

GPA Products Overview

Tutorial Session 1

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August 13, 2013

GPA Products

- Grid Solutions Framework
- openPDC
- SIEGate (supersedes openPG)
- openHistorian
- openXDA
- PMU Connection Tester
- GEP Subscription Tester

GPA Project Relationships

Grid Solutions Framework (GSF)

<http://gsf.codeplex.com/>



GSF Implementations:

openPDC / openHistorian / SIEGate

<http://openpdc.codeplex.com/>

Multiple Open Source Projects

Codeplex Hosted

- Grid Solutions Framework
 - <http://gsf.codeplex.com/>
- Secure Information Exchange Gateway (SIEGate)
 - <http://siegate.codeplex.com/>
- Open Source Phasor Data Concentrator (openPDC)
 - <http://openpdc.codeplex.com/>
- Open Historian
 - <http://openhistorian.codeplex.com/>
- PMU Connection Tester
 - <http://pmuconnectiontester.codeplex.com/>

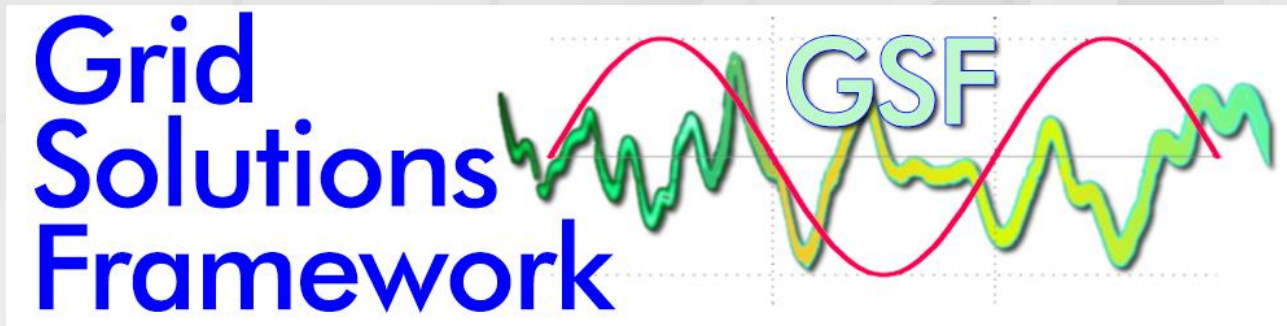
Benefits of CodePlex Hosting

- Team Foundation Server project source control
 - This directly integrates with Visual Studio
- Project contributor forks or patches
 - This allows contributors to suggest formal code updates
- Project release downloads
 - This allows us to control major releases and track downloads
- Discussion forums & mailing lists
 - This allows users to help users and request community help
- Wiki and documentation pages
 - This allows up-to-date online documentation
- Bug and feature request tracker
 - This allows users to post issues for resolution

Accessing Online Documentation

- All online documentation is continually updated by both GPA and contributors.
- Typically you need only go the project's CodePlex site in question and click the "Documentation" tab to get started with system documentation.
- For example, here is the [openPDC Documentation Link](#) - on this page you can navigate to:
 - Getting Started
 - Frequently Asked Questions
 - Major Component Overviews
 - How-to Guides, etc.

GPA Development Framework



Grid Solutions Framework (GSF)

