can connect to the interface data collection computers in a variety of ways. Examples of data sources are:

- Distributed Control Systems (DCS’s),
- Programmable Logic Controllers (PLC’s),
- laboratory information systems (LIM’s),
- Supervisory Control and Data Acquisition systems (SCADA),
- manual loggers,
- EPA data loggers,
- network devices,
- Business Information (BI) systems,
- Business planning databases.

To acquire data from these sources it is necessary to utilize a PI Interface or PI Connector. The interface or connector may be simple such as a file reader or complex, such as the interface or connector that uses the OPC protocol. For more information on OPC, see www.opcfoundation.org.

2.8 Data Collection Computers

Data Collection computers (also known as nodes) run one or more PI Interfaces and/or PI Connectors. PI Interfaces collect data from the targeted data source and send the collected data to the Data Archive. Each different data source needs a PI Interface that can interpret the protocol used by the source. OSIsoft has over 450 different interfaces.

PI Connectors collects not only data from the targeted data source, but also checks the structure and automatically create PI Points, AF Elements and AF Attributes accordingly. Currently there are over 20 PI Connectors with more being developed.

To collect data from a source, the Data Archive (and AF Server for PI Connectors) security must be configured appropriately. The PI Interface itself must be configured, as well as the attributes of the Data Archive point - also known as a tag, or more properly, the data stream. There is a correspondence between the metadata (attributes) of the point in the Data Archive database and the point’s attributes in the data source. Matching the two sets of point attributes is crucial to sustainable and timely data collection by the PI Interface.

PI Connectors, as mentioned above, create PI Points automatically, therefore the correspondence between the metadata is handled by the same way. There are only several PI Points attributes, which can be modified after the creation by PI Connector.

Necessary steps in collecting data are:

- ensure the network between the data source and the Data Archive and AF server is configured,
• ensure the data source is working,
• install and configure the appropriate PI Interface or PI Connector,
• create and configure points as required on the Data Archive for PI Interface,
• check that the points are receiving data.

These steps will be covered in detail later.
2.9 Directed Activity – Where is Your Data?

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section. Your instructor will have directions.

Activity Objectives
To understand the places data can be gathered and where they can be stored in the PI System environment.

Approach
Previously you listed types of data – real-time and otherwise. Decide what type of data you may get from various data sources and where this data will be stored and why. How big a part will AF play in your environment?
The instructor will facilitate the discussion.
3. PI System Planning

Objectives:

- Discuss Highly Available Systems
- What you need to get through firewalls
- Understand your calculation options

To ensure the integrity of your PI environment steps must be taken to implement backups, redundancy and high availability of the all components.

3.1 Data Archive server High Availability

Data Archive High Availability (HA) enhances the reliability of the Data Archive by providing alternate sources of the same time-series data for users. Data Archive Replication enables alternate data sources by synchronizing the configuration of multiple servers. This allows interfaces to buffer data to multiple servers with the same point configuration. PI Clients can retrieve data from any of the servers without changing data references. You will be implementing a highly available architecture on day 3.

Consult the Data Archive Installation and Upgrade Guide for details.

3.2 PI Interface & PI Connector Failover

PI Interfaces are based on a standard interface template (UniInt) that can potentially support interface failover. Depending on the data source, an interface can automatically switch between redundant copies of the interface run on separate interface computers. This provides uninterrupted collection of process data even when one of the interfaces is unable to collect data for any reason. When maintenance, hardware failure, or network failure causes one interface to become unavailable, the redundant interface automatically starts collecting and buffering data to send to the PI Server.

UniInt interfaces can also restart without a connection to the PI Server. As the interface runs, it receives updates to the list of points and their parameters and writes the information—including the point scan list—to a local disk file. Subsequent starts of the interface can use the local copy of the point information to start up without a connection to the PI Server. This is called “Disconnected startup” and is recommended for production interfaces.

PI Connectors that support failover work internally on a different principle, but the goal is the same. To provide the uninterrupted data collection in case when the connection to data source from one instance is broken or the instance stops working. PI Connectors do not read the
points from Data Archive and do not store the point parameters in a local disk file, thus do not need connection to Data Archive or AF Server to be able to start. Therefore, we can say they always run in “Disconnected Startup”

Each PI Interface or PI Connector manual has comprehensive details of how to implement failover.

3.3 Planning for Security

Objectives
- Introduce PI security
- Understand how network and environment affect PI Security.
- Discuss Mappings
- Discuss the applicability of Trusts if necessary

3.3.1 What is Security?

Computer security has two parts:

**Authentication**
Who is the user, and how do we confirm that the user is really whom she says?

**Authorization**
What is the user allowed to do?

Security is always a balance.

You want to use what is most secure, easy to configure, and provide for minimal Maintenance. That is why we suggest using Windows Active Directory security. It is something that you probably have now in your domains and can easily accommodate the PI System. We call this Windows Integrated Security.

To connect to the AF SQL database OSIsoft recommends that you use Windows authentication because it is more secure than SQL Server authentication. Objects and their effective permissions are based on the Windows user identity. The permission sets for all users are stored as Windows security descriptors associated with certain types of objects and collections within AF.
3.4 Securing the Environment and the Server

PI is consistent with, and best supported by, implementation in a corporate network secured computing environment. This usually includes:

- Domain security for users, directories, and applications
- Router security including router-based firewalls
- Antivirus programs and regular operating system patches
- Controlled access by remote parties

Fixed IP addresses are usually applied to interface computers and server computers, while DHCP IP addresses is the norm for user clients. PI is usually implemented in domains and all data communications to PI are through TCP/IP response packets. However, PI data can be accessed without joining the domain since file access in the Data Archive server from any remote computer is unnecessary. PI’s lookup server name can be entered into the Domain Name Server associated with its fixed IP address. PI can stand alone, sharing no files and inaccessible by anyone except the local computer administrator and users. This access can be provided by remote terminal client services.

- Install the server in a secured area with a locked door.
- Have uninterruptible power supply and air conditioning.
- Have unique passwords for both the local administrator and the piadmin PI user.
- Have a screen saver, which locks out idle sessions and requires password re-entry.
- Do not use the PI Server computer to access the Internet via a browser. Instead, download the required files on another computer and transfer them by flash drive or other media.
- Do not install client software (Microsoft Office, PI ProcessBook, etc.) on your server. This will encourage the server's use as a client and is not recommended.
3.5 How Things Connect to the PI System

In order to plan where things will “live” in your Enterprise it is important to understand how connections are made to the various parts of the PI System.

- PI Interfaces can connect using a **PI TRUST** or **WINDOWS INTEGRATED SECURITY** (since PI API for WIS) for authentication.
- PI Connectors must connect to Data Archive and AF via **WINDOWS INTEGRATED SECURITY**
- Users must connect to the Data Archive Server using **WINDOWS INTEGRATED SECURITY**. (Legacy Explicit Login and PI Trust are not recommended)
- Users must connect to AF and our thin clients using **WINDOWS INTEGRATED SECURITY**.

What implications does this have in your domain?
3.6 Asset Analytics & Calculations

Analytics & Calculations are defined in AF server over defined assets and asset structure and PI Analysis Service is the calculation engine.

An AF Analysis consists of an expression that performs a calculation, and the scheduling for its execution. It takes existing values as inputs to produce new outputs, new calculated values or event frames. You can specify attributes from anywhere in your AF hierarchy as inputs to an analysis.

Every analysis is associated with an element or, preferably, with an element template. You can save analysis outputs by mapping them to attributes on that element or element template.

Three types of analysis are available:

- Expression
- Rollup
- Event frame generation
- SQC

As indicated previously AF can be used for asset-based calculations. In the AF Help file is a list of Data Reference Functions that can be utilised. The calculations can be one formula or a sequence of calculations and can have many input attributes. Calculations may be derived that use PI point data, and both internal and external table data, as well as static attribute data.

For more information see the PI System Explorer section of %PIHOME%/help/AF.chm, or type ‘calculation’ in the Search tab.
4. Data Flow

- Describe the data flow through the PI System
- Describe reporting by exception
- Describe the compression test
- Describe the data structures in the Data Archive

4.1 Data Flow: From the Source to the PI Server

In order to determine that everything was installed and set up correctly (and checking for proper function in the future), it is key that you understand the various data structures or “touch points” that the data encounters along the way.

The Data Archive stores data in the form of events. *Each event has a value and a timestamp* that indicates what time the value was collected. The PI Interfaces collect data from the data sources and typically use exception reporting, meaning that they pass significant events on to the Data Archive and discard the rest. If the buffering service is configured on the data collection node, then the events go through the buffering service. If the interface node cannot connect to the Data Archive, the buffering service holds the data until the Data Archive connection is restored.
The PI Connectors collect data and timestamps from the data sources, but they do not timestamp the data and do not perform the exception reporting. All PI Connectors have their own internal buffering which is separate from buffer for PI Interfaces. PI Connector’s buffer is capable of buffering information for point and asset creation.

4.2 Data Flow on the Data Collection Computers

As described earlier, the PI Interface has three basic functions:

1. Collect data
2. Timestamp the data (or validate that a timestamp is provided by the device)
3. Apply the Exception Deviation

Applying the exception parameters is referred to as “Reporting by Exception.”

PI Connector has these four basic functions

1. Crawl the data source for information about data and their structure
2. Create the appropriate points in Data Archive and asset structure in AF
3. Collect data
4. Check for updates on the data source to update it on PI Server side

4.3 Reporting by Exception

The object of exception reporting is simply to reduce noise. In other words, for the PI Interface to send you the data you are interested in, rather than taxing the network connection by sending data that is not meaningful. It is up to the user to decide the terms for ‘meaningful’.

Exception reporting uses a simple dead band algorithm to determine whether to send events to the Data Archive. For each point, you can set exception reporting specifications that create the dead band. The PI Interface ignores values that fall inside the dead band.

The dead band is expressed as a deviation and is applied equally in positive and negative manner. There is also a maximum time applied.

As mentioned earlier, PI Connectors do not perform exception reporting.
In the above illustration, values A, E, and F are reported to the Data Archive. Value A is the last reported value, values B, C, D and E fall within the exception dead band, but value F falls outside the dead band, so the interface reports value F and its previous value, in this case, E.

These exception parameters are set on a per point basis.

**Note 1:** Some PI interfaces do not support exception reporting. You know enough by now to check the documentation.

**Note 2:** ExcMin is typically set to 0. It is rarely used.
4.4 Group Questions – Data Flow

The following questions are intended to reinforce key information, or discover a new insight. Your instructor may choose to have you try answer the questions on your own or have the group answer them togeth aloud.

Questions

1. Why would we apply an Exception Maximum (ExcMax)?

2. How would you “turn OFF” reporting by exception?

3. Give at least one valid reason why you would turn OFF exception processing for a point.

4.5 Snapshot

The Snapshot Table is simply the “current” or most recent value for each point in the Data Archive.

The Snapshot subsystem populates this table and performs the Compression Algorithm Calculation. (As it will be explained later, in PI Buffer Subsystem for PI Interfaces, compression is performed back on the data collection machine).

When a new value is received, it is compared to the previous value.

- If that value indicates that the previous value passes compression, then the previous value is **sent on** and the new value is retained as the new “current” value.
- If that value indicates that the previous value fails compression, then the previous value is **discarded**, and the new value is retained as the new “current” value.
4.6 Directed Exercise – PI Snapshot Values

You are invited to watch what the instructor is doing or perform the same steps at the same time to explore the different concepts presented in this chapter or section.

Activity Objectives
- Determine which events from PI Interface will make it to the Snapshot in Data Archive.

Approach
Consider the following attribute values for a PI point:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExcDevPercent</td>
<td>2%</td>
</tr>
<tr>
<td>ExcMax</td>
<td>180 seconds</td>
</tr>
<tr>
<td>Span</td>
<td>200 units</td>
</tr>
<tr>
<td>Zero</td>
<td>0 units</td>
</tr>
</tbody>
</table>

The current snapshot received in the Data Archive for this point is:

Value: 70.3  Timestamp: 10:00:00

Which of the following values collected by the PI Interface (shown on the next page) pass the exception test?

<table>
<thead>
<tr>
<th>Time</th>
<th>Value</th>
<th>Snapshot Time</th>
<th>Current Snapshot</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00:00</td>
<td>70.3</td>
<td>10:00:00</td>
<td>70.3</td>
</tr>
<tr>
<td>10:01:00</td>
<td>67.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:02:00</td>
<td>71.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:03:00</td>
<td>70.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:04:00</td>
<td>68.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:05:00</td>
<td>66.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:06:00</td>
<td>65.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:07:00</td>
<td>64.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:08:00</td>
<td>60.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:09:00</td>
<td>63.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.7 Compression

The point of compression testing is to store just enough data to reproduce the original data from the data source, within the limits of accuracy required. It is up to the user to decide the limits of accuracy.

The compression process applies a deviation in a similar manner to exception except that it takes into account the slope of the data.

In the following illustration, all the events fall around the same straight line. In a simple case like this, there is no need to store all the points on the line. If you store just two points, you can recreate the point value for any other time, with the accuracy of ±compdev.

The same principle applies to compressing real-world data. The Data Archive uses a sophisticated compression algorithm to determine which events it needs to keep in order to provide an accurate data history. The CompDev and CompMax attributes allow you to control the granularity of the compression algorithm.

Like the exception parameters, these compression parameters are also set on a per point basis.
4.8 Compression Test, Cumulative Impact and Defaults

There is a cumulative impact of the exception and compression process. This is illustrated in the slide shown below:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>After Compression</td>
<td>Cumulative Results</td>
<td>Time</td>
</tr>
<tr>
<td>Temperature</td>
<td>After Compression</td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The animation in slide is not 100% correct how Compression works and it should only present the algorithm in a simple demonstration. For more detailed info please see KB00699 – Compression Explained

Tip

If you create a point in the Data Archive and do not specify values for exception and compression specifications, the default values will be used. This should be avoided because the exception and compression values for each point should correctly reflect the desired point values. PI Connectors create points with the default values, which can be changed later on, but exception attributes are ignored.

The default values for exception and compression are as follow:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExcDevPercent</td>
<td>0.1 (% of span)</td>
</tr>
<tr>
<td>ExcMax</td>
<td>600 (10 minutes)</td>
</tr>
<tr>
<td>CompDevPercent</td>
<td>0.2 (% of span)</td>
</tr>
<tr>
<td>CompMax</td>
<td>28800 (8 hours)</td>
</tr>
<tr>
<td>Zero</td>
<td>0</td>
</tr>
<tr>
<td>Span</td>
<td>100</td>
</tr>
</tbody>
</table>

If you turn exception and compression off, you may adversely affect the performance of the system by archiving many more values than necessary. For example, a valve scanned every few seconds. With no exception or compression, the value of OPEN would be recorded thousands of times unnecessarily. While disk space is cheap, the more limiting factor is the speed of retrieval. Disk latency and network bandwidth limitations may impede performance when retrieving data.

As a starting point recommendation for these settings, we recommend setting the compression deviation (CompDev) to the minimum change measurable by the instrument. The exception deviation (ExcDev) should be set to half of the compression deviation. It is important to note that these are only starting point recommendations and you should inspect your data for the desired resolution. In some cases, it may be advisable to turn off exception and compression entirely. To achieve this, set the exception deviation (ExcDev) and the exception maximum (ExcMax) to 0. Turn off compression directly (Compressing set to Off), although it is recommended to leave compression On, and Compdev at 0. If set properly, the Data Archive will archive values that reflect an accurate change in the device, without wasting space on duplicating values or losing meaningful values.
4.9 PI Archives

The data tables that the PI System stores data in files that are called "Archives." Archives have the following characteristics:

- Starting from Data Archive 2015, Archives are either Historical or Future
- Historical Archives are fixed sized files
- Future Archives are dynamical sized files
- Archives must be registered
- The Data Archive only writes current values to one file at a time
- Historical Archives are sequential in time
- An archive has all of the data for every point in the system for the period bounded by its start and end times.
- Each archive has an associated Annotation file

Historical Archive files vs. Future Archive Files

With the addition of Future Data, the Data Archive has two types of archive files: Historical archives and Future archives. The historical archive files are only used to store historical data while the future archive files can store both future and historical data.

Data in future archives is never mixed or interchanged with data in historical archives. When time passes, and future data moves into the past, it is still stored in the same future archives.

Fixed Files vs. Dynamical Files

When you create historical archives, they are created of a fixed size and the memory is allocated upon creation to minimize the potential of fragmentation on disk.

You have the option of creating dynamic archives. Dynamic archives are files that grow as they are filled. Dynamic archives should only be used for backfilling purposes.

Full fixed archive file will automatically become dynamic when you backfill data.

When you create future archives, they are created with an initial size of 1MB. If the data stored in that archives ever exceed 1MB the future archive grows dynamically to store the extra data.

Archives Must Be Registered

In order for the Data Archive to access the data in an archive, the archive must be registered (often referred to as "mounted" in other systems). The archives can be located on any drive available to the Data Archive, as long as they is adequate bandwidth.

Future Archives with non-sequential data

Future archives are optimized for non-sequential data unlike real-time data stored in the historical archives. This way future archive are only created when necessary.

Every future archive file have a pre-determined time range of 1 month but can be created manually for longer period.
5. Data Archive Server Requirements

Objectives:

- Define the hardware requirements of the Data Archive
- Define the hardware requirements of the AF Server
- Describe the virtualization support for the PI System

5.1 Hardware Sizing

On OSIsoft Tech Support webpage, “Online Hardware Sizing Tool” can be found. In addition, there is Excel spreadsheet downloadable.

https://techsupport.osisoft.com/troubleshooting/hardwaresizing/

This spreadsheet gives recommendations for the following hardware resources based on current or anticipated load and data volume.

- Storage Capacity
- Disk Throughput (IOPS)
- CPU Count
- Memory (RAM)
- Network Bandwidth

The amount of disk space required depends primarily on the number of PI points that the PI system will collect. See below to calculate the necessary disk space.

<table>
<thead>
<tr>
<th>Data Archive Component</th>
<th>Space Requirement</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Archive and PI Software Development Kit (PI SDK)</td>
<td>160 MB 100 MB temporary disk space for installation</td>
<td>PI SDK includes the PI API.</td>
</tr>
<tr>
<td>Data Archive databases</td>
<td>11 MB per 1000 points + 1 MB</td>
<td>Located on the same computer as the PI Server.</td>
</tr>
<tr>
<td>Message log files</td>
<td>10 MB</td>
<td>Located on the same computer as PI Server, in the pi\log directory.</td>
</tr>
<tr>
<td>PI Archive files</td>
<td>10 MB per 1000 points</td>
<td></td>
</tr>
<tr>
<td>PI event queue</td>
<td>5 MB per 1000 points</td>
<td>OSIsoft recommends that you place the event queue on a different physical drive from the PI archive files.</td>
</tr>
<tr>
<td>Rollback backup (upgrade only)</td>
<td>Size of Data Archive databases + primary archive</td>
<td>The PI Archive setup program performs a minimal backup during the upgrade.</td>
</tr>
</tbody>
</table>
For Data Archive, AF server, and Microsoft SQL Server, one or more Microsoft Windows compatible computers, with a 64-bit operating system is required.

For best performance and improved security, OSIsoft recommends that you install SQL Server on a different computer from PI Server. If you plan to install SQL Server on the same node as the Data Archive, the SQL Express Edition should be installed so that the SQL Server does not compete with system resources with the PI Server. The SQL Express Edition is limited to using only a single physical CPU and 1 GB of RAM.

It is recommended that the AF server and Data Archive server be installed on different computers if:

- AF server will use time-series data from multiple PI Servers
- AF server is configured for high availability (such as a load balanced AF server, AF servers connected to a mirrored SQL Server, or AF servers connected to clustered SQL Servers).

The number of required computers depends on the size and complexity of the PI System. The size of a PI System depends on the number of PI points and the number of units (elements) of equipment (such as mixers, tanks, or meters or whatever else you have added into the asset database).

A simple, small system will have the Data Archive, the AF Server and SQL Server (the free SQL Server Express may be used) installed on the same hardware (or virtualised) server, as shown below.

For distributed systems with large workloads and point counts, and with multiple PI Servers or Data Archive Server collectives that link to a central AF database, OSIsoft recommends that you install Data Archive Server collectives with two or more AF Servers with a Network Load Balancer over them, and Microsoft SQL Server on separate, redundant computers to achieve the best level of performance and scalability. This type of system is depicted below.
5.2 Virtualization

OSIsoft supports the virtualization of the PI System on the virtualization platforms of Microsoft Hyper-V and VMWare ESX Server. A PI System sized using “Online hardware sizing tool” will operate on a virtualized platform when using the recommended configurations.

In addition to the recommended architectures, there are five core principles of note when implementing the PI System on a virtualized platform.

*Principle 1 – A Virtual Machine is just another brand of machine.*

*Principle 2 – Enterprise solutions must use enterprise class virtualization and hardware.*

*Principle 3 – Do not mix virtual and physical implementations on the same host.*

*Principle 4 – Ensure qualified support of the virtual environment.*

*Principle 5 – Thorough testing of the PI System on both physical and virtual platforms, using a custom configuration should be undertaken.*

For more information, see “Virtualization and the PI System.”
5.3 Group Exercise – Define the Architecture

A group activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives
Describe the Windows hardware & software environment necessary for the installation of PI.

Problem Description
You need to provision a new PI System installation. Your PI System will have the following characteristics:

- You plan on building 25,000 points in your PI System
- Your design includes an extensive use of the AF Server and calculating a large amount of analyses
- Your design includes usage of PI Vision
- The company has a dedicated SQL server to host all application databases
- For the purpose of the exercise you plan to have 1 client machine designated for smart clients

Approach

- Working as a group, define the architecture (hardware and software) required for a simple PI System. Decide how many separate nodes will be necessary and which PI components they will have.
- Using the Hardware Sizing spreadsheet, define the necessary hardware configuration for each node.
- List the software that must be installed on each one.
- Assume the data collector will have an OPC server installed.
- What are the pros and cons of a single virtualization host for a PI System?

(Use this space and the space on the next page for your answers)
(Page Blank for Exercise)
6. Adding Power to the PI Environment

Objectives

- Reiterate the components of a small PI system
- Provide further information on the more complex PI systems

6.1 A Simple PI System

As we have seen, the simplest recommended PI System consists of just two computers:

- a single computer for the AF and Data Archive,
- a single computer running the PI Interface / PI Connector that collects the real time data.

Above, the PI Interface / PI Connector is running as a service on the same computer as the source of the data. As the data is collected, it is transferred in a timely manner to the PI Server. The users then request data from the AF and/or Data Archive Server as required. Tools such as PI ProcessBook or PI Vision will sign up for updates so that any new data arriving at the Data Archive Server is displayed on the client as it is received. There is no need for manual refreshing of the displays.

6.2 Expand PI System Components as Needed

As the needs of the PI environment grow, multiple components are added to expand the capabilities of the systems. If the AF server becomes a bottleneck for the system because of its extensive size, the AF server may be moved to a separate server. When sophisticated calculations are applied, the PI Analysis Service can also be moved to a separate server not to compete with resources on AF Server. This may result in a PI system configuration as shown below. The arrows indicate the direction of data flow.
6.3 When You Need to Bet Your Business on PI

There may come a time when the PI environment is vital to the running of the company. At such a time, it may be necessary to evaluate a Highly Available (HA) PI system. The PI System includes features that facilitate making data highly available. These include the ability to conduct online backups, the distributed nature of data collection within the PI System, and the availability of fault-tolerant third-party solutions that provide redundant hardware solutions. The PI environment has been designed to provide fault tolerance via server replication and PI Interface / PI Connector failover.

6.3.1 Data Archive Server Replication

The PI High Availability (HA) design provides for multiple Data Archives, each acting as an independent storage for the time series data. These Data Archives function as a unit called a collective. A PI Collective has two types of servers:

- Primary - the main server in a collective where configuration changes are made
- Secondary - the remaining servers in a collective

These servers automatically adopt configuration changes made on the primary but receive data from the data source individually via a technique called N-way buffering, explained later.

6.3.2 AF High Availability Options

There are several high availability (HA) options for AF, both for the Microsoft SQL Server that hosts the AF database (PIFD) and for the AF application server itself.
MS SQL Server options:
- **AlwaysOn Availability Group** (preferred option)
- Clustered
- Mirrored
- Transactional Replication (with AF Collective)

AF application server options:
- Clustered
- **Load Balancing** (preferred option)
- AF Collective

The preferred and recommended option currently is to use the Network Load Balancer over set of AF servers. Those AF servers have redundant SQL back-end that is using of the options (preferred AlwaysOn Availability Group, Clustered SQL server or Mirrored SQL servers)
For the overview of Always On Availability Groups for MS SQL Server, see the article https://msdn.microsoft.com/en-us/library/ff877884
Note: AF Collective Warning!

AF Collective is not a recommended solution now as applications that require writes to the AF Configuration database (Asset Analytics and Notifications), or applications that write Event Frames will NOT work when the AF Collective primary server is unavailable, as secondary AF Collective members are Read-Only.

For additional details especially for Pros and Cons of every solution, see KB 00634.

Consult the AF Installation & Upgrade Guide for details.
6.3.3 PI Interface & PI Connector Buffering and Failover

The interface buffering service writes time-series data directly to all members of the collective, buffering data temporarily for those unable to receive data for a period. This mechanism assures that time-series data stored in each current archive is an exact duplicate of the other current archives in the collective.

The connector buffering is internal and installed with it. No configuration is necessary. Many PI Interfaces and PI Connectors incorporate failover mechanisms that allow for redundant data collectors. If one copy of the PI Interface or PI Connector shuts down then another will take over the data collection. Tomorrow you will be exploring interface buffering, and on day 3 you will explore implementing PI Interface and PI Connector failover.

6.3.4 PI Visualization Suite

PI Visualization Suite (for example, PI Vision, PI ProcessBook, PI DataLink) can automatically switch from the primary Data Archive Server to any of the replicated servers in the event connection to the primary is unavailable; guaranteeing that all clients always have read-access to PI data.

6.3.5 Connecting multiple PI Servers

It is possible to combine data from widely distributed PI sites to a corporate PI System. This allows corporate access to designated data on the distributed site PI collectives without interfering with the site servers.

Many companies do not have only one PI Server, especially global companies. One potential architecture creates a PI Server for each site and a central PI Server that collects aggregated data from each site. Either each site can have its own AF server or use centralized AF that serves multiple Data Archives.
The **PItoPI Interface** allows the aggregation of this data by copying data from one Data Archive and making it available on another server. When a corporate Data Archive is connected via the PItoPI Interface to remote site Data Archives, then required site data (such as KPIs) can be presented (with history) at the corporate level. Dissemination of selected data from the remote sites via the corporate PI System to corporate users becomes possible.

The **PI System Connector** has similar functionality, but more advanced.

- It reads the AF structure from a source AF server and sends the objects to a destination AF server.
- All PI points referenced within the AF object structure and their data are also collected from the source Data Archive and sent to the destination Data Archive.
- The PI Connector continually monitors changes on the source AF database objects and reflects those changes to the destination AF database.
- The PI Point data is initially backfilled to the destination and then monitored for current data changes.

### 6.3.6 PI Cloud Connect

PI Cloud Connect allows the quick, easy and secure exchange PI System data between companies. Instead of providing a spreadsheet or a VPN connection for every vendor or business partner that you work with, a connection via PI Cloud Connect is available to publish PI System data. To select the data you want to share, and just who you want to share it with. Your suppliers can then make a connection to PI Cloud Connect and subscribe to the data feed that you control.

Some vendors may already have a PI System today. If you want to exchange data with a vendor who does not currently have a PI System, OSIsoft has a way to deliver on-prem (on-premises) software based on subscription licensing and pricing.

**PI Cloud Connect for Asset Owner**

![Diagram showing PI Cloud Connect for Asset Owner](image)
6.3.7 PI System Access

The PI System Access family of products is designed to support the implementation of custom applications on top of the PI System. PI System Access supports the integration of PI System data with other applications and business systems such as Microsoft Office or SQL Server, Enterprise Resource Planning systems (ERPs), reporting and analytics platforms, web portals, geospatial and maintenance systems, just to name a few.

The PI System Access suite covers a wide range of use cases in various environments, programming languages, operating systems and infrastructures.

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI SQL Framework</td>
<td>The products in this category expose the PI System as a relational database and are particularly useful where the PI System has a role to play in Reporting or Business Intelligence (BI) scenarios, where it must interact with other products or systems that communicate using the Structured Query Language (SQL) as well as in custom application development.</td>
</tr>
<tr>
<td>PI OLEDB Provider</td>
<td>The PI OLEDB data provider, together with the PI Server's underlying PI SQL subsystem, implements SQL language to allow relational queries to the PI System.</td>
</tr>
<tr>
<td>PI OLEDB Enterprise</td>
<td>PI OLEDB Enterprise is an OLE DB data provider you can use to access asset metadata stored in the Asset Framework (AF). It includes PI OLEDB Provider.</td>
</tr>
<tr>
<td>PI JDBC Driver</td>
<td>PI JDBC Driver is a Java Database Connectivity driver that provides robust data access to the PI System. PI JDBC Driver offers much of the same functionality as the PI OLEDB Provider.</td>
</tr>
<tr>
<td>PI ODBC Client</td>
<td>The PI ODBC Client: used to bring process data into any ODBC-compliant client application.</td>
</tr>
<tr>
<td>PI Web API</td>
<td>The PI Web API provides a resource oriented and HTTP(S) based interaction model to data contained within the PI System. The PI Web API provides a resource oriented and HTTP(S) based interaction model to data contained within the PI System. Although the technologies within the PI Web API are suitable for a broad range of needs, they are primarily targeted at supporting web and mobile application development scenarios.</td>
</tr>
<tr>
<td>PI .NET Framework</td>
<td>The PI .NET Framework provides a comprehensive, high performance, Windows based programmatic interface to the PI System. The primary technology within this family is the AF SDK.</td>
</tr>
<tr>
<td>Asset Framework SDK (AF SDK)</td>
<td>Provides programmatic access to PI Server data (Data Archive and AF). AF Code examples and programming references for the AFSDK are available (once installed). AF SDK is Available at the developers site at <a href="https://pisquare.osisoft.com/community/developers-club">https://pisquare.osisoft.com/community/developers-club</a></td>
</tr>
</tbody>
</table>
6.3.8 Exercise – Define your Ideal PI system

Designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives

Map a network path from data source to the CEO’s desk.

Problem Description

You will be implementing a PI System in your Enterprise and, for once, money is no object. You have to design a PI Environment.

Approach

Draw a network architecture diagram of your environment showing all major appliances and software that will let the CEO display data from all data sites on her desktop, in both thin and thick client modes.
(Page Blank for Exercise)
6.4 Group Questions – Review of PI Components so far

The following questions are intended to reinforce key information, or to discover a new insight. Your instructor may choose to have you try to answer the questions on your own or have the group answer them together aloud.

Questions

1. Which manual would you read before installing the PI Server?

2. What OS software platforms are supported?

3. Where would you find the user guide document for PI Clients like PI Vision, PI DataLink?

4. When would you install the MS SQL Server on a separate computer form Data Archive and AF Server?
7. Installing the PI Server

Objectives

- Review the pre-installation check list
- Describe the steps to obtain a License File
- Know the steps for installation of the PI Server
- Become familiar with the directory structure of Data Archive (PI folder)
- Start and stop the Data Archive server

7.1 Pre-installation Checks

It is critical that you perform the pre-installation checks. If you neglect this step in some cases you will get an error, and in others, the installation will stop.

- Log on as Administrator (or with administrative privileges). The installer must be either the administrator or member of the local Administrators group. In addition, the account must have write permission to MS SQL Server. Validate that the user has the correct permissions.

- **Always check the Data Archive Server operating system clock when installing any PI System.** Ensure the clock on each machine has the correct time and it is in the correct time zone. In your work environment, all clocks should be synchronised from a network time source. Changing the clock after installation will cause problems.

- Update Windows. A properly updated Windows Operating System will have the required prerequisites. If you require any prerequisite components, you will need to install them before the installation proceeds.

- Install Microsoft SQL Server. The version you use is your choice. You now should know the pros and cons of each of the available offerings.

- Obtain your PI Server License File. Download the file from the tech support site; an explanation is forthcoming.

7.2 Supported Operating Systems

Starting with Data Archive 2016, only 64-bit version is available and requires a 64-bit Operating System. For production systems, this version or higher of Data Archive can be deployed on the following Microsoft Windows Server operating systems, in decreasing order of recommendation:

- Windows Server 2016 – all editions; in both Full and Core installations
- Windows Server 2012 R2 – all editions; in both Full and Core installations
- Windows Server 2012 – all editions; in both Full and Core installations
- Windows Server 2018 R2 SP1 – Full installation
7.3 License File Activation

A license activation file must be generated before the Data Archive server is installed. The OSIsoft Technical Support Web site provides an online tool called My License Activations (MLA) that allows you to generate your site-specific PI Server license activation file. This license file controls which applications can run on the Data Archive Server and displays running parameters, such as the point count limit.

When the license activation file is generated, view the PI Server Manifest to verify the server details and then download the Machine Signature File (MSF) Generator Utility to create a signature file that identifies some characteristics of the computer for licensing purposes.

The PI Server install kit is capable to generate the Machine Signature File (MSF) by itself, you must copy it to a local disk on the Data Archive Server computer and then run the kit.

The kit will generate the MSF file to Documents folder of user running it.

i.e. C:\Users\<username>\Documents

If the Data Archive Server is on a virtual machine (VM), run the utility on the VM. If you generate the MSF on the wrong computer (on your laptop, for example) then the license activation file will match the laptop computer. If you install Data Archive Server on a different computer or VM, the server will not run as expected. The license file must be present during the installation.
It can be on a flash drive, CD, or any media that can be read by Data Archive Server during installation. The setup program copies the license file to the %PISERVER%\dat directory during installation; the original file will no longer be used.

License Generation

A machine signature file (MSF) is needed to generate a machine-specific license file from the OSIsoft Tech Support website. Setup has proactively created an MSF file in your Documents folder. Click here to show the MSF file in folder.

The MSF file created by this setup kit is guaranteed to generate a license file that is compatible with PI Server Installer. For this reason use the MSF file created by this setup kit instead of an MSF file created by other tools.

Consult the PI Server License Activation Files section of the Data Archive Installation and Upgrade Guide for full details.

7.4 Gathering Installation information.

The following information is requested during the installation:

- Location of the PI server license file – ask your instructor.