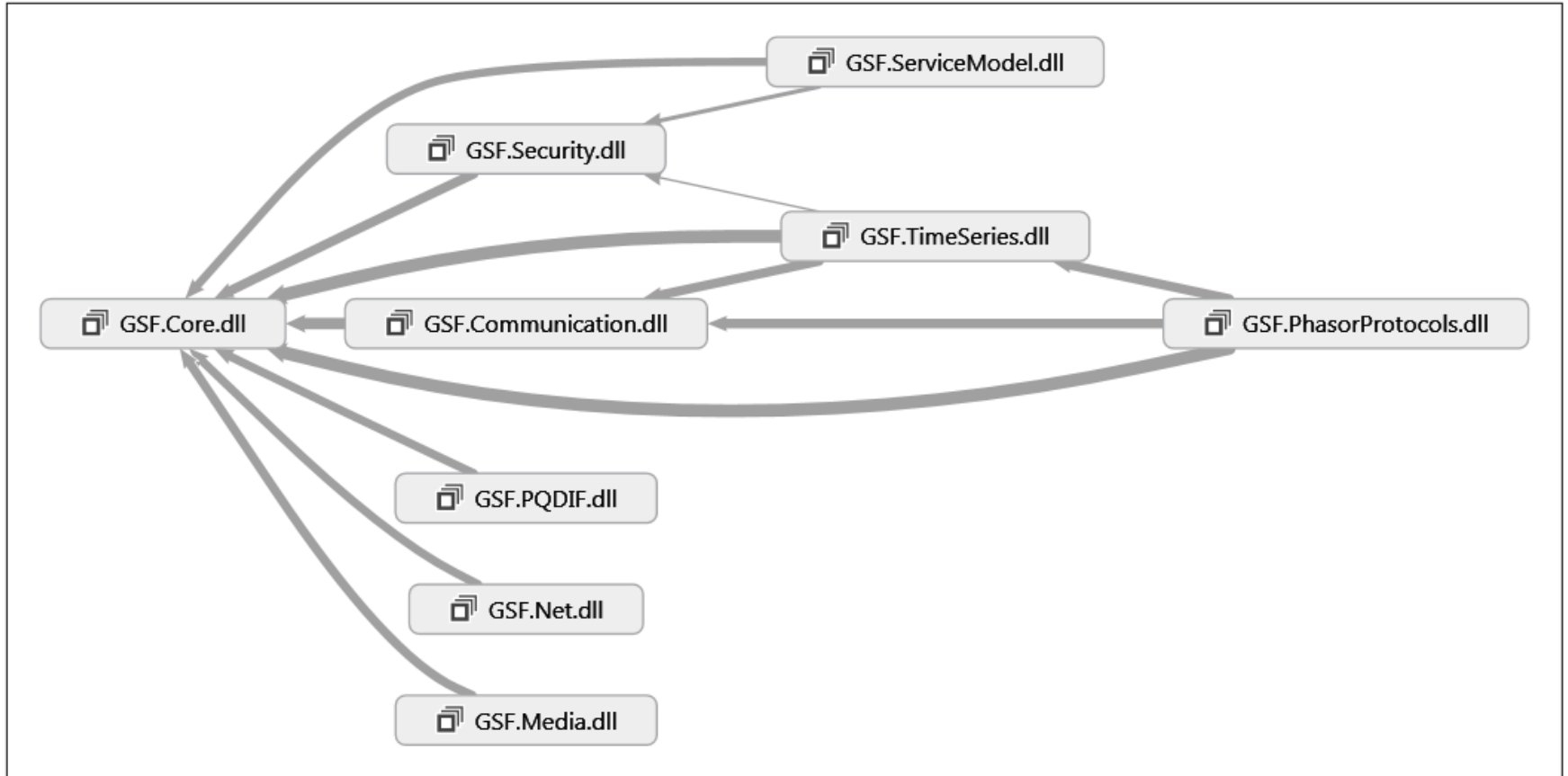
- New software development platform that was initially created as a combination of the Time-Series Framework and the TVA Code Library with a goal to increase performance and security
- Full namespace refactoring and projects targeted to compile with the new Microsoft 4.5 Framework (Released August 2012)
- New core features and improvements are only implemented in the GSF (only a few bug fixes flowed back to the original projects)

<http://gsf.codeplex.com/>

Grid Solutions Framework Purpose

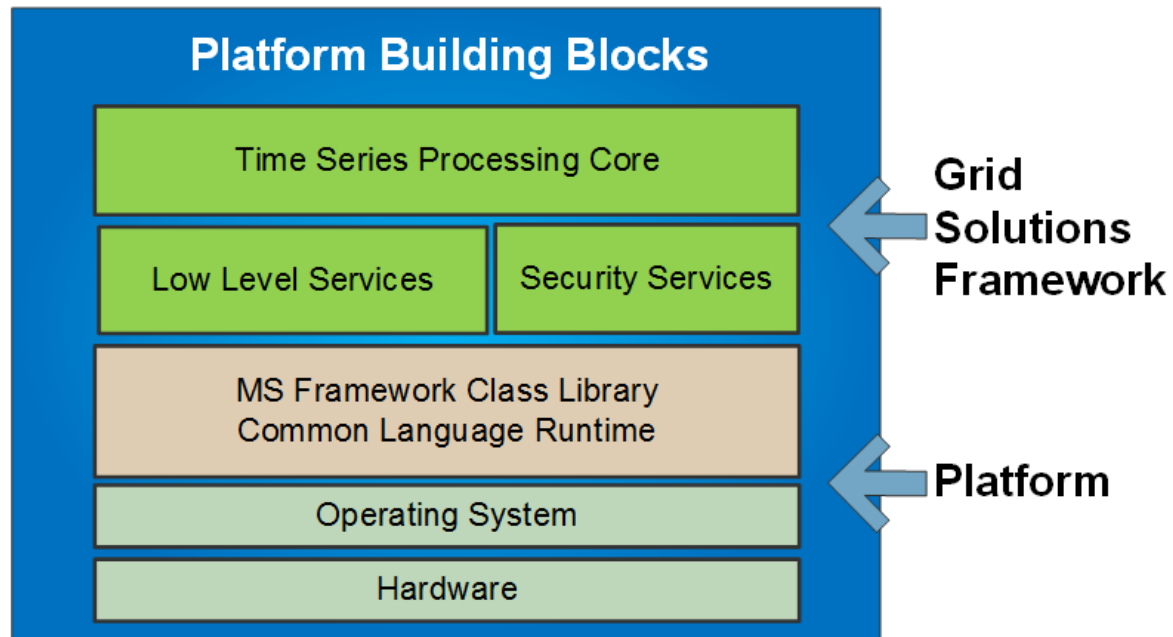
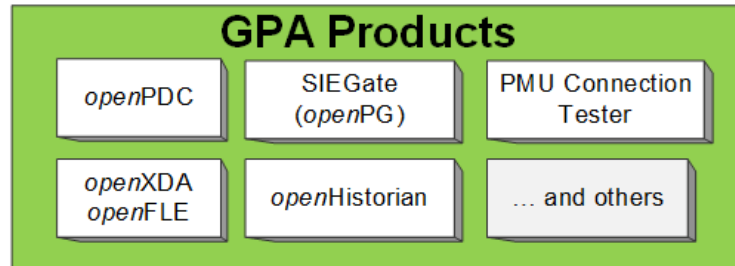
- General purpose open source library of .NET code used by many utilities and various open source projects that contains a large variety of code useful for nearly any .NET project.
- Consists of hundreds of classes that extend and expand the functionality included in the .NET Framework making more complex .NET features easier to use and adds functions not included in the .NET Framework.
- Used since it provides a standard development platform, improves development speed and increases reliability.