Normally, the following installation locations apply:

- AF files (.exe, .dll, SQL scripts) are installed in %PIHOME64%\AF and %PIHOME%\AF – “\Program Files\PIPC\AF” and “\Program Files (x86)\PIPC\AF”
- Data Archive binary files (.exe) are installed in %PISERVER%\bin - “\Program Files\PI\bin”
- Archives are installed on the largest drive
  - e.g. if the C drive is the largest C:\Program Files\PI\arc
  - D:\Program Files\PI\arc if D: is the largest drive
- The Event Queue file is installed on the 2nd largest drive
  - If C: is 2nd largest then C:\Program Files\PI\queue
  - If E: is 2nd largest then E:\PI\queue

The defaults are:

- PI SDK path - \Program Files\PIPC
- Data Archive path - \Program Files\PI
- Archives path - \PI\arc
- Future Archives path - \PI\arc\future
- Event Queues - \PI\queue
- For the default archive, size see below.
7.4.1 Archive Sizing

Archives are sized with at least 2KB for each point in the system. If your Data Archive will have 5,000 points or less then you can safely use the default value (currently 256MB). The default archive size is 3 KB x the total number of points rounded to the nearest power of 2 with a minimum of 512MB and maximum of 10GB, as per the following:

<table>
<thead>
<tr>
<th>Licensed Point Count</th>
<th>Archive Size (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 87,381</td>
<td>256 (2^8)</td>
</tr>
<tr>
<td>87,382 to 174,762</td>
<td>512 (2^9)</td>
</tr>
<tr>
<td>174,763 to 349,525</td>
<td>1,024 (2^10)</td>
</tr>
<tr>
<td>349,526 to 699,050</td>
<td>2,048 (2^11)</td>
</tr>
<tr>
<td>699,051 to 1,398,101</td>
<td>4,096 (2^12)</td>
</tr>
<tr>
<td>1,398,102 to 2,796,202</td>
<td>8,192 (2^13)</td>
</tr>
<tr>
<td>2,796,203 or greater</td>
<td>10,240 (capped)</td>
</tr>
</tbody>
</table>

Select a size so that at least 2 archive files can fit in the Windows File System Cache (FSC). This is because mostly the Data Archive Server will write/read from the 2-3 most recent archive files. The FSC can use all of the RAM on 64-bit systems. The following guidelines for memory apply:

<table>
<thead>
<tr>
<th>Physical Memory (MB)</th>
<th>Archive Size (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1,535</td>
<td>256 (2^8)</td>
</tr>
<tr>
<td>1,536 to 3,071</td>
<td>512 (2^9)</td>
</tr>
<tr>
<td>3,072 to 6,143</td>
<td>1,024 (2^10)</td>
</tr>
<tr>
<td>6,144 to 12,287</td>
<td>2,048 (2^11)</td>
</tr>
<tr>
<td>12,288 to 24,575</td>
<td>4,096 (2^12)</td>
</tr>
<tr>
<td>24,576 to 30,719</td>
<td>8,192 (2^13)</td>
</tr>
<tr>
<td>30,720 or greater</td>
<td>10,240 (capped)</td>
</tr>
</tbody>
</table>
7.5 Directed Activity – PI Server Installation Pre-requisites

In this part of the class, you will perform a learning activity to reinforce the concepts presented in this section.

Activity Objectives

- Understand the necessary information to install PI Server. In other words, Read the Manual!

Approach

Answer the following questions as a group:

1. Describe the supported SQL Server versions.

2. At what stage will the PI Server installation install the SQL server?

3. Can the AF SQL database be created manually?

4. Do end users connect to the SQL Server?

5. How to verify if MS SQL Server is installed?
7.6 Directed Exercise – Install the PI Server

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Exercise Objectives

- Install the PI Server and related services and features

Description

You are ready to begin the PI System installation.

You should have validated the prerequisites and Microsoft SQL Server, have the install kit and license file, and performed all the computer checks (clock, etc.) You did, didn’t you?

Approach

1. In the installation folder, you will find the PI Server installation kit.

2. Right-click and “Run as Administrator”. After the Welcome screen, where you can deselect the participation in PI System Customer Experience Improvement Program there is a feature selection screen where we check the components we would like to install. Select all beside PI Notifications Service and PI System Directory.
3. Select the installation directories for 64-bit and 32-bit PIPC folders and PI Data Archive Directory. In our case it is:

- D:\Program Files\PIPC
- D:\Program Files (x86)\PIPC
- D:\Program Files\PI

**Important Note:** Since unified installed kit PI Server 2018, the fresh installation of Data Archive by default no longer installs these subsystems and interfaces:

- PI AF Link Subsystem
- PI Alarm Subsystem
- PI Performance Equation Scheduler
- PI Batch Subsystem
- PI Performance Monitor Interface
- PI Ping Interface
- PI SNMP Interface
- PI TCP Response Interface

If you wish to install those components, you switch to Individual Features section and tick the box. For upgrade from previous versions of Data Archive those components remain.
4. Select the SQL server provided. In our case **PISRV1\SQLEXPRESS**. Keep the checks that AF SQL Database scripts will be installed and executed. Ensure the MS SQL Server is started before installation.

![SQL Server Connection](image)

5. For Data Archive section select the License Directory and Data Directories

- License Directory to **D:\Install Kits**
- Historical Archives to **E:\PIArchives**
- Future Archive to **E:\PIArchives\future**
- Event Queues to **E:\PIEventQ**

In Archive settings you can modify the size for historical archives to lesser size than precalculated size (viz. chapter Archive Sizing)
6. At the PI Web API page, keep the default settings for Configuration Instance Name and Data Directory. For SSL certificate select the only available certificate **PI Web API**

7. Select the services accounts:
   - AF Application Service: **PISCHOOL\PIAF_SVC**
   - PI Analysis Service: **PISCHOOL\PIAnalysis_SVC**
   - PI Web API and PI Web API Crawler: **PISCHOOL\PIWebAPI_SVC**

8. Finish the installation.

9. After the installation is finished, run the PI Web API admin utility.

10. Connect to the PISRV1 AF Server and proceed
11. Keep the default 443 port

12. The password for PISCHOOL\PIWebAPI_SVC is prefilled from previous insertion.

13. Keep the default submitted URL

14. Accept the changes and wait for confirmation of executed jobs

**Confirmation**

<table>
<thead>
<tr>
<th>Job</th>
<th>Result</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prepare Setup Job</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application Data Folder Setup Job</td>
<td>Done</td>
<td></td>
</tr>
<tr>
<td>PI Web API Windows Service SID Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certificate Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URL ACL Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listen Port Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firewall Exception Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration Store Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI Indexed Search Crawler Windows Setup Job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Setup Job</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The installation is now FINISHED. 
Manually stop the Data Archive by running the script %PISERVER%\adm\pisrvstop.bat.

How do you start the Data Archive system? __________________________________________________________

And some of the PI Live Tiles on the All Apps screen are…

While you’re there, find out what they do…

---

AboutPI-SDK

PI System Explorer

PI System Management

PI Collective Manager
7.7 Directed Activity – Validate the Installation

Now you are going to see if it works.

Activity Objectives

- Become familiar with the PI SMT console
- Understand PI Time Format
- Find PI Points using the Tag (Point) Search
- View data

Approach

When the Data Archive is installed, it comes with a sample interface called the Random Interface. This interface does just that, produces configurable continuous streams of random data – either sine waves or pink noise. This interface is used for training and simulations. The sinewave in particular can be used in troubleshooting and to determine the health of the Data Archive.

In this activity connect to your newly installed Data Archive and determine if there is data for the sample tags driven by the Random Interface.

Run the PISDKUtility.

Click on Connections in the PI-SDK branch.

The dialogue box invoked displays all of the Data Archive systems configured, in our case, one. Click in the checkbox next to your Data Archive to connect and validate your connection by validating:

- Connected user
- PI Version
- Operating system

Note: The first time the PI SDK is installed anywhere, a default Data Archive is needed. This is why, even if you have never configured a Data Archive server, at least one server should appear in your PI Connection Manager.
Validate your connection by running `%PIHOME%\bin\apisnap` and provide the point name Sinusoid.

```
D:\Program Files\PI\bin\apisnap
APISNAP version 1.6.0.22
PI-API version 1.6.8.22
Attempting connection to default PI server
Attempting connection to PI8V1
Enter tagname: sinusoid

Tag = SINUSOID Point Number = 1 Type = Real-32
12 Hour Sine Wave

  Snapshot value
  Value = 10.942 22-Dec-16 10:17:16
  Status = Good

  Latest archive value
  Value = 9.8753 22-Dec-16 10:13:16
  Status = Good

Enter tagname: _
```

### 7.7.1 Validation using PI System Management Tools (PI SMT)

The PI System Management Tools (PI SMT) is the tool most commonly used by PI System Administrators. It allows a person with the correct credentials to perform any action.

**Tip**

Using the PI SMT on the same computer as the Data Archive server will most likely give you unlimited access. Use with caution.

Once connected there are a number of ways to determine the status of the Data Archive system.

- Use the **Data → Current Values** plugin to show the current values for any points.
• See historical values for points in **Data → Archive Editor**
- Search the message log files (under Operations → Message Logs)

![Message Log Image]

- View applications currently connected to the server in Operations → Network Manager Statistics

![Network Manager Statistics Image]
7.8 Overview of Management Tools for PI

PI System Management Tools (PI SMT) are tools used to administer the Data Archive servers from client connections. The PI System Manager Tools install kit is included with every Data Archive server and is available as a separate download. The PI System Management Tool kit includes the following programs. Running the main setup kit will automatically install and run all the individual setup kits.

- **PI System Management Tools (PI SMT), with many plug-ins.**
  - is a set of easy-to-use tools that allow you to perform all the basic PI Server administration tasks

- **PI Collective Manager**
  - This tool allows an administrator to create a new PI Server collective, look at the status of existing collectives and their member nodes, and edit the collective and member node properties

- **PI System Tray**
  - PI System Tray monitors the default PI Server (or PI Server collective) and the AF application service associated with the default AF server.

- **PowerShell Tools for the PI System**
  - PowerShell Tools for the PI System is a set of cmdlets for Windows PowerShell, which allows you to manage a PI System. This enables PI System administrators to create reusable scripts for commonly needed or bulk system management operations.

- **PI Builder**
  - is installed as part of AF Services, it is also included as part of the Data Archive installation kit

For further information on any of these tools access the HELP in each tool or visit http://livelibrary.osisoft.com
7.9 Time and the Data Archive

The Data Archive stores data in the form of events. Each event has a value and a timestamp that indicates the collection time of the value.

7.9.1 Daylight Savings Time

The Data Archive stores all values with a time that is converted to UNIX time i.e. PI stores timestamps as the number of seconds expired since January 1, 1970 GMT. This means that each day of the year has exactly 24 hours. Any adjustments for time, such as time zone or Daylight-Saving Time (DST), are made by the local machine clock of the user looking at the data. Display sequencing and math operations are performed on the UTC basis. The displayed time is interpreted by looking at the time zone on the client or server and re-converting this data time into a local time.

PI servers, data collection computers, and client computers should all have their time zones and times set correctly and synchronized. As the PI clients and Data Archive know what time zone, they are in, so data can be viewed in either Server Time or Client Time. This is determined by a setting in the client tool.

**Note:** It is important that all of the computers involved in collecting data (Data Archive, data collection computers, etc.) have their operating system clocks set correctly.

For most current PI Interfaces, events are sent to the server with UTC timestamps. All PI Connectors are sending the events with UTC timestamp too. If the PI Interface time is *more than ten minutes ahead* of the Data Archive, the Data Archive cannot handle the time difference and discards the data; it is considered a future event.

Automatic DST changes will not cause a problem when all computers observe the same rules. That is, either all computers change their clocks twice a year at the same time or they do not.

**Note:** Situations where some computers change their clocks when others do not can cause data loss.

The Data Archive automatically adjusts data according to daylight savings time transitions. By default, only the current DST transitions are known. They are provided by the operating system. To make sure that past transitions between daylight savings times are correct, you need to update the localhost.tz file on your Data Archive.
To verify that the DST rules, run `pidiag -tz` in the `\PI\adm` folder to check the time zone and DST transitions table of your Data Archive. If you anticipate backfilling data into the archives from years in the past, you will need to get a replacement `localhost.tz` for your timezone file from the techsupport.osisoft.com site by searching for `localhost.tz` in the downloads area.

Note: To check all the DST changes from year 1970 up to year 2038 run the command: `pidiag -tz -sys -dump`. This will list all dates when DST occurs (if DST is applied).
8. PI Interfaces

Objectives:

- Define a PI Interface
- Identify the basic components of the PI Interface installation
- Discuss the variety of architecture possibilities
- Describe how to connect PI Interfaces in a secure way
- Install and configure PI Interface
- Configure the basic PI Interface parameters

8.1 The PI Interface Defined

A PI Interface plays a critical role in the PI System. It performs the following tasks:
1. Connects to the data source
2. Timestamps the data (or ensures the data received is stamped at the source)
3. Formats the data correctly
4. Send the data to the Data Archive
8.2 Directed Activity – Preparing to Install PI Interface for OPC

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section.

Activity Objectives

Normally before you begin PI Interface installation, you would identify your data source. Since we are in a training environment, we will use an OPC DA Simulator. It has been configured to generate a set of sample data from simulated pumps.

You will install the PI Interface on the same computer as the data source – in this case the OPC DA Server Simulator.

The OPC server we use is made available by the OPC Foundation as the download “OPC Data Access 3.00 Binaries”. These files are available at http://www.opcfoundation.org/. Search for “OPC DA Sample Binaries.” Consult the OPC Foundation website for details if you wish to obtain a copy.
Fill in the following architecture diagram with the Hostnames and IP Addresses of your machines:

<table>
<thead>
<tr>
<th>OPC DA Server with PI Interface for OPC DA</th>
<th>Data Archive</th>
</tr>
</thead>
</table>

**Hostname:**

**IP address:**

**Hostname:**

**IP address:**

---

⚠️ **Tip**

It is a good idea to stick with the same configuration credentials when setting up the PI Interface and PI Buffering. If you use an IP Address in the PI Interface hostname then make sure you use the IP Address in the PI Buffering configuration, and vice versa.
8.3 Directed Activity – Validating communication between the Data Archive Server and the PI Interface

Install the PI ICU and PI API for Windows Integrated Security software and validate the connection.

Activity Objectives

• Validate the connection between PI Interface and Data Archive server.

Approach

What does ICU stand for?

1. Install the PI ICU software on the data collection computer. This will give you the required software to test the connection. You will be asked for the directories for the PI SDK and the name of your Data Archive.

**Installation Directories**

Either specify new installation directories or accept the defaults

<table>
<thead>
<tr>
<th>Directive</th>
<th>Directory</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIHOME</td>
<td>D:\Program Files (x86)\PIPC</td>
</tr>
<tr>
<td>PIHOME64</td>
<td>D:\Program Files\PIPC</td>
</tr>
</tbody>
</table>

**Default Values**

Please specify values for the following variables.

<table>
<thead>
<tr>
<th>Directive</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default PI Server</td>
<td>PISRV1</td>
</tr>
</tbody>
</table>

2. After the PI ICU installation, run the install kit for **PI Buffer Subsystem** to upgrade to the newest buffering.

3. Then install the **PI API for Windows Integrated Security**.

You will be prompted with a warning that PI API for WIS does not support PI Trusts and explicit logins.
Note: PI API for Windows Integrated Security should replace the previous PI API versions that rely upon PI Trusts or explicit logins for authentications. With PI API for WIS Windows authentication becomes the only supported authentication model for PI API-based applications, such as PI Interfaces on the node where it was installed.

Windows Integrated Security is a more secure authentication model than PI Trusts for authenticating users!

4. After installation, verify the connection to the Data Archive.

The apisnap (%pihome%\bin) utility validates the PI API connection to the Data Archive.

```
D:\Program Files (x86)\PIPC\bin>apisnap pisrv1
APISNAP version 2.0.1.35
PI-API version 2.0.1.35
Attempting connection to pisrv1
Error connecting to PI Server node pisrv1: [-1] Unable to connect to server
D:\Program Files (x86)\PIPC\bin>
```
The PI Connection Manager validates the **PI SDK** connection to a Data Archive. It is accessible with the **PISDKUtility** as seen previously.

![Error Message]

**These tests fail.**

What do you think you will need, based on earlier discussions, to connect? – think security!
8.4 PI Security for connecting PI Interfaces

For obvious reasons, the PI Interface needs to connect to the Data Archive. With PI API for WIS, a PI Interface is able to authenticate using the Windows account the application service is running under if **PI Mapping** to a proper **PI Identity** exists. We will be talking about PI Mappings and PI Identities later in the Security chapter.

With previous PI API version, which is part of the PI ICU or PI Interface install kit, the application cannot log in so it must rely on a mechanism called a **PI Trust** to gain access. PI Trust simply assigns a connecting program to the PI Identity. The PI Data Archive checks all incoming connections for a PI Trust if not disabled.

A good tool to view connections to the PI System is the Network Manager Statistics plug in in the PI SMT.

Previous PI API versions used a protocol that only sends the IP Address and an encoded application name in its communication. PI Trusts should be based on those parameters.

The application name used in the connection for PI Interfaces is an encoded phrase that takes *the first four letters* of the interface name and the capital letter “E”. The best way to verify this is to start the interface and watch the denied connection in the Data Archive using the Message Log plug-in of the PI SMT.

For example, the **Random** Interface will use the phrase **RandE**.

PI API for Windows Integrated Security is using the *Windows authentication protocol*.
8.5 About PI Trusts

To create PI Trusts, use the PI SMT Mappings and Trusts plug in.
You can use the Wizard or the Advanced selection to create a PI Trust – they perform the exact same function.

⚠️ Tip

Trusts should follow the OSIsoft Field Service Technical Standard “2+ convention”. That is, a PI Trust to the PI Interface based on IP Address AND the executable name. You want to create Trusts SPECIFIC to the executable that is connecting to PI. It is not safe practice to map trusts to the `piadmin` user.

Some may find the Wizard confusing because understanding when to use a “PI API Application” or “PI SDK application on a Windows NT based OS” might not be intuitive.
Select Advanced instead of Wizard. This presents all the options in one dialog box.
8.6 Directed Activity – IP Addressing in Trusts

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section.

Activity Objectives

- Create an IP Address Filter for a PI Trust

Approach

In the PI Trust mechanism, if you use IP Address you must specify a Netmask. However, the relationship between IP Address and NetMask in the PI Trust database is the same as the relationship between network destination and net mask in a TCP/IP routing table. Any valid subnet and IP address combination is supported. If you use this mechanism to allow access to all addresses in a subnet, you must set the bits corresponding to your subnet to zero.