GSF Primary Assemblies



**66 Total Assemblies, Over 329,000 Lines of Code and Comments,
200,000 Lines of Code without Comments**

All Latest Products are Built using GSF



GSF Time-series Library

- Core collection of classes used to manage, process and respond to dynamic changes in fast moving streaming time-series data in real-time.
- Allows applications to be architected as measurement routing systems using “Input”, “Action” and “Output” adapter layer.
- Any application can host the framework which will allow a system to become a “real-time measurement bus”.

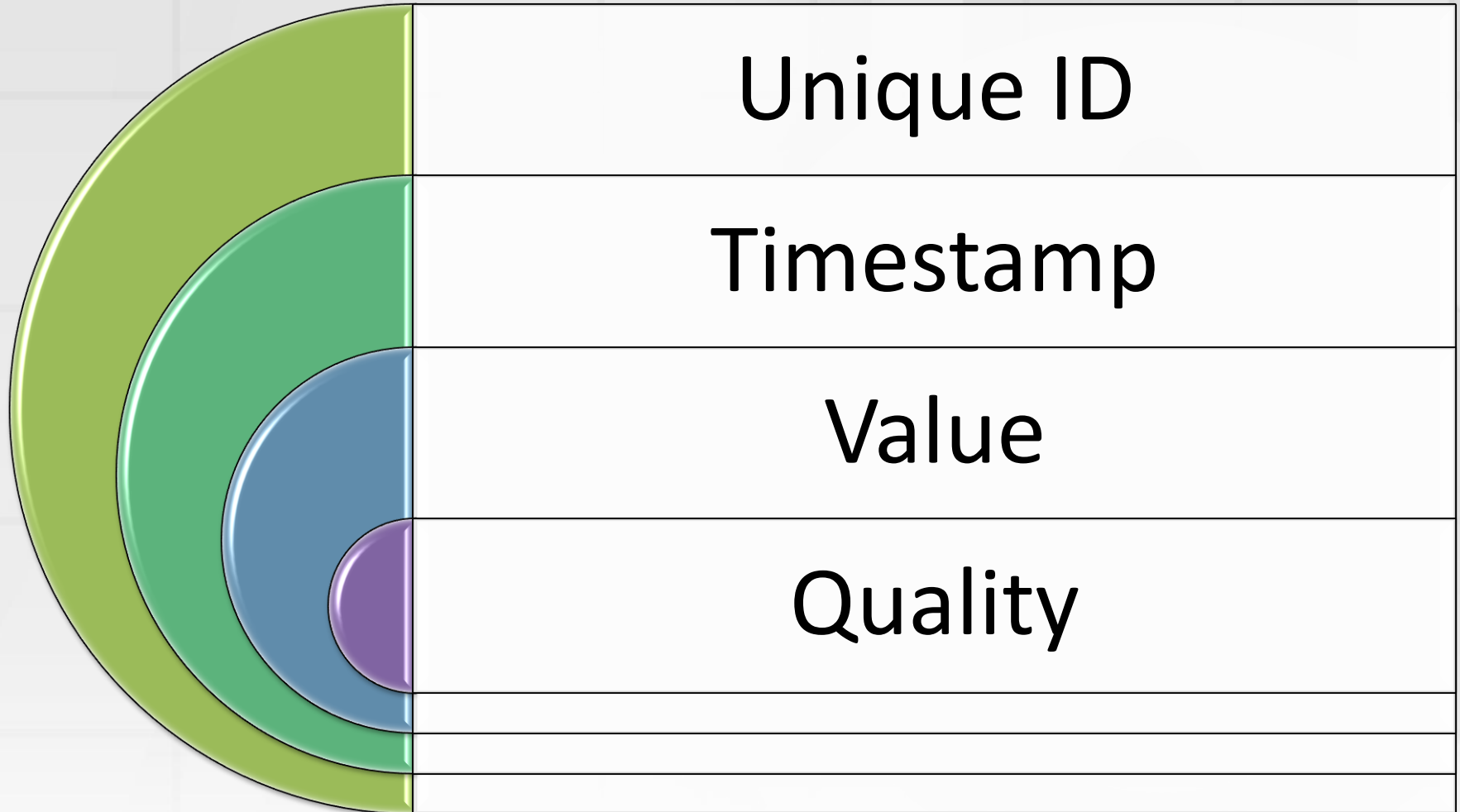
Measurements

- Numeric quantities that have been acquired at a source device are often known as points, signals, events, or time-series values. Inside GSF they are known as ***measurements***:
 - Examples include: temperature, voltage, vibration, location, luminosity and phasors.

Understanding “Measurements”

- A “measurement” as it is understood in the Grid Solutions Framework has many aliases:
 - Signal
 - Point
 - Tag
 - Time-series Value
- The primary components of the measurement are:
 - Timestamp
 - Value
 - Identification

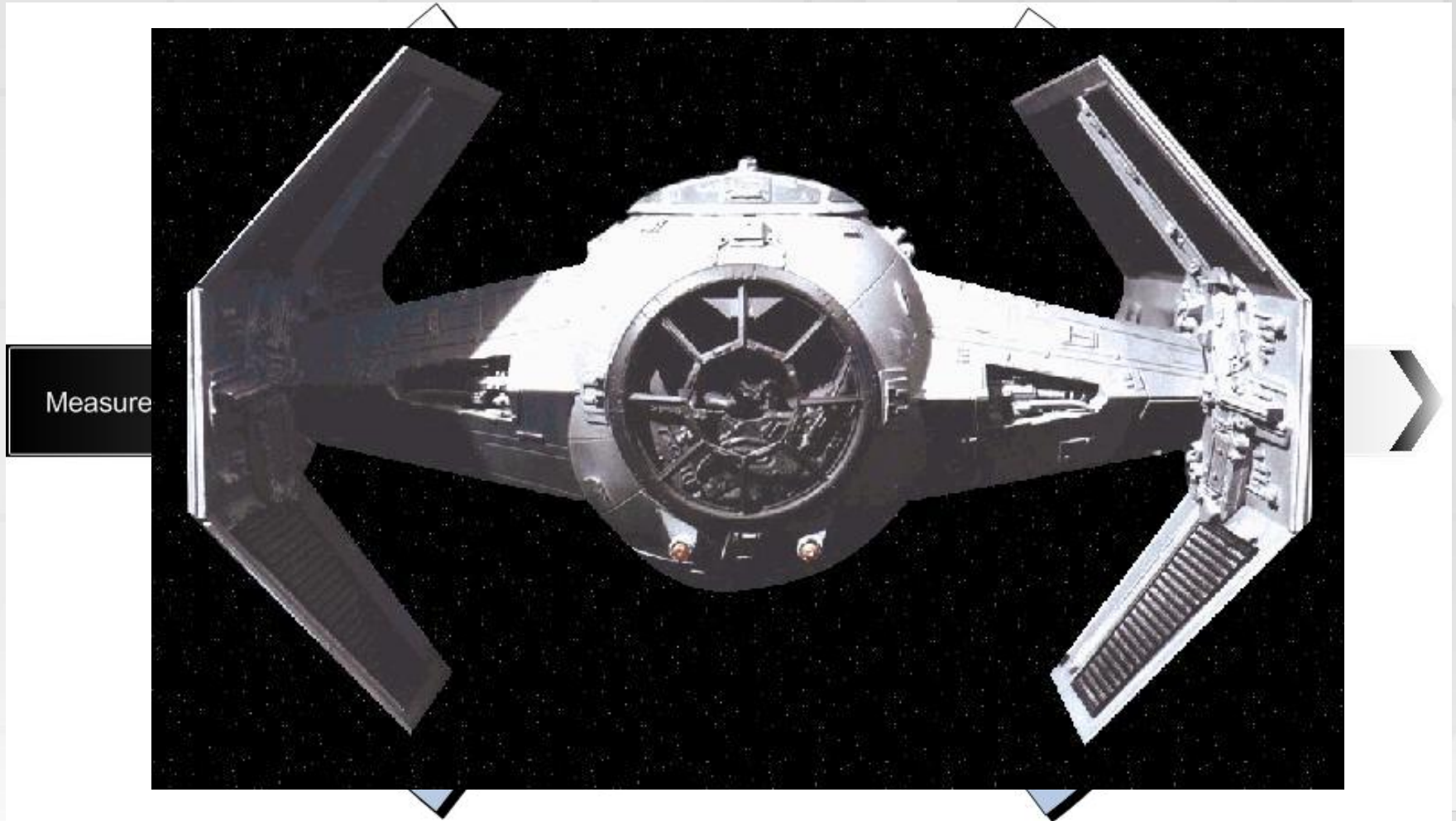
Measurement Structure



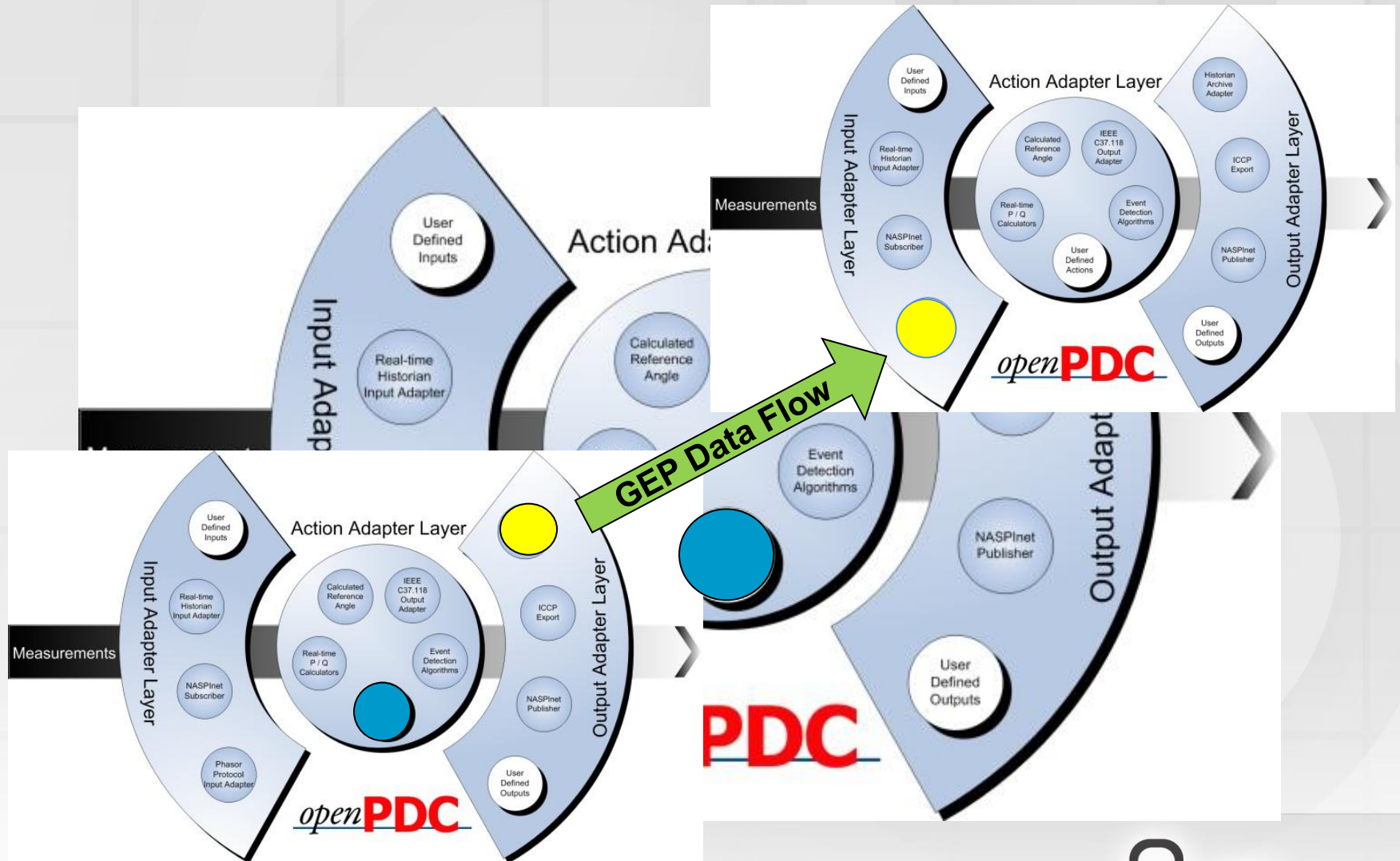
Measurement Identification

- Guid:
 - 128-bit randomly generated integer that is statistically going to be unique in the world, examples:
 - 7ACDEE91-661B-42A0-82C1-081090D0CA38
 - 532863E4-8C3A-4F84-8366-0C8A4711EA6F
 - 4E3548FD-470E-45DF-8C44-138936805BB6
- Measurement “Key”:
 - Two part identifier represented by a “Source” string and a numeric “ID”, examples:
 - PPA:2
 - STAT:42
 - SHELBY:39

Overview of the Adapter Architecture Layer



Scalable Adapter Distribution



Interface Obligations

IInputAdapter

Producer

- Creates New Data

IActionAdapter

**Consumer /
Producer**

- Creates New Data
- Processes Data

IOutputAdapter

Consumer

- Processes Measurements

Ideal Behaviors

Parsing
Mapping
Creation

Processing
Sorting
Creation

Processing
Queuing
Dissemination

Input Adapters

Purpose:
MAP

- Collect and parse streaming data, assign incoming measurements an ID.