<table>
<thead>
<tr>
<th>Row</th>
<th>Trust IP Address</th>
<th>Trust NetMask</th>
<th>Machine IP Address</th>
<th>Result of AND</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None (0.0.0.0)</td>
<td>None (0.0.0.0)</td>
<td>192.168.168.121</td>
<td>0.0.0.0</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>192.168.168.0</td>
<td>255.255.255.0</td>
<td>192.168.168.121</td>
<td>192.168.168.0</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>192.168.168.0</td>
<td>255.255.255.0</td>
<td>192.168.175.004</td>
<td>192.168.175.0</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>192.168.168.222</td>
<td>255.255.255.255</td>
<td>192.168.168.22</td>
<td>192.168.168.22</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>192.168.168.222</td>
<td>255.255.255.255</td>
<td>192.168.168.20</td>
<td>192.168.168.20</td>
<td>No</td>
</tr>
</tbody>
</table>

Answer the following questions:

1. What computers would the following combination apply to:
   192.168.1.0 / 255.255.255.0

2. How would you construct a trust specifically for the machine with IP Address 192.168.10.54?
8.7 PI Interface & PI Connector Installation Considerations

8.7.1 Where do you install the PI Interface or PI Connector?

Several architectures are possible with PI Interfaces or PI Connectors. Examples are shown below:

- **Architecture A**: The Data Source and PI Interface or PI Connector are installed on the same machine with stand-alone Data Archive.
- **Architecture B**: The Data Source, PI Interface or PI Connector and Data Archive are all installed on separate machines.
- **Architecture C**: PI Interface or PI Connector is installed on the Data Archive server

Having seen the above recommendations, what would you say was the least difficult configuration?
As a group, discuss the advantages, disadvantages and example application for each architecture:

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Example application</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 8.7.2 Data Collection Node Clock

Before you install and configure the PI Interface or PI Connector, make sure that the clocks on the Data Collection machine and Data Archive machine are relatively close. They do not have to be exact.

⚠️ **Tip**  
PI Interface or PI Connector that is more than 30 minutes “off” the server clock will not run, and data for Real-time data points with a timestamp more than 10 minutes into the future will be discarded!

### 8.7.3 DST Rules

It does not matter so much that your computers obey DST, as long as the servers and your PI Interfaces or PI Connectors are configured the same way and observe the same rules!
8.8 Directed Activity – PI Interfaces - What is installed?

Your instructor will have directions.

Activity Objectives

• Install the PI Interface for OPC DA and identify the PI Interface components.

Approach

Every PI Interface has at least four components that are installed on the data collection computer (many PI Interfaces have additional files – refer to the manual for details).

The image below illustrates the basic components for the PI Interface for OPC DA. Write the functions next to the icons.

OPCInt.exe

OPCInt.bat

PI_OPCCInt
ReleaseNotes.txt

PI_OPCCInt.docx
8.9 Directed Activity – PI Interface Parameters Dissected

In this part of the class, you will learn the common PI Interface switches

Activity Objectives

- Learn the PI Interface startup file switch syntax.

Approach

Navigate to the unconfigured startup batch file “OPCInt.bat_new” for the PI Interface for OPC DA. Edit the file to open it in Notepad. The elements in the startup file are parameters or “switches.”

Open PI Interface manual (any manual).

Answer the following questions concerning the startup parameters:

1. What does the /HOST parameter mean? What formats are acceptable?

2. What does the /ID parameter do?

3. What does the /PS parameter refer to?

4. What is the link between /ID and /PS?

5. What is the /F parameter used for? What formats are acceptable? What is an “offset” and why is it used?
Notes on scan frequencies.

| /f=SS.## | The /f parameter defines the time period between scans in terms of hours (HH), minutes (MM), seconds (SS) and sub-seconds (##). The scans can be scheduled to occur at discrete moments in time with an optional time offset specified in terms of hours (hh), minutes (mm), seconds (ss), and sub-seconds (##). If HH and MM are omitted, then the time period that is specified is assumed to be in seconds. Each instance of the /f parameter on the command-line defines a scan class for the interface. There is no limit to the number of scan classes that can be defined. The first occurrence of the /f parameter on the command-line defines the first scan class of the interface and so on. PI Points are associated with a particular scan class via the Location4 PI Point attribute. |
| /f=SS.##,ss.## | Required for reading scan-based inputs |
| /f=HH:MM:SS.## | or |
| /f=HH:MM:SS.,hh:mm:ss.## | Two scan classes are defined in the following example: /f=00:01:00,00:00:05 /f=00:00:07 or, equivalently: /f=60,5 /f=7 |
| | The first scan class has a scanning frequency of 1 minute with an offset of 5 seconds, and the second scan class has a scanning frequency of 7 seconds. When an offset is specified, the scans occur at discrete moments in time according to the formula: scan times = (reference time) + n(frequency) + offset where n is an integer and the reference time is midnight on the day that the interface was started. In the above example, frequency is 60 seconds and offset is 5 seconds for the first scan class. This means that if the interface was started at 05:06:06, the first scan would be at 05:07:05, the second scan would be at 05:08:05, and so on. Since no offset is specified for the second scan class, the absolute scan times are undefined. |
| Wall Clock Scheduling | Scan classes that strictly adhere to wall clock scheduling are possible. This feature is available for interfaces that run on Windows and/or UNIX. For example, /f=24:00:00,08:00:00 corresponds to 1 scan a day starting at 8 AM. However, after a Daylight Saving Time change, the scan would occur either at 7 AM or 9 AM, depending upon the direction of the time shift. To schedule a scan once a day at 8 AM (even across daylight saving time), use /f=24:00:00,00:08:00,L. The ,L at the end of the scan class tells Unilnt to use the wall clock scheduling algorithm. |
8.10 Group Recap Questions

The following questions are intended to reinforce key information, or to discover a new insight. Your instructor may choose to have you try to answer the questions on your own or have the group answer them together aloud.

Questions
Which of the following scan classes may collect data at a different time to the others?

/f=5,10
/f=00:00:05, 00:03:05
/f=5,0
/f=00:00:05

Define scan classes for:

A scan every hour which scans at 10 minutes past each hour.

A scan every minute, on the minute.

A scan every 15 seconds with no preference on when the first scan is done.

A scan every 12 hours commencing at 7:00pm

What is the default scan time?
8.11 Directed Activity – PI Interface Documentation

Learn how to read a manual.

Activity Objectives

- Describe the reasons why the PI Interface Documentation is critical to the proper installation and configuration of PI Interface.

Approach

In computing, many applications can be installed without the documentation getting in your way. *This does not apply to PI Interfaces.*

Navigate to and open the PI Interface for OPC DA Documentation. Go through the document sections and describe where key information can be found. Answer the following questions:

1. Will the interface run on a Windows 7 platform?

2. What PI Point types are supported?

3. Can this PI Interface write data back to the data source?

4. What is the maximum point count for this PI Interface?

5. What methods of Failover are supported?

6. Is vendor software required?

7. Is Disconnected start-up supported?

Tip

The PI Interface documentation will help you with the configuration of the PI Interface.
8.12 PI Interface Configuration Utility

PI ICU allows system managers to easily configure and maintain PI Interfaces. It automatically stores needed information on the server, and in the PI Interface start-up file (.bat). The ICU can only configure PI Interfaces that run on the same computer as the ICU.

The PI Interface Configuration Utility (PI ICU) is simply a GUI for editing the startup batch file.

One thing to keep in mind is that the PI ICU **READS** from the PI Module Database but also **WRITES** to the PI Interface startup batch file, as well as **updating** the MDB entry.

Tip
If you use the PI ICU to edit an interface startup file, do not edit the startup file manually – your changes will be lost the next time someone uses the PI ICU.

This also means you will need to run the PI ICU under the user that has **write** access to the PI Module Database on Data Archive.
8.13 Exercise – PI Interface for OPC DA Configuration with PI ICU

Follow the instructor

Exercise Objectives

- Configure the PI Interface for OPC DA with PI ICU.
- Start the PI OPC Interface as a Windows service.

Problem Description

You need to set up the PI Interface for OPC DA to collect data. An OPC Data Simulator (OPCSample.OpcDa20Server.1) is installed on your computers (or your instructor will give you directions on where to install it.)

Approach

- Use the PI OPC Client Tool to find your OPC Server.
- Configure the PI Interface for OPC DA with the OPC server name and test the setup. The following walk through shows you what needs to be done. In the next section, you will get your hands dirty.

Before you start:

Set the security for PI ICU and PI Interface on the Data Archive, use PI System Management Tools (PI SMT) to:

1. Create new PI Mapping for the PISCHOOL\Student01 account and map it to the piadmins group in order to provide PI ICU write access to the PI Module Database.
2. Create new PI Identity called PlInterfaces&Buffer and map it to the PISCHOOL\PIOPCDA_SVC user.
3. Modify the Database Security in PI-SMT and add the PIInterfaces&Buffer PI Identity to the following tables: PIPoint with Read&Write access. (Note: The PI Security concept will be discussed in a separate chapter)

Use PI Interface Configuration Utility (PI ICU) to configure the PI Interface for OPC DA:

1. Open PI ICU.
2. Open the PI Interface for OPC DA start-up file with the PI ICU. You are looking for the OPCINT.BAT_NEW file located in the %pihome%\Interfaces\OPCInt folder.

Tip

Import the .bat.new file into PI ICU and then save the file. Note the new .bat file in the appropriate PI Interface folder.
3. Select the PISRV1 from the drop down list. Now you are ready to configure the PI Interface

8.13.1 The PI ICU General Section

/PS = Point Source (which interface?)

/ID = Interface ID  (which instance of the interface?)

/F = Frequency/Scan Class (how often to read a value?)
8.13.2 The PI ICU Interface Specific Section

Specific to each interface. In this case OPCint.

/OPCSTOPSTAT = IntfShut (write a value on shutdown)
/_SERVER= node::name (the machine and OPC Server name)
/TS = Timestamp Source

4. Set the OPC server name to the OPC DA server simulator
   **OPCSample.OpcDa20Server.1**.

   **Hint**: Obtain the name of the OPC Server Name by using the PI OPC Tool. The PI
   OPC Client Tool is installed with the OPC Interface and is found in the apps screen
   under PI System or **PI System → PI-OPCClient**.

5. In OPCInt section – Data Handling check **Write Status to Tags on Shutdown**
8.13.3 The PI ICU UniInt Section

*UniInt* is short for Universal Interface. It is reusable code integrated in many of OSIsoft’s interfaces to include generic functions such as establishing a connection to the PI Data Archive computer and monitoring the PI Point database for changes. This section is applicable to most, though not all interfaces. For most of the PI Interfaces the option Write Status to Tags on Shutdown is selected here, but for PI Interface for OPC DA it is ignored, and it is set in the OPCInt plug-in -> Data Handling section.

6. Recommended is also check the option *Include Point Source in the header of log messages.*

8.13.4 The PI ICU Service Section

7. Use PI ICU to create the interface Windows service. Select the `[Domain]\UserName` and define the account under which the PI-opcint1 service will be created. In our case, it is `PISCHOOL\PIOPCDA_SVC`. 
8. Start the Interface

There are two ways to start the interface:

- Interactive *(run the interface yourself) Used only for testing!*
- Non-Interactive *(start the Windows Service using services.msc from Start, Run… ) or from within the PI ICU*
- Start the interface interactively to confirm operation. Look for connections to both the Data Archive and the OPC server.
- Start the PI Interface as a Windows service and confirm proper start-up by using the PISDKUtility to monitor the message log.

⚠️ **Tip**  Validate that the interface can be started by the Windows service before you consider your configuration complete. It is possible that you can start the interface interactively using your permissions; however, the Windows service may not have the correct permissions and fail.
When starting the interface, check for errors in the log file.

9. View the log file with the PISDKUtility

On buffered data collectors, you will want the PI Interface to be dependent on the PI Buffer Subsystem (PIBuffss). This will assure that the buffer starts before the PI Interface, because if PI Interface starts before the PI Buffer Subsystem it will start sending values to the PI Data Archive directly, thus bypassing the buffer.

You will create the points collected by this PI Interface in the next chapter.
9. PI Points

Objectives

- Define a PI Point
- Describe the different point types
- Describe the basic point attributes
- Build and edit points with Point Builder
- Describe a digital state set
- Create a digital state set
- Create digital state points
- Build and edit points with the PI Builder add-in to Excel.
- Connect the OPC data to PI points

9.1 What is a PI Point?

A PI point is a unique storage point for data in the PI Server.

For more information see "PI Point Classes and Attributes" (chapter 4) in *Data Archive System Management Guide*.

Some examples are:

- A flow rate from a flow meter (would use floating point [also known as float, real] data)
- A DCS controller’s mode of operation (may use digital or discrete data)
- The batch number of a product (can use one of float, integer, or string data)
- Text comments from an operator (using string [character] data)
- The result of a calculation (float or integer data)
- Memory % usage in a server (uses floating point data)

**Note:** Some industries and customers use the term “tag.” In the PI system, *point, tag* and *data stream* are synonymous.
9.1.1 Point Class

The Point Class is simply the name for a defined set of point attributes. The Data Archive is pre-configured with the point classes you will need. The typical PI System has no need for additional point classes.

All points are based on the Base point class. However, these points do not have the complete set of attributes required to collect data via an interface. Although points created by PI Connectors are of Base point class.

The Classic point class contains all of the Base point class plus all of the attributes required by the interface to connect to the data source and collect data.

Tip There are a handful of predefined “point classes” in the PI System and you can create your own, but these are special situations. Most of the points you will create will use the classic point class.

9.1.2 Point Type

The Data Archive, designed to collect and store time-series data, can store almost any data type.

There is no absolute when selecting point type but matching the PI point type with the data type on the source is usually a good start. For example, if the data source indicates that the data collected is a REAL32 then you would most likely use Float32 (a 32-bit floating-point value).

Tip The PI Float16 is not a real data type – it was made up for the PI Server. It is actually a floating-point value scaled to a 16-bit integer. Developed decades ago when disk space was scarce and expensive, you should not use this point type unless you have a specific reason to do so.
9.2 Directed Exercise – Data Types

You are invited to interact with the instructor to explore the different concepts presented in this section.

Problem Description
Identify the type of data that might be associated with each of the following:

Example: A temperature Sensor ___ a floating-point value ___

<table>
<thead>
<tr>
<th>switch position</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch ID</td>
<td></td>
</tr>
<tr>
<td>operator comments</td>
<td></td>
</tr>
<tr>
<td>calculation results</td>
<td></td>
</tr>
<tr>
<td>% remaining server disk space</td>
<td></td>
</tr>
<tr>
<td>current reaction phase</td>
<td></td>
</tr>
<tr>
<td>conveyor load</td>
<td></td>
</tr>
</tbody>
</table>

The table below lists the common PI Data Types. List another few examples to the point type in the second column.

| Digital     |                      |
| Int16       |                      |
| Int32       |                      |
| Float32     |                      |
| Float64     |                      |
| String      |                      |
9.3 Directed Activity – Point Attributes

Research point attributes.

Activity Objectives

- Describe the Point Attributes for a **Classic** point

Approach

You may need to use the documentation for this exercise.

Use the table on the next page.

Match the attribute description to the attribute name for selected Point Attributes for the **CLASSIC** point class.

Each person will research attributes and match the proper description.

When you are done with the exercise, the instructor will go through each attribute to review them.

To complete the activity, you can use "Base Class Point Attributes" and "Classic Class Point Attributes" in *Data Archive System Management Guide*. 
<table>
<thead>
<tr>
<th>N.</th>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CompDev</td>
<td>Flag set to ON (1) for a point to be archived. Set to OFF (0) to stop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>archiving of a point.</td>
</tr>
<tr>
<td>2</td>
<td>Span</td>
<td>Flag set to ON (1) to apply compression algorithm to a point. Set to OFF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0) to record every values in the archive.</td>
</tr>
<tr>
<td>3</td>
<td>Zero</td>
<td>Deviation for compression algorithm in engineering units.</td>
</tr>
<tr>
<td>4</td>
<td>ExcDev</td>
<td>Specifies the name of the digital state set associated with the tag.</td>
</tr>
<tr>
<td>5</td>
<td>Shutdown</td>
<td>Controls the format of numeric values on screens and in reports.</td>
</tr>
<tr>
<td>6</td>
<td>Archiving</td>
<td>Describes the units of the measurement.</td>
</tr>
<tr>
<td>7</td>
<td>Location1</td>
<td>Provides additional information. Some interfaces use it to encode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>additional configuration information.</td>
</tr>
<tr>
<td>8</td>
<td>Future</td>
<td>Specification of a deviation for exception-reporting.</td>
</tr>
<tr>
<td>9</td>
<td>ExcMax</td>
<td>Maximum time for compression. Duplicate values are archived if the elapsed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>time exceeds the value.</td>
</tr>
<tr>
<td>10</td>
<td>DigitalSet</td>
<td>Associates a tag with an interface or PI application</td>
</tr>
<tr>
<td>11</td>
<td>ExcMin</td>
<td>Records a time-stamped event to a tag when the archive was shut down.</td>
</tr>
<tr>
<td>12</td>
<td>EngUnits</td>
<td>Minimum time for exception-reporting. For interface points the value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>should be 0.</td>
</tr>
<tr>
<td>13</td>
<td>Compressing</td>
<td>The difference between the top of the range and the bottom of the range.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Required for all numeric data type points.</td>
</tr>
<tr>
<td>14</td>
<td>PointSource</td>
<td>Defines how numeric values are interpolated. Flag set to OFF (0) for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>values as continuous signal. Set to ON (1) for discrete values.</td>
</tr>
<tr>
<td>15</td>
<td>CompMax</td>
<td>Used by some interfaces as the tag in the external system.</td>
</tr>
<tr>
<td>16</td>
<td>Location4</td>
<td>Maximum time for exception-reporting. Duplicate values are archived if</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the elapsed time exceeds the value.</td>
</tr>
<tr>
<td>17</td>
<td>InstrumentTag</td>
<td>Specifies the interface ID for most of the interfaces.</td>
</tr>
<tr>
<td>18</td>
<td>Step</td>
<td>Flag set to ON (1) for a point to receive values with future timestamps.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Set to OFF (0) for a point to receive historical values.</td>
</tr>
<tr>
<td>19</td>
<td>ExDesc</td>
<td>Specifies the scan class number for most of the interfaces.</td>
</tr>
<tr>
<td>20</td>
<td>DisplayDigits</td>
<td>Indicates the lowest values possible. Required for all numeric data type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>points.</td>
</tr>
</tbody>
</table>
9.4 Creating and Managing PI Points

There are many ways to create points in the PI Server. Throughout the course, we will show you the most common.