Output Adapters

Purpose:
QUEUE

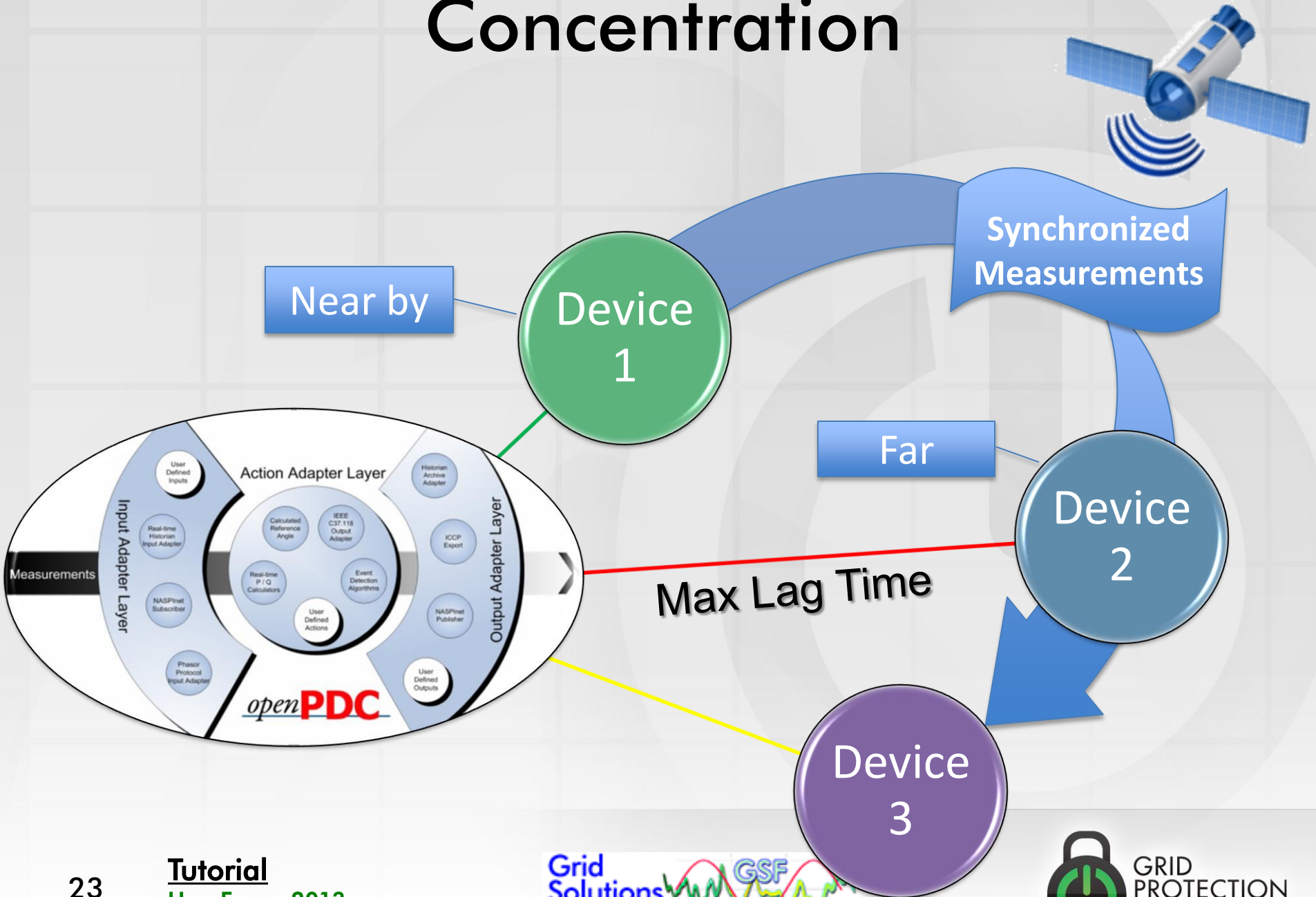
- Queue up measurement data for transmission to archival systems.