One tool that may be used to build and edit points is **Point Builder** in PI SMT.

The Point Builder plug-in for PI SMT is a graphical tool that allows the user to create and edit PI points. This tool allows the system manager to set the attributes for each point individually during PI point creation and allows you to edit them afterward. Some attributes are system assigned and cannot be changed.

![Point Builder in PI SMT](image)

It is possible to rename a point while preserving the historical data associated with it. It is also possible to delete a point, in which case the associated archived data is **no longer accessible**!
9.5 PI Point Attributes and PI Interfaces

Remember the statement, “always reading the documentation manual”? Each interface can use point attributes in a different manner. That is why each interface documentation specifies what point attributes are used and how.

Listed below are the common point attributes and how they are commonly used. **ALWAYS consult the interface manual.**

<table>
<thead>
<tr>
<th>Instrument Tag</th>
<th>Name of the point/location in the source data system. <em>Often it must match the data source exactly!</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended Descriptor</td>
<td>Place for detailed query instructions (uncommon).</td>
</tr>
<tr>
<td>Future Data</td>
<td>If defined as ‘Allow’ it means that events with time stamps in the future may be stored.</td>
</tr>
<tr>
<td>Exception Specifications</td>
<td>Defines a significant change in value.</td>
</tr>
<tr>
<td>Point Source</td>
<td>Must match the value set in the interface configuration. See the /PS parameter in the interface start-up file.</td>
</tr>
<tr>
<td>Location1</td>
<td><em>Typically,</em> the Location1 field is used for the interface instance number (/ID)</td>
</tr>
<tr>
<td>Location4</td>
<td><em>Typically,</em> the field is the scan class number. (/f)</td>
</tr>
<tr>
<td>Scan</td>
<td>Include the PI point in the list of points to scan (always set to ON)</td>
</tr>
</tbody>
</table>

⚠️ **Tip**  
*Instrument Tags are often case sensitive.* Copy and paste this information directly into PI SMT or PI point builder from the PI OPC Client Tool when possible.
The most common cause of malfunctioning new points is incorrect mapping of PI point attributes to the data source or the interface configuration.

### 9.5.1 A Word about Future Data.

The Data Archive accepts data with timestamps up until January 2038. January 1970 is the past limit for all points.

In order to store future data, a point must be created with the “Stored Values” point attribute set to 1, or ‘Future data’. By default, the “Stored Values” attribute is set to 0 (Real-time data). This cannot be modified after a point has been created. Points with the attribute set to 0 will reject data with timestamps more than 10 minutes into the future.

Generally speaking, future points should be used when storing data that is not collected sequentially in chronological order. For example, process or operational data should be kept in historical points because it is measured and collected in real time. On the other hand, forecasts and predictive data over an arbitrary time range are suited for future points.

Data for all future points is stored in separate archive files. Future data never moves to the historical archive files even after the future data ages into the past. The archive files for future points will be created automatically as data is written to the points and are resized dynamically. Each future archive has an initial size of 1 MB and grows dynamically, and the duration of the archive is always one calendar month. If neither the initial size nor the duration is desirable, archives can be manually created and registered.
9.6 Polled, Advised or Output Points

Many interfaces have different methods of retrieving data. All three read types of points are read asynchronously by the interface and the same data routines process all updates. The method is often set in a Location Code.

These are described below.

**Polled**

For polled points, the interface sends an asynchronous refresh call for the group (points of the same scan class). This is often the most common method for reading data and is supported by virtually every interface.

**Advise**

Advise points “listen” for new events. For advise points (referred to as read on change in the OPC Standard), the data source sends data whenever a new value is read into the server’s cache. Not all interfaces support the Advise method.

---

**Tip**

Often the Advice method of reading data is the most efficient and best performing.

---

**Caution:** Do not mix advised points and polled points in the same group (i.e. scan class). Some interfaces do not tolerate this and will not function correctly.

---

**Output Points**

Output points read a separate PI Point and write the value out to the data source. These often reference calculation points which values are calculated by PI Analysis Service and are performing a calculation that cannot be performed on the data source. Not all interfaces support bi-directional data.
9.7 Directed Activity – PI Vision

Watch the data trend!

Activity Objectives

- Finish the PI Vision configuration
- Create a simple trend to examine point data

Approach

PI Vision is a web-based PI Client. Usually it is installed after proper installation and configuration of PI Server. Due to the syntax of this course when PI Server does not exist at the beginning of the class we need to finish a couple of configuration steps for the pre-installed PI Vision on PISRV2 machine.

1. In PI SMT create a new PI Identity called PIWebApp and it’s mapping to the PISCHOOL:PIWebAPI_SVC account.

2. In Database Security in PI SMT add PIWebApp identity with Read permissions to the following databases: PIDBSEC, PIMAPPING, PIPOINT, PIUSER. Those are the minimum-security settings for PI Vision.

3. On PISRV2 open PI System Explorer and go to File – Connection and click on Add Data Server and add PISRV1

4. Open Chrome web browser and click on bookmark “PI Vision Admin”. This will bring you to the Overview section of PI Vision administration page.

5. Locate section Data Servers Allowed and click on Manage Configuration.
6. You will see the PISRV1 in the list. Click on Test Connection. It will turn to green check mark.

<table>
<thead>
<tr>
<th>Status</th>
<th>Server</th>
<th>Version</th>
<th>Role</th>
<th>Connecting As</th>
<th>PI User</th>
<th>Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PISRV1</td>
<td>3.4.420.1182</td>
<td>Application Pool</td>
<td>PISCHOOL/PIWebAPI_SVC</td>
<td>PIWebApp</td>
<td>PIWorld</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PISCHOOL/student01</td>
<td>piadmin</td>
</tr>
</tbody>
</table>

7. Check the Allow box and hit Save button.
8. From web browser bookmarks bar click on PI Vision to open the PI Vision home page.
9. Click on New Display button + New Display
10. Find some points from Random or Ramp Soak interface like SINUSOID, CDT158, BA:LEVEL.1, BA:CONC.1 etc. and place them on the display as different objects.
9.8 Exercise – OPC Points

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives
- Build PI OPC Points.
- Validate PI OPC points are collecting data from an OPC server.

Problem Description
You have a set of Pumps connected to your PI OPC Server generating data. (You have already configured your PI Interface for OPC DA).

You need to create points in the Data Archive.

Approach
Use the PI OPCClient tool (installed with the PI Interface for OPC DA) to examine your OPC Server. You should notice that there are a series of pumps. These pumps each have points associated with them, collecting simulated data.
Use the PI OPC Manual and the information contained in the PI ICU to configure the points for the first pump only. **Do not** build the Status point just yet. Pay particular attention to the Location codes (1,3,4); and the relationship between the PI point attribute Instrumenttag and the OPC ItemID.

For more information, see "PI Point Configuration" in *PI.OPCInt manual.*
9.9 **Digital State Sets**

9.9.1 **Digital State Sets**

Points of type **Digital** are used to store data values that have discrete states exemplified above. These are typically states such as Open/Closed for a valve or On/Off for a switch. While the user is interested in the actual state, PI stores this information as an integer. This integer is then associated with a **Digital State Set**; a grouping of these states. Whenever the value is requested, PI retrieves the integer value, does a lookup in the Digital State Set, and then presents the associated text value.

Digital Sets are kept in a common table for all points of type Digital to access. The Digital State Set must exist prior to the creation of the digital point. When defining a point use the **DigitalSet** attribute to store the associated Digital Set name. The digital states are case preserving, but not case sensitive, so you can refer to them with upper and lower case, but any display will show the configured upper or lower case. There is a large default set called **System** that contains system error messages and other information. All points, including non-digital points, can receive and archive a state from the System digital states set (Shutdown, PtCreated, Over Range, Under Range, I/O Timeout, etc.).

Do not edit the SYSTEM set on your system.
9.9.2 Creating digital state sets

Create Digital States with the Digital States plug-in under the Points section in PI SMT. This allows you to create new Digital States, copy and paste existing Digital states, and edit or delete existing Digital States. Digital Sets are local to the Data Archive, so if you require the same Digital Sets on multiple Data Archives, you need to export and import the list of sets and states as a .csv file or copy / paste the state sets from one server to another by opening multiple Data Archives inside the plug-in.

To create a new Digital Set, select the Server then the New icon in the menu bar. You can also right click and select Add Set from the pop-up menu. A new table will appear with two columns. These columns are State Number and State Name. The State Name field corresponds to the states of the data source and is manually entered, although is a facility for importing digital states. The State Number field corresponds to the integer that PI will store in the archive for that digital state. This field is populated automatically, starting at a value of 0 and increasing by 1 from there. Once you have fully entered all of your digital states, remember to save the new digital states by clicking on the Save icon in the toolbar.

Note: Additions and edits to Digital Sets are immediately available on the Data Archive. However, most client applications, including PI SMT, cache the Digital Sets. This means that you may have to exit and restart the client application for any changes to be visible.
9.10 Exercise – Create a Digital State Set and Point

This activity is designed to maximize learning in a specific topic area.

Exercise Objectives

- To create a digital state set and point.

Problem Description

A new controller has been installed in your plant, and the OPC Data server for which you configured an interface in an earlier exercise is collecting its data. It has digital points.

You have decided to create a point to archive this controller’s mode of operation. However, in order to build the point you will first need a digital state set.

Use the PI OPC Tool (or other appropriate OPC tool in your own environment) to examine the digital states. Can you see the state changes?

The table on the right shows the correlation between state names and numbers.

<table>
<thead>
<tr>
<th>State Name</th>
<th>State Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopped</td>
<td>0</td>
</tr>
<tr>
<td>LOW</td>
<td>1</td>
</tr>
<tr>
<td>Normal</td>
<td>2</td>
</tr>
<tr>
<td>HIGH</td>
<td>3</td>
</tr>
<tr>
<td>Error</td>
<td>4</td>
</tr>
</tbody>
</table>

Approach

Open the PI SMT Digital States plug-in and create a Digital State Set called **PumpStatus**.

And remember to save it, and restart PI SMT.

Why?

________________________________________________________

Use the SMT Point Builder to create a digital point **Pump1.Status** with the instrumenttag attribute **Sample Process/Pump1/Status**. Do not forget the attributes Digital Set, point source, location1, location3, location4. What should the STEP attribute be set to?

Wait for the interface to start collecting data for the new point.
9.11 PI Builder

The PI Builder is an add-in to Microsoft Excel. The spreadsheet format is convenient when viewing and editing in bulk, with a row for each point or element and a column for each attribute.

The tool best suited to bulk build and edit points is **PI Builder**

PI Builder requires the spreadsheet to have the following layout:

- The attribute names are listed in the top row.
- The point names are listed in the second column.
- Each point has its attributes listed under the headings in the top row, one point per row.
- Select a point row by putting X in the first column. Import or export operations are performed on these selected points only.

**Tip**

Like every powerful tool, PI Builder can save you a lot of time, or do a lot of damage if not used carefully. Be Careful!

9.11.1 Enabling Delete

Notice that the Delete action is not enabled by default. There is no “undelete” for a point. *If you delete a point by accident, you cannot get their history back.* The history is inaccessible or lost. Entire systems have been deleted by accident.

It is recommended that you only enable Delete when you need to; be *extremely* careful when using it. Turning the point attribute SCAN to OFF is a better alternative.

9.11.2 Export only What Matters

OSIsoft recommends that you export only attributes that have been changed; *that is, remove any unchanged columns.* If you don’t do this, then all the attributes are exported, not only those that have changed.

Moreover, only export the points (rows) that are new or that you have changed.
9.12 Exercise – PI Builder

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Exercise Objectives

- Create points in bulk using the PI Builder
- Modify points in bulk using the PI Builder

Problem Description

Create the remainder of the points for the interface without tedious necessity of using the PI SMT Point Builder Tool.

Approach

- Import the OPC points you have created so far into Excel from the Data Archive.

![Image of Tag Search]

- Check the OPC Server for the remaining data points.

Use the PI Builder to build one line for each new point for the other pumps and export the definitions to the Data Archive.

You may choose to use the Pumps_DCS_Export spreadsheet provided in the Exercise Files directory, to convert from DCS type tags to PI points.

In either PI SMT or PI Vision, validate that the points are collecting data.

**Do not proceed** beyond this point until all points are collecting data.
Many of the remaining course exercises are dependent on this exercise. Information on building and managing points is found in *Data Archive Introduction to System Management.* Consult *Data Archive Reference Guide* for information on Digital Sets. See PI Builder User Guide for information on the PI Builder for Excel.

What are common causes for no data being collected?
10. AF Tools

Objectives

- Introduce the PI System Explorer
- Describe elements and attributes
- Build elements and templates
- Build elements with the PI Builder add-in to Excel.

10.1 Assets – The Basic Building Blocks in the AF server

What is an Asset?

The Asset Framework (AF) Server is a part of the PI System. It contains asset or “metadata” usually organized according to the assets containing the attributes monitored. AF can be helpful to users of the Data Archive who know the assets but are not familiar with attribute nomenclature. With assets, data can be located without understanding the technical details of each piece of equipment.

Properly configured assets are helpful in finding all the SCADA points associated with a specific piece of equipment, as well as non-SCADA information such as serial numbers, maintenance dates and/or calculations associated with a particular type of asset.

AF allows you to base similar objects on a single template. Templates define a set of base attributes for all the objects that use that template. Create the template once and you can create as many elements based on the template as are needed.

Modifying a template results in the change automatically propagating to all elements based on that template.

10.2 The PI System Explorer

The PI System Explorer (PSE) is your access to the AF databases. Use the Explorer to configure the objects that represent your process, for example, tanks, transformers, pumps, boilers, meters. The PSE allows the definition of units of measure (UOM), templates, enumeration sets, and so forth. Use PSE to specify security permissions and default databases. All work can be checked in and out of the databases with the PSE.
10.3 The PI Builder

The *PI Builder* add-in to Excel is a tool allowing AF configuration in Excel, as well as point configuration. In the case of AF, it enables bulk importation and exporting of elements and attributes, to and from the AF database.

The element search dialog in PI Builder showing how to search for all pumps under the element search root of 'Site Pumps'.
10.4 Directed Activity – Explore the Power of AF

Your instructor will coach you if you need assistance during the activity.

Exercise Objectives

- Explore features of AF
- Implement an asset hierarchy
- Build a PI Vision display
- The goal of the exercise is to build a meaningful AF structure and build a display based on the asset hierarchy shown.

Exercise Description

AF allows the definition of consistent representations of organization assets and equipment and uses these representations in simple or complex analyses that yield actionable information.

Without AF, displaying the data from five pumps in PI Vision may require five different displays. With the usage of Element Template in AF, only one display need be created.

Approach

1. Use the PSE to create a new database within the AF environment. Select Database, New Database and enter a database name, ‘Pumps’, Select the database just created.
2. Create an element named “Site Pumps”, precisely.
3. Right-click on ‘Site Pumps’ element to create Child Element of “Site Pumps” and name it Pump1
4. Start adding attributes according the following description:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Value</th>
<th>Data Reference</th>
<th>UOM</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>string</td>
<td></td>
<td>String Builder</td>
<td>none</td>
<td>Right(&quot;%Element%&quot;,1)</td>
</tr>
<tr>
<td>Fluid</td>
<td>string</td>
<td>water</td>
<td>none</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>Flowrate</td>
<td>single</td>
<td></td>
<td>PI Point</td>
<td>L/s (from Volume Flow Rate UoM)</td>
<td>%element%.%attribute%</td>
</tr>
<tr>
<td>PumpSpeed</td>
<td>single</td>
<td></td>
<td>PI Point</td>
<td>RPM (from Angular Velocity UoM)</td>
<td>%element%.%attribute%</td>
</tr>
</tbody>
</table>
5. Check that all values are correct. And **Check In** the changes.

6. To create the other four pumps, make a **template** from Pump 1. Create an element template “**PumpTemplate**” by using *Convert to Template* when right clicking Pump1 in the Elements pane. Go to Library and rename the template to just **Pump**.

7. Leave ‘Include Tag Creation’ unticked as shown below and ensure the ‘Substituted’ definitions are used. **Remove the %ID%** from Suggested Point Name and click Apply.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>PI Point</th>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>BearingTemp</td>
<td>single</td>
<td>PI Point</td>
<td>°C (from Temperature UoM)</td>
<td>%element%.%attribute%</td>
</tr>
<tr>
<td>OilPressure</td>
<td>single</td>
<td>PI Point</td>
<td>kPa (from Pressure UoM)</td>
<td>%element%.%attribute%</td>
</tr>
<tr>
<td>OutputFlowRate</td>
<td>single</td>
<td>PI Point</td>
<td>L/s (from Volume Flow Rate UoM)</td>
<td>%element%.%attribute%</td>
</tr>
<tr>
<td>Status</td>
<td>string</td>
<td>PI Point</td>
<td>none</td>
<td>%element%.%attribute%</td>
</tr>
<tr>
<td>FlowDelta</td>
<td>single</td>
<td>Formula</td>
<td>L/s (from Volume Flow Rate UoM)</td>
<td>A=OutputFlowRate, B=FlowRate; A-B</td>
</tr>
</tbody>
</table>
8. Create new Elements from PumpTemplate1 until you have all 5 Pumps.
9. When you use the template, it will automatically associate the correct PI points with the attribute. **Why does this work?**
10. Modify each pump’s **Fluid** attribute (or choose whatever liquids are available in the table):

<table>
<thead>
<tr>
<th>Unit</th>
<th>Pump</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 2</td>
<td>Pump2</td>
<td>Acetone</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Pump3</td>
<td>Castor Oil</td>
</tr>
<tr>
<td>Unit 4</td>
<td>Pump4</td>
<td>Dioxan</td>
</tr>
<tr>
<td>Unit 5</td>
<td>Pump5</td>
<td>Gasoline</td>
</tr>
</tbody>
</table>

11. We need to add our Pumps AF database to PI Vision configuration. Open the PI Vision Administration again and in Overview page locate Asset Servers/Databases Allowed section.
12. Click on Manage Configuration and tick the box next to Pumps database and hit Save button.

13. Open PI Vision main page and click on “New Display”
14. Navigate to one of the Pump elements
15. Create a new PI Vision display to show the characteristic of the Pump asset in a trend (OutputFlowRate, OilPressure,Flowrate), and the pump unit number and fluid type as values. Display the FlowDelta in another trend (to see that the formula calculation is backfilled by the PI Vision).
16. Save the display by clicking on **Save**, name it and hit Save.
17. Because our Pumps elements are based on the same Element template, PI Vision automatically recognizes it and enables option to switch between assets, therefore one display can show data from all our Pumps.
11. PI Connectors

Objectives

- Introduction to PI Connectors
- PI Connectors characteristics and comparison with PI Interfaces
- Get to know the OPC UA standard
- Configuring the PI Connector for OPC UA.

PI Connectors are the new generation of applications that simplify the process of adding new data to the PI System by scanning data sources and discovering data items. Data streams are then auto-configured on the PI Server. There is no need to manually create PI Points during initial setup or in the future. The PI Connector does this for you by continually monitoring the source. A reference model is built in the AF server acting as a mirror image of the data source.

11.1 General Characteristics

11.1.1 PI Interfaces vs. PI Connectors Comparison

The main differences between PI Interfaces and PI Connectors are summarized in the following table:

<table>
<thead>
<tr>
<th></th>
<th>PI Interface</th>
<th>PI Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI Points</td>
<td>Must create PI Points</td>
<td>Auto-discovers &amp; creates as needed</td>
</tr>
<tr>
<td>Point Type</td>
<td>Classic</td>
<td>Base</td>
</tr>
<tr>
<td>Buffering</td>
<td>Manually configure buffering</td>
<td>Automatic built-in buffering</td>
</tr>
<tr>
<td>Data types</td>
<td>Time-series data only</td>
<td>Time-series &amp; meta data (Asset structure, Event Frames)</td>
</tr>
<tr>
<td>Administration</td>
<td>Only locally</td>
<td>Locally &amp; Remotely</td>
</tr>
<tr>
<td>Configuration changes</td>
<td>Interface restart required</td>
<td>Does not require restart</td>
</tr>
<tr>
<td>Number of instances</td>
<td>Once instance per data source</td>
<td>Only one instance on a server for multiple data sources</td>
</tr>
<tr>
<td>Exception filtering</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Development environment</td>
<td>PI API</td>
<td>AF SDK</td>
</tr>
</tbody>
</table>
11.1.2 Buffering data

Connectors are inherently capable of buffering data whenever data flows from one process boundary to another. Buffering is always on and is not user configurable. There are no separate processes associated with buffering. Each connector process itself buffers the data. Configuration for buffering is limited to specifying the folder during setup to determine where data is buffered.

Buffering to PI System servers (Data Archive and AF Server) includes time-series values, tag creation, and asset creation events.

Note: PI Connector's buffering is not PI Collective aware. Every member must be added independently as a standalone server to the Server list.

11.1.3 Modifications to PI Connector's AF structure

It is possible to modify the AF structure that is generated by the PI Connector, but with several limitations and only a few actions allowed.

The supported modifications are:
- Adding custom AF attributes to the elements created by PI Connector
- Adding Extended Properties to the element template
- Assigning a category to attribute templates
- Adding PI AF Analysis rules directly to an element or element template

Unsupported modifications:
- Deleting element templates created by PI Connector
- Renaming element templates created by PI Connector
- Deleting template attributes created by PI Connector
- Renaming template attributes created by PI Connector

11.1.4 Modifications of PI Connector's PI Points configuration

It is possible to modify selected point attributes after they are created by PI Connector.
- Modification of the compression settings attributes
- Modification of PI Point security settings
- Attributes like Step, Scan, Archiving, Span, Zero, Typical Value

It is not possible to:
- Change the tag name
- Extended Descriptor
11.2 PI Connector for OPC UA

5 Things to Know About the OPC UA Servers

1. **OPC UA is the successor to OPC classic:** OPC DA (Data Access), OPC HDA (Historical Data Access) and OPC A&E (Alarms and Events) are all bundled into OPC UA. Instead of DCOM, which has several drawbacks such as frequent configuration issues, lower security and limitation to Microsoft Windows OS only, certificates are used for security.

2. **OPC UA is platform-independent and extremely scalable:** Classic OPC protocols were built for Microsoft operating systems (as DCOM was leveraged). OPC UA can operate on any platform. OPC UA is being deployed to everything from small chips with less than 64K memory (Nano Profile) to large workstations.

3. **A sophisticated address space model:** One should be able to model data, systems, machines and even entire plants into the OPC UA address space.

4. **OPC UA supports client-server architecture:** The OPC UA server is much more sophisticated than other factory floor systems such as Modbus, EtherNet/IP and BACnet. OPC UA servers can be configured to accept connections with any number of clients. The servers will never initiate connections. An interesting aspect of this relationship is that a server device can allow a client to dynamically discover what level of interoperability is supported, what services are offered, and type definitions for data types and objects.

5. **OPC UA is NOT just a protocol:** It’s a common misconception that OPC UA is just another protocol (Set of rules that govern the transfer of information from one computer to another). Even though OPC UA specifies the rules for communication between computers, its vision is more than just moving data. OPC UA is about complete interoperability.

OPC UA is now using its own binary TCP protocol for communication in form `opc.tcp://Server:<port>`

PI Connector for OPC UA copies contextual and time-series data from OPC UA servers to Data Archive and AF Servers. Static OPC UA variables are mapped to AF elements and attributes, dynamic variables are converted to PI Points. Before starting, users have an option to browse the whole OPC UA address space and export the OPC UA Type Definitions into a .csv file. The list of Type Definitions and their Attributes can be used for constraining the amount OPC UA objects replicated to the PI System.

The connector supports the Data Access (DA) and the Historical Data Access (HDA) parts of the OPC UA specification.
If connector is started without a filter file (you will see what it is during the configuration exercise), it will not browse the UA hierarchy and only create one AF element named according the configured data source and creates four PI points, which reflect the status of the OPC UA Server.

⚠️ **Tip**  
It is a good practice to start the connector for the first time without the filter file and verify that the OPC UA Server object has been created in AF. Browsing the whole OPC UA address space might take a long time or even time-out.

For more details consult the *PI Connector for OPC UA User Guide*
11.3 Exercise – Install the PI Connector for OPC UA

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives
- Install the PI Connector for OPC UA

Description
This exercise will guide you through the PI Connectors installation.

Approach
1. In the installation folder, select the PI Connector for OPC UA installation kit. Run as Administrator.
2. As mentioned PI Connectors are using AF SDK, therefore PI AF Client is always bundled within the installation kit.
3. Fill the information about the Asset Server (AF) – PISRV1
4. Only PI AF SDK .NET 4 can be installed. No other components are required.

Moving to the installation of the PI Connector itself.
5. Enter the port number for PI Connector administration page and check the availability. (You may keep the default port number)

![Port Configuration](image)

Port is available, click Next to continue.

Next, define the account under which the PI Connector for OPC UA Windows Service will run and will authenticate to AF Server and Data Archive.

6. Insert the PISCHOOL\PIOPCUA_SVC account and validate username and password combination.

![Windows Service Configuration](image)

Valid name and password combination.

7. Then you may specify the location of PI Connector buffer files. By default, they are installed into C:\ProgramData\OSIsoft\Tau, but we will select custom location D:\PIBuffer.
8. Start the installation and as the final step add our user Student01 to the local group *PI Connector Administrators*.

9. Verify that the PI Connector for OPC UA was installed. In Start menu under PI System there is PI Connector for OPC UA Administration link. If you click on that, you will be asked for entering the credentials of the user that was added to the PI Connectors Administrators local group (i.e. `PISCHOOL\Student01`) to load the configuration page.
11.4 Directed Activity – Configuring PI Connector for OPC UA

Follow the instructor to guide you through the configuration settings until the asset structure and points are created.

Activity Objectives

- Prepare the security settings for PI Connector on Data Archive and AF Server
- Use the OPC UA Client Tool to verify the connection to the OPC UA Server and browse the structure
- Configure the PI Connector via Administration UI
- Verify the asset structure and points were created after starting the connector

Before You Start

On Data Archive:

a. In PI SMT create new PI identity PIConnectors and mapped it to the PISCHOOL\PIOPCUA_SVC windows account.

b. In Database Security section, add the PIConnectors identity to the PIDS and PIPOINT tables with Read & Write permissions.

On AF Server:

a. Open PSE and create new database “Boilers”.

b. In the Select Database window click on “…” (3 dots) button, then right-click on the AF server and select Properties.
c. In Identities tab on blank space do right-click, select New Identity, and name it PIConnectors, then switch to Mappings and click on Add. Search for PISCHOOL\PIOPCUA_SVC account and confirm.

d. Again, in Select Database window do right-click on Boilers database and select Security.

e. Add the PIConnectors identity to the list and check Read/Write and Read/Write Data.

Approach
To get data from OPC UA demo server, it needs to run first because the simulation server cannot run in the background as a service.

1. Go to Start menu and find UaDemoServer and start it. A console window with server opc.tcp URL appears.
a. The URL `opc.tcp://PIINT1:4841` will be used in PI Connector configuration and in OPC UA Client to get the Node ID of the object we would like to use as a root.

2. Go to Start menu and find **UaExpert** application
   a. start it
   b. use the opc.tcp URL of the server to add it to the list
   c. connect to it.

3. Explorer the Address Space of the UA Demo Server.
   a. We do not want to copy the whole structure to the PI System, but only **PLC1** object and its sublevels. Therefore, PLC1 will be our root.

4. Every object is identified by its NodeId, which consists of **Namespaceindex** and **Identifier**, that makes a unique combination.
   a. Using the abbreviations “ns” for Namespaceindex and “s” for Identifier, and divided by semicolon, we define our Node ID `ns=4;s=PLC1`. 

![Image](image-url)
Note: There are several OPC UA Clients from different vendors. In some of them, you need to put together the Node ID using the Namespace index and Identifier. Some can display the Node ID directly in ns=<index>;s=<ID> form.

5. Open the PI Connector for OPC UA administration page.
   a. Navigate to Server List section, where you define the destination Data Archive and AF Server.
   b. Type PISRV1 to both fields in PI Data servers’ section and click on Add.
   c. Type PISRV1 to both fields in PI Asset servers’ section and click on Add.
   d. Enter Boilers as the target PI Asset Database.
      i. Define Root PI Asset Path as Connector otherwise assets will be created at root.
      ii. Click on Keep these settings.

6. Until the connector is started, the status is Disconnected for Data Archive and AF Server.

7. Navigate to Data Source List.

8. Enter the data source name (i.e. UA Demo) or anything you like.

9. Click on Add and configure to proceed to the main configuration page.
   a. Enter the server URL opc.tcp://PIINT1:4841 and click on Discover Available Endpoints. You will be prompted to refresh the page.
   b. From Discovered Endpoints menu select the one with [None:None:Binary].
Note: OSIsoft strongly recommends using the highest available security profile; employing the [NONE:NONE:BINARY] profile is not recommended for anything else than testing purposes!

10. In Root NodeIds enter our PLC1 **ns=4;s=PLC1** NodeId

11. Export available Type Definitions into the .csv file.

12. Open the file in MS Excel on PISRV1 and check if.

13. For each selected OPC UA Type Definition the connector will create the corresponding AF Template.

14. If the Type Definition is incomplete or even missing, you need to name the AF Template manually.

<table>
<thead>
<tr>
<th>Select</th>
<th>Template name</th>
<th>Attribute name</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>FB_Blower</td>
<td>ns=4;s=MAIN.fBBlower2</td>
</tr>
<tr>
<td>x</td>
<td>rSetFillLevel</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rSteamDemand</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>CtrlProgramType</td>
<td>ns=4;s=MAIN</td>
</tr>
<tr>
<td>x</td>
<td>FB_OutputPipe</td>
<td>ns=4;s=MAIN.fBBlower1Pipe1002</td>
</tr>
<tr>
<td>x</td>
<td>rSteamDemand</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rSteamFlow</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>FB_Drum</td>
<td>ns=4;s=MAIN.fBBlower2.Drum1001</td>
</tr>
<tr>
<td>x</td>
<td>rFillLevel</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rFlowIn</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rFlowOut</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>FolderType.E5BE2B02</td>
<td>ns=4;s=PLC1.ParameterSet</td>
</tr>
<tr>
<td>x</td>
<td>bAutoMode</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>counter</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rMaxSteamerPressure</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rMaxFillLevel</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rMaxValveState</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>ConfigurableObjectType</td>
<td>ns=4;s=PLC1.Tasks</td>
</tr>
<tr>
<td>x</td>
<td>FB_InputPipe</td>
<td>ns=4;s=MAIN.fBBlower1Pipe1001</td>
</tr>
<tr>
<td>x</td>
<td>rFeedwaterRate</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>rValveOpening</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>UnifiedPtType</td>
<td>ns=4;s=PLC1</td>
</tr>
<tr>
<td>x</td>
<td>DeviceManual</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>DeviceRevision</td>
<td></td>
</tr>
</tbody>
</table>

15. Save the .csv file

   a. Place it back to PIINT1 to the location of your choosing
   b. Load it back in the Data Source configuration page
   c. Save it
16. Go back to the Overview page and start the PI Connector.
17. In PI SMT check if PI Points were created.
   a. By default, they have **OPC UA** point source.
   b. In addition, in Boilers AF database check the Element structure created and AF Templates. Below is the comparison of the structure in OPC UA Server and in AF Server.
11.5 Group Recap Question – PI Connectors

The following questions are intended to reinforce key information presented in this chapter or section.

Answer the following questions:

1. What other type of data can be buffered by PI Connectors internal buffer beside time-series data?

2. Can you administer multiple PI Connectors on multiple servers from a single computer?

3. Why does stopping the PI Connector in Administration UI does not also stop the PI Connector Windows Service?

4. To which databases on Data Archive does the PI Connector identity need Read & Write access?
12. PI Buffer Subsystem

Objectives

- Describe PI Buffer Subsystem
- Configure PI Buffer Subsystem
- Validate the function of the PI Buffer Subsystem

Throughout this section, you will refer to various sections in the *PI Buffer Subsystem User Guide*. Please open this document.

12.1 What is PI Buffer Subsystem?

Data sent from the PI Interface to the Data Archive are redirected to the buffering process, which stores and forwards events to the home node.

If data flow to any of the associated Data Archives is interrupted, then data are buffered to a queue file. When the buffering process is shut down, the data are still located in the queue file. Using FIFO (first-in, first-out), the data are then flushed to the Data Archive. Multiple interfaces on a single data acquisition computer share the same buffering process and store data in the same buffer queue file.

When connection is reestablished to the associated Data Archives the buffers are flushed chronologically until all data has been transferred.

Tip

Unless you have a specific reason why you do not want to preserve your data, you should always configure buffering for PI Interface!

PI Buffer Subsystem runs as an automatic Windows service under either a Local System or custom service account, which is recommended option.

12.2 The Buffering Mechanism

How does it work?

Put simply, the buffering mechanism intercepts the data as the interface sends it and the buffering application manages the communication between the data collection computer and the Data Archive.
There are three buffers used to process events: two memory buffers and a file buffer. Depending on the amount of data being buffered, the buffering process can be in one of three states. Initially, it uses a single memory buffer. When that fills, it switches to using dual memory buffers. When these buffers become full, it switches to using dual memory buffers and a file.

There are three distinct stages in the PI Buffer Subsystem data that flows from the PI Interface to the Data Archives. These stages are:

1. **Data Validation and Compression Marking:** PIbufss consumes the data, validating timestamps and values. If point-level compression is enabled, events are marked either as snapshot only or to be archived.

2. **N-Way Splitting and Queuing:** Once validated and marked for compression, all events are stored in, as many queues as there are targeted nodes (pibufq_<GUID>.0000.dat). The GUID generated is unique for each Data Archive. Non-replicated Data Archives require only a single queue.

3. **Sending Data to the Data Archive:** Whenever the corresponding Data Archive is running and accepting data, queued events are sent to the remote server’s Snapshot Subsystem. There events marked to be archived goes through Event Queue and Archive Cache into the Archive Subsystem for permanent storage.
12.3 Exercise – Configuring the PI Buffer Subsystem

Let’s have our way with Buffering.

Exercise Objectives

- Configure Buffering
- Validate data is being buffered
- Configure and verify buffering on a data acquisition node.

Problem Description

If the Data Archive is shut down or disconnected from the network, you need to have data buffering installed and configured on the data acquisition computer to avoid data loss.

Before You Start

- On PISRV1 in PI SMT create a new mapping to PIInterfaces&Buffer PI Identity for account PISCHOOL\PIBuffer_SVC.

Approach

1. Use the PI ICU to open the Buffering Manager.
2. To enable buffering on a data collector, follow these steps in PI ICU. (Buffering is configured through entries in the piclient.ini file.)
3. Select Buffering from the Tools menu in PI ICU.
4. Select Continue with configuration.
5. Check the Data Archive to confirm the PI Interfaces and services for which you want to configure buffering and click Next.
6. The next step will grant you the possibility to manage the security used by the PI Buffer Subsystem to connect to the Data Archive. By default, the Windows account to run the PI Buffering service is **LocalSystem**. Click on **Change** and enter the account `PISCHOOL\PIBuffer_SVC` - Click **Next**.