Action Adapters

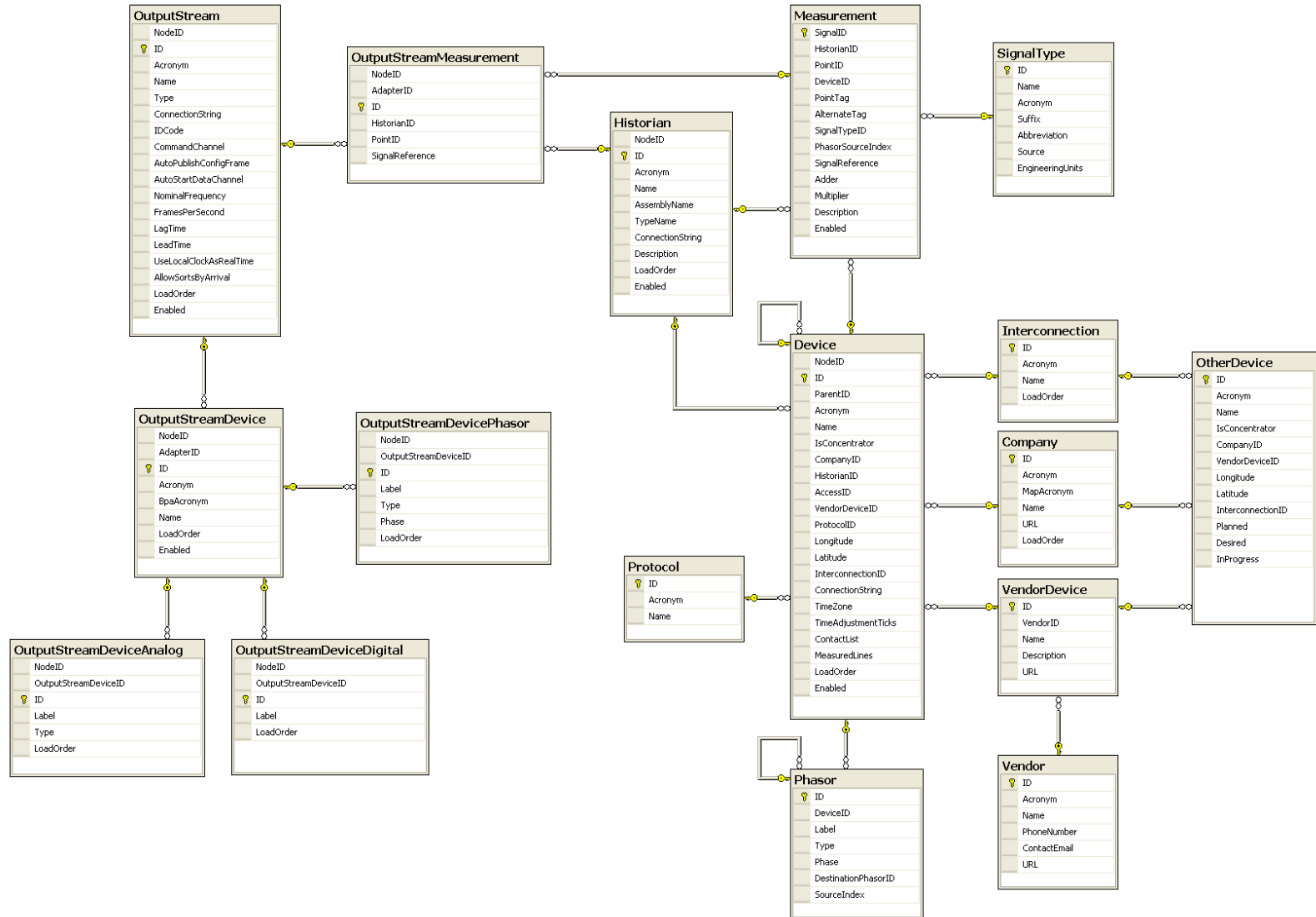
Purpose:
SORT

- Sort measurement data by time and process the data for same time-slice.

Concentration



The Configuration Data Structure



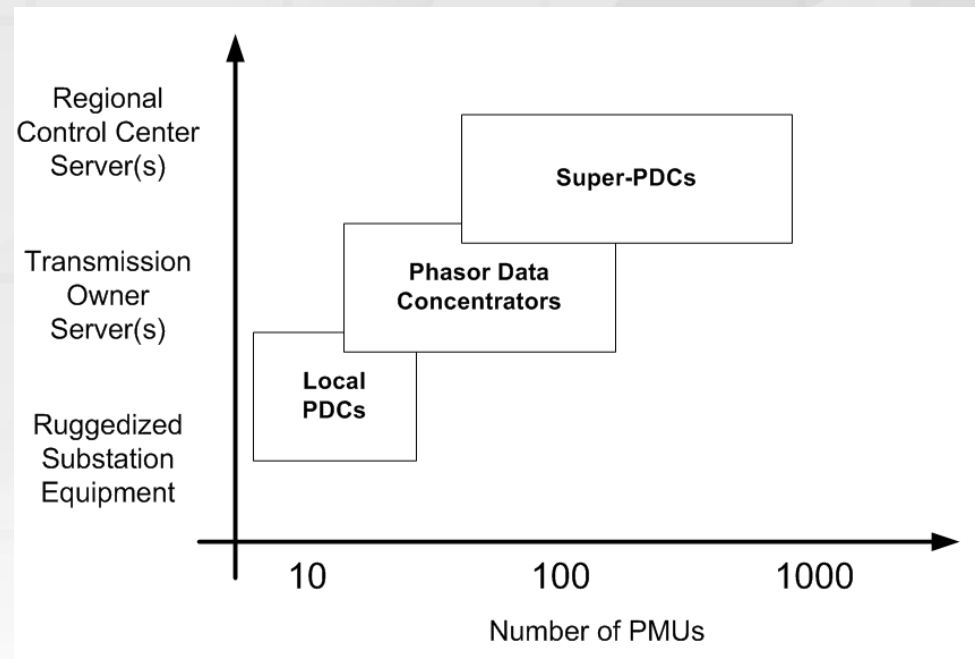
Phasor Data Concentrator



What is a PDC?