---

6. The next step will grant you the possibility to manage the security used by the PI Buffer Subsystem to connect to the Data Archive. By default, the Windows account to run the PI Buffering service is **LocalSystem**. Click on **Change** and enter the account `PISCHOOL\PIBuffer_SVC` - Click **Next**.

---

7. This account does not have access to the Data Archive. Select **PI mapping** option. Browse for PI identity `PIInterfaces&Buffer` and click **Create**. Buffering manager will re-run the security test and the access is now granted.
8. Select the Buffer Queues location. For this environment set the location to \PIBuffer. OSIsoft strongly recommends not having the buffer queue on the same drive as the OS to avoid failure on the interface node by filling the main drive.

9. The last window will run a verification on the status of the PI Buffer Subsystem. If there are no errors, exit the installation wizard.
10. Once the installation wizard completed and closed the Buffering Manager window will open showing the status and statistics of the PI Buffer Subsystem.

**Tip**

**Caution**: The Buffering mechanism will *NOT* collect data unless it starts *BEFORE* an interface.

After configuring OPCInt and buffering through the PI ICU, pibufss is added to the service dependency.

11. Restart the PI ICU to show the new field **Buffering status** in General tab. It should be **On**.
12. Data should go through the PI Buffer Subsystem. You can restart the PI Interface for OPC DA service to be sure.
12.4 Directed Activity - Validating Data Buffering

How it is possible to verify that our data are buffered.

Activity Objectives

- Validate that PI Buffer Subsystem is collecting data

Approach

On the Data Archive:

1. Create a PI Vision display showing the data from one of your OPC points for the last hour.

On the data collector computer:

2. Validate that you are buffering data from the previous directed activity. Use `%pihome64%\bin>pibufss –cfg`. If you see SendingData then events are flowing through.

3. Disconnect the data collection computer from the network or alternatively shut the Data Archive down by running pisrvstop.bat as Administrator or type command `%pihome64%\bin>pibufss –bc stop`

4. Monitor the buffered queue with `%pihome64%\bin>pibufss –qs`.
In the screenshot above you can see that the **Events in Queue** are increasing.

5. Wait a few minutes to build up buffered data. (you can check your PI ProcessBook display for a “flat line”)
6. Now reconnect the interface computer to the network or restart the Data Archive or type `%pihome64%\bin\pibufss –bc start`.

In the screenshot above you can see that the number of **Events in Queue** is now zero and the queued data were flushed. When there are no events queued, **Total Event Writes** and **Total Event Reads** counters need to match.

7. In PI Vision display, verify the data is recovered from the buffer.

In the Buffering Manager, the buffering statistics update automatically in order to show the Global Buffering Status, the estimated buffer capacity, the events in queue, and the total events sent in real time:

![Buffering Manager Screenshot](image)

The Global Buffering Status in green, the event in queue not increasing, and total events sent value increasing indicates a healthy and working PI Buffer Subsystem.

Objectives

- Describe the function of the PI License in the connecting logic
- Describe how users connect
- Describe the security implications of working on the server box
- Describe the ACL syntax and how access is granted
- Create and manage PI identities
- Configure PI mappings
- Configure PI database security
- Configure PI point security
- Configure PI security settings

For the PI System to be useful people have to be able to get critical data to make decisions. In this chapter, we will address the methods and best practices for allowing users proper access to their data.

13.1 Difference between Data Archive and AF Server security

A PI System has two components: Data Archive and AF Server. Data Archive as well as AF Server (starting from AF Server 2.7 version) cannot be directly tied to Active Directory.

In the Data Archive, we can set security on a PI Database or PI Point. In AF Server on Databases, Elements, Analysis, Templates etc. using PI Identities and AF Identities. We create mappings (or if necessary trusts on Data Archive; AF Server uses only WIS) to grant connections access and to decide with which PI Identity or AF Identity that connection is associated.
Caution: Do we do not recommend using piusers and pigroups as they are less secure than PI Identities.

Having logged into the computer via corporate windows account, the CEO is automatically authenticated on the Data Archive or AF Server. To accomplish this, PI System uses mapping of users’ active directory group to a PI Identity or AF Identity. The identity specifies the read/write permissions for accessing both configuration settings and data on the Data Archive and on the AF Server.

13.2 The PI License Subsystem

The PI License subsystem has the capability to determine what applications are allowed. However, as of the current version the only elements that are actually metered is the point count and percentage match to the machine configuration from the MSF file which should have not drop down below 50% match.

Applications may generate messages such as:

```
0 pinetmgr 20-Oct-05 11:34:07
> License Warning (non-fatal): [-12221] Not licensed to use this client application. Level: 3 Process name: PointBuilder.exe(5676) ID: 51
```

You do not need to respond in any way – these are informational.

You can use the License plug in in PI SMT to view your license statistics.

Even though it is not used, a connection will always check with the License Subsystem while connecting.
13.3 Connection Logic

The diagram on the following page illustrates the connection logic for users.

Tip You should avoid using the native piusers and pigroups in your security scheme. They are inherently insecure and are included for legacy systems.

13.4 Working on the Data Archive

A default loopback PI Trust (!Proxy_127!) exists on the Data Archive that grants piadmin access to all applications running locally on the Data Archive machine.

By default, no login is required to use the command prompt utilities on the Data Archive (piconfig, piartool, pidiag, etc.). You can force a login by modifying the CheckUtilitylogin tuning parameter on the Data Archive. For the change to take effect, the Data Archive must be restarted.
13.5 Granting Access

Each connecting user is associated with a PI Identity (or piuser or pigroup) and that PI Identity has permissions explicitly granted by an ACL.

13.5.1 Granting Access – the ACL

An Access Control List (ACL) string defines the access permissions for that entry. Choices are “read” and/or “write.” The syntax is:

```
| Identity1:A(r,w) | Identity2:A(r) |
```

Where Identity1 can read and write and Identity2 can only read.

13.5.2 Granting Access - Application

You will apply the ACL in general in one of two places: the DBSecurity or PI Point attributes. In the DBSecurity Table, you grant access to data structures on a global level. You can also apply access permissions on a point-by-point basis.

13.6 The Database Security Table

In other applications, such as Microsoft SQL Server, each object has their own security control settings. There is the same concept in the Data Archive, and all of the database tables are collected in one place. These are shown in the Database Security plugin in PI SMT.

**Note:** You must have WRITE access to the PIPOINT database to create new points. You do not need this privilege to edit the configuration or data of the points once created. That access is controlled by PI point security.
The table below lists the common database tables used for user access:

<table>
<thead>
<tr>
<th>Database</th>
<th>Controls…</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIDS</td>
<td>Access to Digital States and Digital Sets.</td>
</tr>
<tr>
<td>PI Modules</td>
<td>Access to the Modules. This is an important option as some programs (such as PI ICU) and users may require PI Module Database access.</td>
</tr>
<tr>
<td>PIPOINT</td>
<td>Top-level access to Points, Points Classes and Attribute Sets. Editing existing PI points can be provided through the PI point security configuration on a point-by-point basis.</td>
</tr>
</tbody>
</table>

For more information, see *Data Archive Security Configuration Guide*. 
13.7 Group Discussion – Default Security

How secure do you want to be?

Activity Objectives

- Determine how security is applied

Approach

Open PI SMT. Examine the DB Security Table. Also, examine the security settings for the point SINUSOID in Point Builder. Your instructor will give you a few minutes to complete the answers and then facilitate a discussion.

Use these resources to answer the following questions:

1. What are the default security permissions for the objects in the DB Security table (hint – there are two)?

2. Why would no read access be provided for PI World identity for some of the tables?

3. What is the default security setting for the PIPOINT database table?

4. What scenarios can you think of that would require different settings for PI Point security?

5. One table allows PIWorld Write access. Which one is it, and why would it be configured that way?
13.8 Managing PI Identities and Mappings

The Identities, Users, & Groups plug-in in PI SMT allow you to create and manage PI Identities, PI Users and PI Groups. Several entries are created by default during installation. When configured, you can use the security entries to specify security settings throughout the Data Archive, including PI databases security and PI point security.

Tip

Ideally, you will have one Identity for each Active Directory Group you will use to access the PI System.

About PIWorld Identity

The PIWorld identity represents the Everyone concept of Windows; it specifies the rights of non-explicit users or groups. All authenticated PI Server users automatically get the access permissions defined for PIWorld (in addition to any other access permissions they have been granted).

By default, PIWorld is granted read access to most PI Server databases and objects. You can change the access permissions granted PIWorld, but you cannot delete this identity. The PIWorld identity cannot be used in a mapping or a trust.

You can disable PIWorld. If you do that, then users no longer get PIWorld access along with their explicitly granted access permissions. This is a recommended action for fresh installations of PI System. This can be risky for PI System upgrades. You might be relying on PIWorld access in a number of places without knowing it.
13.9 Exercise – Set Security

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives

- Create PI Identities that will be mapped to Windows Users and Groups
- Configure point security for data access

Problem Description

You have many users requiring access to your PI System, but they all have different tasks to do that require different levels of access to the points. Therefore, you want to grant access to the Data Archive and its resources based user roles.

Your instructor will indicate which domain groups you will map the default PI Identities to:

**PI Engineers** = __ Eric Engineer password: __________________
**PI Operators** = __ Olga Operator password: __________________
**PI Supervisors** = __ Sue Supervisor password: ________________

You need to create a security structure that enforces the following business rules:

- The point **BA:LEVEL.1** is a sensitive financial calculation and it data should only be visible to the Plant Supervisors (PI Supervisors Identity).
- The **BA:CONC.1** point needs to be able to be written to by your Operators (PI Operators Identity). It can be read by anyone.
- Your engineers (PI Engineers) need to be able to edit the attributes of all of the **BA:*** points.

Test your security rules. Here are some suggestions (you may need to log off and on between tests, as different users or use Right Click, ‘Run As’ on PI SMT):
1. Log on as someone not in the Supervisors group and try to search for the point \textbf{BA:LEVEL.1}. What result do you get?

2. Log on as someone not in the Engineers group and try to edit a point. What result do you get?

3. Test the operator access to \textbf{BA:CONC1} with PI SMT – Data – Archive Editor. Can she add or change data in any other point?
13.10 The “Security Slider”

There are several levels of security that can be implemented on the Data Archive. A summary of your setting can be found in the Security Settings plug-in in PI SMT.

In a good security environment, you will set the slider to a minimum of explicit logins disabled. This should not affect you at all if you avoid using piusers and pigroups.

With the new PI API for Windows Integrated Security applied on all data collection nodes it is possible to move the slider to the top level. However to achieve this selection the PI API for WIS has to be installed on Data Archive too. Disabling the API trusts will disable the local loopback trust !Proxy_12! Which is used for local interfaces such as Random and Ramp Soak to connect as they are running under LocalSystem.

1. Create a new mapping to piadmins to BUILTIN\Administrators local group.
2. Install PI API for WIS on PISRV1.
3. Check the Network Manager Statistic, there should be no trust in Trust column, instead local interfaces are now authenticated as Windows User NT AUTHORITY\SYSTEM.
4. Move the Security Slider to the top, click on Save and restart the PI Base Subsystem. Or restart the Data Archive using pisrvstop and pisrvstart.
14. High Availability

Objectives:

- Describe the components of High Availability
- Create a High Availability PI Collective
- Implement PI Interface and PI Connector Failover
- List the limitations of PI High Availability
- Discuss complex architecture scenarios

14.1 Directed Activity – Components of PI High Availability

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section.

Activity Objectives

- Define the components of PI High Availability

Approach

Start with the diagram below:
High Availability requires three (3) components all working together to function properly. These components are:

- PI Interface / PI Connector failover and/or N-Way buffering;
- Data Archive server collective;
- PI Client application failover.

Fill it out until it looks like the one below:
14.2 Data Archive Replication

Data Archives replicate by initially cloning the primary source server. All server metadata is replicated.

Tuning parameters are replicated when the PI Collective is created, but then they are independent, because configurations may vary by server machine and thus it should be possible to modify them on each secondary member(s) too. However, they are not replicated when the collective is reinitialized. Message logs are not replicated because the messages are inherent to the specific machine.

PI HA has separate paths for the same time series data for true replication. This is accomplished by replicating the data as it is collected and distributing the data to each server in the collective. Data replication is achieved in the buffering mechanism.

A replication service keeps static, configuration data (point definitions, digital state sets, and so on.) synchronized between the primary and the clones (referred to as secondary nodes).

14.3 Constraints

The PI HA mechanism was designed to function in a situation where the servers and interfaces are all contained within the same domain, and that the domain has a coherent structure. By coherent structure, we are implying a functioning domain controller with reliable DNS resolution.

In addition, to have proper initialization of the secondary nodes, there needs to be Windows file copy access between the servers. Open the related TCP ports. Consult Appendix A to get more details.

At the buffering level, data is replicated. Any data sent to the Data Archive from a source other than a buffer mechanism is not replicated, only written to a single server. The same situation arises with applications designed to read and write to a single server. Currently these include:

- Performance Equations,
- Totalizer points,
- PI Batch Generator,
- Any custom manual data entry applications that do not use the PI SDK or AF SDK.
- *PI SDK and AF SDK applications can take advantage of PI SDK or AF SDK buffering.*
14.4 Directed Activity – HA Pre-Installation Concerns

In this part of the class, you will perform a learning activity to explore the different concepts presented in this chapter or section. You may be invited to watch what the instructor is doing or perform the same steps at the same time. Your instructor will have directions.

Activity Objectives

- Describe the specifics of the HA Installation

Approach

You have many of the same installation concerns as you would a stand-alone PI System. However, there are differences. Review the section on pre-installation and discuss the differences for the Secondary Data Archives.

Open the book to "Install PI Server and create a Collective" in Data Archive Installation and Upgrade Guide.

Your instructor will give you a couple minutes to scan the docs. Answer the following questions:

Do you need another AF Server install?

How do you get a License file for the Secondary?

What version of the Data Archive do I use?
14.5 Pre-Installation Checks

14.5.1 AF Server

Data Archive requires an AF server to be available before the installation. It can be installed on the same machine as the primary Data Archive or on a different machine.

14.5.2 License

A license file will be required. The license file will have to acknowledge at least one secondary server. The license must be obtained against the Primary PI Server.

Make sure the PI license supports collectives. Validate this by checking the license information in PI SMT under Operation > Licensing. Select Resources from the dropdown and expand pilicmgr.MaxSecondaryNodeCount The Amount Left should be greater than “0”.

![PI System Management Tools (Administrator) - Licensing](image)
14.6 Group Exercise - HA Step 1: Revisit Planning and Hardware

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives
Understand the computers involved in the collective.

Problem Description
You need to organize your collective.

Approach
This exercise makes use of four (4) servers. PISRV1 and PISRV2 will be used to establish the Data Archive Collective and PIINT1 and PIINT2 will be used as the data collectors. The PI Interface for OPC DA and PI Connector for OPC UA will be configured on both data collectors and OPC DA and OPC UA Simulators are installed on one PIINT1.

The AF server used will be the one installed on the same computer as the primary Data Archive.

14.7 Collective Manager

Use the Collective Manager to create new PI collectives, configure existing collectives and their servers, and view the status of collectives.

An icon in the diagram represents each server in the collective. A green check mark on the icon indicates that the server is communicating properly. A red X indicates that the server is unavailable. A yellow warning icon indicates that the server is available but has errors. Status and Connection Status show the associated errors.
14.8 Group Exercise - HA Step 2: Form the PI Collective

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives

Learn how to create a collective using the PI Collective Manager

Exercise Description

You need to form a collective by combining two existing Data Archives.

Approach

1. Use the pre-installed Data Archive of the same version on the secondary Data Archive machine PISRV2. Go to folder (Un)lock PI Services and run the batch file Unlock services.bat
2. Add the secondary in the primary server’s PI Connection Manager.
3. Use the PI Collective Manager to initialize the secondary.

On each Data Archive, use the Connection Manager in the PISDKUtility tool to add the Data Archives by their hostnames or IP Addresses. When finished, each Data Archive should have both Data Archives in their respective Connection Manager. Make sure you can see both servers in the PI SMT and use your PI SMT to validate that the servers are running.

Once the Data Archives are established, open the PI Collective Manager and establish the collective based upon your two Data Archives. Run the Collective Manager from Start, All Programs, PI System. Go to File, Create New Collective, and answer the questions. When asked if the primary is an existing server or a newly installed server, select “A newly installed Data Archive”.

Whichever Data Archive is to become the secondary server will lose all its data and databases.

You will need to perform the following:

- Name your collective.
- Select the secondary server from the list in the collective manager display.
- Select the archives from the primary that you want to replicate to the secondary.

Collective creation may take some time depending on how many archives you elected to copy, the size of the archives, and the speed of the network.
The Collective Manager will:

1. Code the collective formation
2. Backup the primary server
3. Shutdown the secondary server
4. Replicate to the secondary server from the primary server backup
5. Restart the secondary server.

When this process is complete, you should see two PI Servers with green check icons.

If you do not see these icons, try to **Reinitialize the Collective**.

You should use the **PI Connection Manager** to verify that you have a Collective and not two individual Data Archives.
14.9 Group Exercise - HA Step 3: Prepare the second data collection node

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Exercise Objectives
Preparation for failover exercise.

Problem Description
You need a second, identical interface and connector for the failover scenario.

Approach
The PI Interface for OPC DA, like many applications, is a COM application. The PI OPC Interface communicates with the OPC Server (data source) through the COM layer. When the applications are running on different machines, they must use DCOM – in this instance COM over TCP/IP.

To configure the DCOM settings you must perform the following steps:

1. On the node with OPC DA server, open the Local Users and Groups (lusrmgr.msc) and add PISCHOOL\PIOPCDA_SVC to the Distributed COM Users group.
2. Open the Component Services console (dcomcnfg.exe), go to Computers -> My Computer -> DCOM Config and find OPC Data Access 2.05a Sample Server. Right click and select Properties.
3. At General tab set Authentication Level to Connect.
4. At Location tab select Run application on this computer (this option may be greyed out)
5. At Security tab select Customize for all 3 permissions, click on Edit and add the Distributed COM Users Group and allow all permissions.
6. At Endpoints tab add the Connection-oriented TCP/IP protocol with Use default endpoints option.
7. At Identity tab select This user and enter out PISCHOOL\PIOPCDA_SVC account.
8. On the remote interface node open Component Services console (dcomcnfg.exe), go to Computers and right-click on My Computer and select Properties.
9. At Default Properties tab verify that Enable Distributed COM on this computer is checked and Default Authentication Level is set to Connect and Default Impersonation Level is set to Identify.
Verify that we are now allowed to connect, browse and read data from OPC DA Server remotely by launching the PI OPC Client under the user **PISCHOOL\PIOPCDA_SVC** (you need to navigate to the executable directly in `%PIHOME%\PI OPC Tools\PI_OPCClient`, hold Shift key and right-click on the OPCClient.exe and select Run as different user)

After the verification, configure the second interface exactly as the first one using the same data source, but point it to the **secondary member** of PI Collective in `/HOST` parameter.

**DO NOT START THE INTERFACE YET!**

Do not forget to configure the PI Buffer Subsystem too, also pointing to secondary!

Note that DCOM configuration can get rather complicated. The two steps listed above work in some cases, but as networks become complicated and security gets tighter more care needs to be taken in configuration. There is an extensive manual on setting up DCOM that you may refer to:

See the “**DCOM Configuration Guide**” for more information on DCOM setup.

**Tip**

Many people feel that DCOM is inherently unsecure. Because of these security concerns, OSIsoft recommends installing the PI Interface for OPC DA on the same computer as the OPC Server. Of course you cannot avoid this in an HA situation.

The PI Connector for OPC UA does not use DCOM to communicate with OPC UA Server anymore, but OPC.TCP protocol. No extra configuration is necessary. Just configure PI Connector the same way as on first data collection node.

**Caution**: Remember that PI Connectors are not Collective aware, so **add both members** to the PI Data Servers list.

**DO NOT START THE CONNECTOR YET!**

Do not forget to add PISRV2 to the PI Data servers list on PIINT1 for PI Connector for OPC UA. Unlike the PI Buffer Subsystem, the PI Connector buffer is not capable to add another member of the collective automatically!
### Overview

#### Connector details

#### Status of the connector

Connector running as PISCHOOL\PIOPCUA_SVC

- **Connector is stopped** - Start connector

#### Data sources

- **UA Demo** (Status unknown)

  Add or modify data sources

#### Servers configured to receive data from the connector

- **PI Data server** : PISRV1  Disconnected
- **PI Data server** : PISRV2  Disconnected
- **PI Asset server** : PISRV1  Disconnected

Add or modify servers

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives

Learn how to test n-way buffering.

Exercise Description

Look at the pump point data on the secondary server. Is it being updated? Why?

You have implemented HA. Test that data is being replicated across your Data Archives in the Collective.

Approach

1. Use `pibufss -cfg` to verify the connections to the Data Archives, or use the Buffering Manager from the ICU.
2. Use `pibufss -ss` to check the amount of data going to the servers.
3. Break the connection between the buffer and a server and use `pibufss -qs` to show the accumulation of data in the buffer or see the Buffering Manager.
4. Restore the connection between buffering and the Data Archive and verify that buffered data is sent to the server. Errors such as those should resolve to show a screenshot like:
For checking the status of PI Connector buffer navigate to Diagnostics section and PI Data Servers tab.
15. Failover Defined

15.1 PI Interface Failover

To minimize data loss during a single point of failure within a system, many PI Interfaces provide two failover schemes:

- **Phase One**: heartbeat synchronization through the data source
- **Phase Two**: heartbeat synchronization through a shared file.

---

**Tip**

Phase 1 is appropriate in two situations: (1) if performance degradation occurs using the shared file or (2) read/write permissions for the shared file cannot be granted to both interfaces.

---

15.1.1 Phase 1

Phase 1 UniInt Failover uses the data source itself to synchronize failover operations and provides a hot failover, no data loss solution when a single point of failure occurs.
For this option, the data source must be able to communicate with and provide data to two interfaces simultaneously. Additionally, the failover configuration requires the interface to support outputs – data is written back to the data source. *This is something that many SCADA engineers view with apprehension, and as such is not recommended.*

15.1.2 Phase 2

Phase 2 UniInt Failover uses a shared file to synchronize failover operations and provides for *hot, warm,* or *cold* failover.

The Phase 2 hot failover configuration provides a no data loss solution for a single point of failure similar to Phase 1. However, in *warm* and *cold* failover configurations, *you can expect a small period of data loss during a single point of failure transition.*

15.2 PI Connector Failover

Only a few PI Connectors currently support failover. The ones that do support failover do not need to communicate with the data source or a shared file like PI Interfaces do, but they communicate directly with each other. If the communication is successful, the connector communicates its own status to the other connector. As long as both connector instances have reliable data source communication, one of the connectors assumes the active role and other takes a backup role. The active connector sends data to both Data Archive and AF Server and the backup connector discards the collected data. PI Connectors support currently *only HOT* failover.
Failover may occur in the following scenarios:

**Starting and stopping the connector**

When one connector is stopped or shut down, it sends a stopped state to its peer, and the peer connector assumes the active role. When the stopped connector is started again, it takes the backup role. The connectors do not support automatic fail-back to the connector that was previously active. In other words, when the original primary comes back online, it will not initiate another failover scenario.

**Data Source connection loss**

When an active connector loses its data source connection, it sends the information about its own data source status to the backup connector. Upon receiving the data source disconnection status from the active connector, the backup connector assumes the active role provided it has a good data source connection. If the backup connector does not have a reliable data source connection, both connectors continue in the same role until one of them resumes a reliable data source connection.

**Force transition to active role**

You can transition the backup connector into an active role by clicking the *Made node active* button at the Failover section of PI Connector UI.

**Connection loss between connectors**

When connector peers cannot communicate with each other, both become active connectors. In this scenario, duplicate data might be sent to PI System. When the connection resumes, both connectors negotiate their data source status, eventually one connector relinquishes the active role, and the other one becomes the backup.
15.3 Group Exercise - HA Step 5: Implement Failover

This activity is designed to maximize learning in a specific topic area. Your instructor will have instructions, and will coach you if you need assistance during the activity.

Exercise Objectives

Implement interface and connector failover.

Exercise Description

You have a working interface/connector and a backup interface/connector. You need to make them work together so when one fails the other takes over. For PI Interfaces configure PHASE 2 HOT Failover.

Approach

Configure the Shared File

1. Choose a location for the shared file. The file can reside on one of the interface nodes but OSIsoft strongly recommends that you put the file on a dedicated file server that has no other role in data collection. In this classroom, it will be simplest to put it on one of the interface computers.

2. Setup a file share folder and assign the permissions so that both primary and backup interfaces have read and write access to the file.

Configure the Interface Parameters

3. Use the Failover section of the PI ICU to enable failover and create two (2) parameters for each interface:
   - Failover ID number for the interface.
   - Failover ID number for its backup interface.

4. Failover ID for each interface must be unique and each interface must know the Failover ID of its backup interface.

Select The Synchronization File Path And File To Use For Failover.

5. Select the HOT type of failover.

6. Ensure that the user name assigned in the Log on as: parameter in the Service section of the PI ICU is a user that has read and write access to the folder where the shared file will reside.

Note: The first interface to start will create the file.
7. All other command line parameters (beside the /HOST) for the primary and secondary interfaces must be identical.

Configure the Digital State Set / PI points
9. Right-click on the Digital State point and select **Create UFO_State Digital State Set on Server** … to create the required digital state set.

10. Right-click on the points and select **Create all points (UFO Phase 2)** to create seven (7) PI points for the interface: the **Active ID, Heartbeat1, Heartbeat2, Device Status 1, Device Status 2, Interface 1 State, and Interface 2 State**.

Repeat for the second interface. You will not have to recreate the digital state set or failover points.
Before you start testing, start Interactive message logging:

```bash
pigetmsg -f
```

This file is in `%pihome\adm` folder, or use the PISDKUtility if you are typographically challenged. On the other hand, select ‘View current PI message log continuously’ from the ICU menu bar.

In order to test that failover is working correctly you will have to have a properly running interface and then start the second. You should see that interface start and become the “Backup.”

Then you can stop the “primary” interface and you should see the change reflected in each log file.

---

**Tip**  
If you have PI ProcessBook you can watch the data on each server and see that it does not get interrupted.

For PI Connector for OPC UA failover configuration at the administration page go to Failover section and **Enable failover**

Enter the Peer Connector Hostname and Peer Connector Port and save. Do the same on the other node and save the configuration. Start the other connector.

Test failover by clicking on **Made node active** button on the backup connector admin page.
After a few seconds of transition period...

…the roles are switched.
15.4 Group Exercise - HA Final Step: The Road Test

This group activity is designed to maximize learning in a specific topic area. Your instructor will have instructions and will coach you if you need assistance during the activity.

Exercise Description
Test the system to make sure all the failover and redundancy solutions are working.

Approach
Perform any or all the following actions:

1. Build a new display in PI Vision with objects displaying the point updated by PI Interface for OPC DA.

2. Using the PI SMT tool, add a random point to the collective by copying CDT158 to CDT69 on the primary server. Returning to PI Vision, failover as necessary until you are connected to the secondary server. Use PI Search to verify that CDT69 exists on your secondary server.

3. Shut down the Primary Data Archive (using %piserver%adm\pisrvstop.bat).
   - Is your PI Vision trend active? Did it switch connections?
   - Check %PIHOME%\bin\pibufss -qs on the primary data collection computer (the one that has that status in the active points) – is the data for the Primary Server queuing?
   - Try to add another Random point. Can you do it?
   - Check your Collective Manager on the secondary server – what does it show?
   - Restart the Primary Data Archive

4. Shutdown the Secondary Data Archive
   - Is your PI Vision trend active? Did it switch connections again? Did the Primary Data Archive lose data while it was down, or did the buffer work?
   - Check %PIHOME%\bin\pibufss -qs on the primary interface computer (the one that has that status in the active points) – is the data for the Secondary Server queuing?
   - Try to add another Random point. Can you do it?
   - Check the Collective Manager on the primary server – what does it show?
   - Restart the Secondary Data Archive
   - Use PI SMT – did the Secondary Server pickup your new Random point? Did the buffer work for the Secondary Data Archive such that you did not lose data?

5. Stop the primary interface (with the ICU or System Services Applet)
   - Did the other interface pick up data collection properly? Do you have updates in PI Vision?
   - Do the Interface Status and Heartbeat points look appropriate?
   - Check the PI Message logs on the interface computers using the PISDKUtility
Failover Defined

- Check pibufss -qs on the secondary interface (now with the primary status). Is it processing data for both servers?
- Restart the primary interface and check for a good start.

7. Stop the “Backup” interface (with the ICU or System Services Applet)
   - Did the other interface pick up data collection properly?
   - Do you have updates in PI Vision?
   - Do the Interface Status and Heartbeat points look appropriate?

Lastly, restart the Backup Interface. Validate that both Data Archives and both interfaces are running correctly.
16. Final Exercise (Optional)

This is a solo activity designed to test your understanding of the material in this course. Ask for assistance if needed. Don’t waste your time just wondering.

Exercise Objectives

- Demonstrate your new skills
- Install and test a simple PI system across different computers.
- Install PI Server (Data Archive and AF)
- Install the PI Interface for OPC DA; configure the interface and buffering
- Build and test points and buffering
- Build AF elements and create templates
- Connect data archive points to AF element attributes
- Show element data in PI Vision display

Problem Description

Your company is implementing a PI System in a plant purchased as part of a corporate acquisition. You are assigned the task of implementing the PI System.

Your success in working with the PI System at your facility has put you right at the top of the list of people to implement the new system. Use the skills learned this week to implement this PI System, from interface to displaying the data to your users.

Fortunately, the facility is small. There are 2 units, each with a number of elements as can be seen from the diagram below. Unfortunately, the process control people were less than helpful when naming the instrument tags and they may not match your AF and point nomenclature.
You will be given a new XML file that replaces the OpcDa20Server.config.xml that is in C:\Program Files (x86)\OPC Foundation\Data Access\Bin

*High Availability is not part of this exercise.*

**Approach**

Alone or in collaboration with others:
- Install the required software on each of the computers
- Implement buffering
- Build and test the points
- Create a new AF database
- Build AF elements and a simple PI Vision display

### 16.1 Preparation

Record the machine information in the following table:

<table>
<thead>
<tr>
<th>Machine</th>
<th>IP Address</th>
<th>Hostname</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI Server</td>
<td></td>
<td>PISRV1</td>
</tr>
<tr>
<td>PI OPC Interface</td>
<td></td>
<td>PIINT1</td>
</tr>
<tr>
<td>Client computer</td>
<td></td>
<td>PIINT2</td>
</tr>
</tbody>
</table>

### 16.1.1 Installation

Install the software on the appropriate machines.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI Server</td>
<td>AF Server, Data Archive Server</td>
</tr>
<tr>
<td>PI OPC Interface</td>
<td>PI ICU, PI OPC Interface,</td>
</tr>
<tr>
<td>Client computer</td>
<td>PI System Management Tools, PI System Explorer</td>
</tr>
</tbody>
</table>

Answer the following questions:
- How did you validate that the Data Archive is installed and functioning properly?
- How did you validate that the AF Server is installed and functioning properly?
16.2 Build Points and Configure Buffering

Install and configure the interface. Use the PI OPC Client to output a list of points on the OPC Server for use in PI Builder.

Make sure you use mappings and not trusts for the security configuration on the interface and buffering. Answer the following questions:

- Is the interface connecting with the proper security (no piadmin mappings)?
- Is buffering intercepting the data? How did you prove this?
- Is data making it to the PI Server and ultimately to the client?
16.3 Build and Test AF Assets

- Using AF templates build the AF structure for the assets in your facility. It may look like the picture to the left.
- Construct an analysis rule that calculates the difference between Pump 1 flow and the Pump 5 flow such that the history is available. **Hint:** You will need to create a writable PI point that receives the output of the calculation.
- The flow units for the flows are l/min for the points and L/s in AF. Resolve this discrepancy, similarly for hPa and kPa on the pressure measurements.
- You may want to show all measurements in the AF using US customary units.
- Note the form of the Item ID below.

Answer the following questions:

- Do your asset attribute values show correctly in PI System Explorer?
- What is the authentication method?

16.4 Visualizing Data

Build a PI Vision **element relative** display showing your equipment.

Answer the following questions:

- Can you switch between the assets seamlessly when a new display created?
- Do your element values show correctly in PI Vision?

Finished!

Plenty of drawing space below...
17. Appendix A – Ports

You will have to open certain network ports for the applications to communicate.

The following ports may need to be opened on a firewall to allow access to the PI System or other associated services. This information is found under OSIsoft Technical Support Knowledge Base Articles # 2820OSI8, KB00751 and KB01162.

<table>
<thead>
<tr>
<th>Port</th>
<th>Service - Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>WINS - Windows name resolution</td>
</tr>
<tr>
<td>53</td>
<td>DNS - Name resolution</td>
</tr>
<tr>
<td>80</td>
<td>HTTP, HTTPS, SharePoint - for PI WebParts, iViews, PI Vision</td>
</tr>
<tr>
<td>88</td>
<td>Kerberos - Windows 2000, XP authentication</td>
</tr>
<tr>
<td>123</td>
<td>NTPNetwork - Time protocol, for clock synchronization</td>
</tr>
<tr>
<td>135</td>
<td>DCOM port mapper - Windows authentication, DCOM applications including OPC. Port is high risk and is usually blocked</td>
</tr>
<tr>
<td>137</td>
<td>NETBIOS Name Service - NetBIOS name resolution. Ports 137 -139 are considered high-risk and are usually blocked.</td>
</tr>
<tr>
<td>138</td>
<td>NETBIOS Datagram Service - Ports 137 - 139 are considered high-risk and are usually blocked.</td>
</tr>
<tr>
<td>139</td>
<td>NETBIOS Session Service - Ports 137 - 139 are considered high-risk and are usually blocked.</td>
</tr>
<tr>
<td>389</td>
<td>LDAP</td>
</tr>
<tr>
<td>443</td>
<td>HTTPS and SSL for websites</td>
</tr>
<tr>
<td>445</td>
<td>MS Windows port for accessing administration shares, services, other Microsoft resources, and for initialising a collective.</td>
</tr>
<tr>
<td>636</td>
<td>LDAP SSL.</td>
</tr>
<tr>
<td>1521</td>
<td>Oracle SQL*Net, for iViews</td>
</tr>
<tr>
<td>3268</td>
<td>LDAP GC</td>
</tr>
<tr>
<td>Number</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>3268</td>
<td>LDAP GC SSL</td>
</tr>
<tr>
<td>3389</td>
<td>Windows Remote desktop - Remote desktop for PI server administration</td>
</tr>
<tr>
<td>5450</td>
<td>PI Network Manager (subsystem of the Data Archive)</td>
</tr>
<tr>
<td>5456</td>
<td>ACE - Used by ACE 2 scheduler to allow connections from the ACE Web Service</td>
</tr>
<tr>
<td>5457</td>
<td>Asset Framework (AF)</td>
</tr>
<tr>
<td>5458</td>
<td>PI Notifications</td>
</tr>
<tr>
<td>5459</td>
<td>PI OLEDB Enterprise, PI JDBC Driver</td>
</tr>
<tr>
<td>5459</td>
<td>PI Web Services, PI Vision</td>
</tr>
<tr>
<td>5461</td>
<td>PI JDBC Driver - Used to allow connections to the PI SQL Data Access Server</td>
</tr>
</tbody>
</table>