- *Phasor Data Concentrator (PDC)* – Receives and time-synchronizes phasor data from multiple PMUs to produce a real-time, time-aligned output data stream. A PDC can exchange phasor data with PDCs at other locations. Through use of multiple PDCs, multiple layers of concentration can be implemented within an individual synchrophasor data system.

From NERC RAPIR Report Draft, June 2010



How is a PDC typically used?

- To create a time-synchronize measurement data set
 - In the substation
 - For the Transmission Operator
 - For the Reliability Coordinator
- To distribute phasor data to applications
- To parse C37.118 for use by other systems

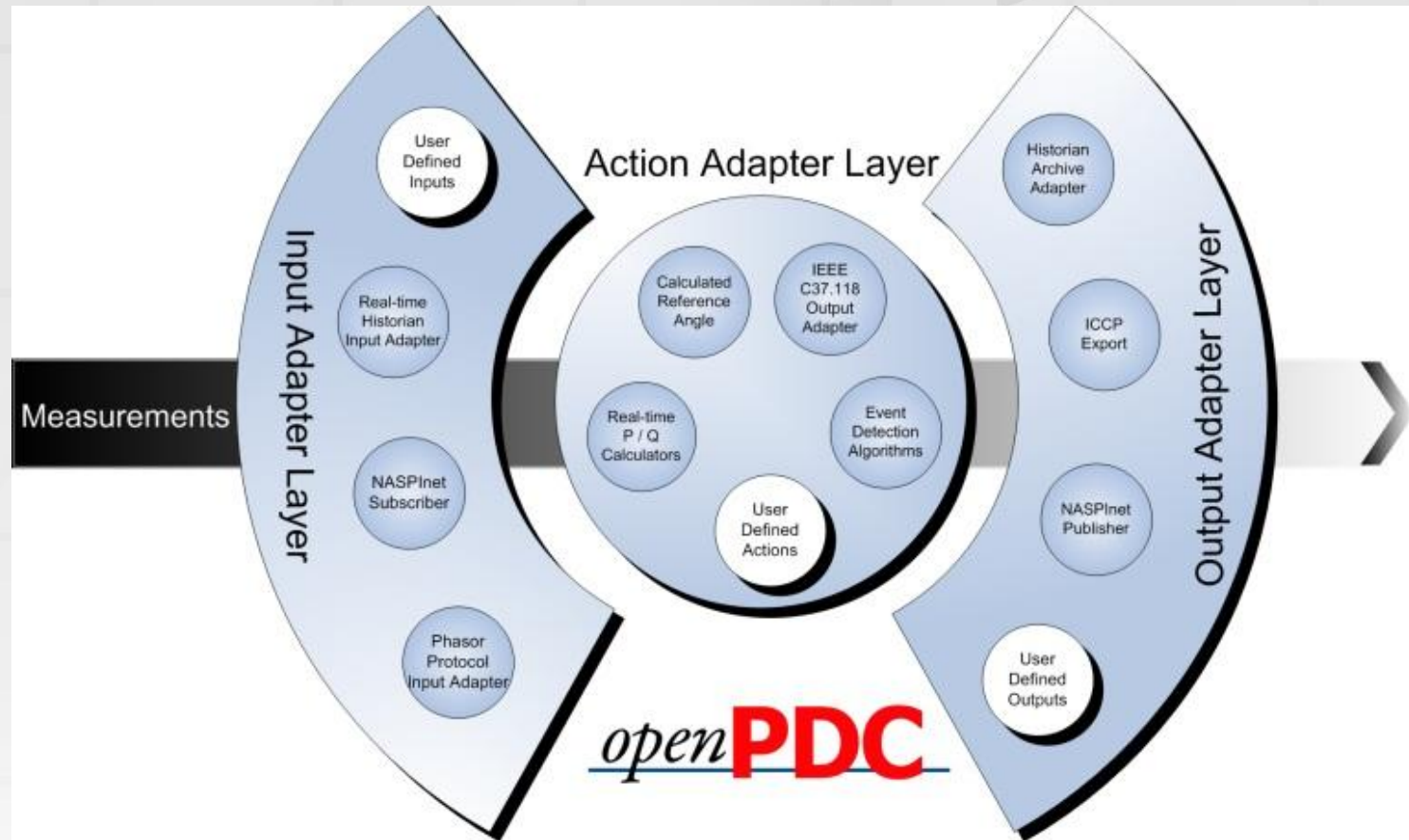
Who “touches” a PDC?

- A PDC is like an RTU-Data Concentrator for a SCADA system
- PDC’s are back-office tools, administered by specialists, that are likely to soon be part of critical infrastructure
- For compliance and good configuration control, PDC change is tightly managed

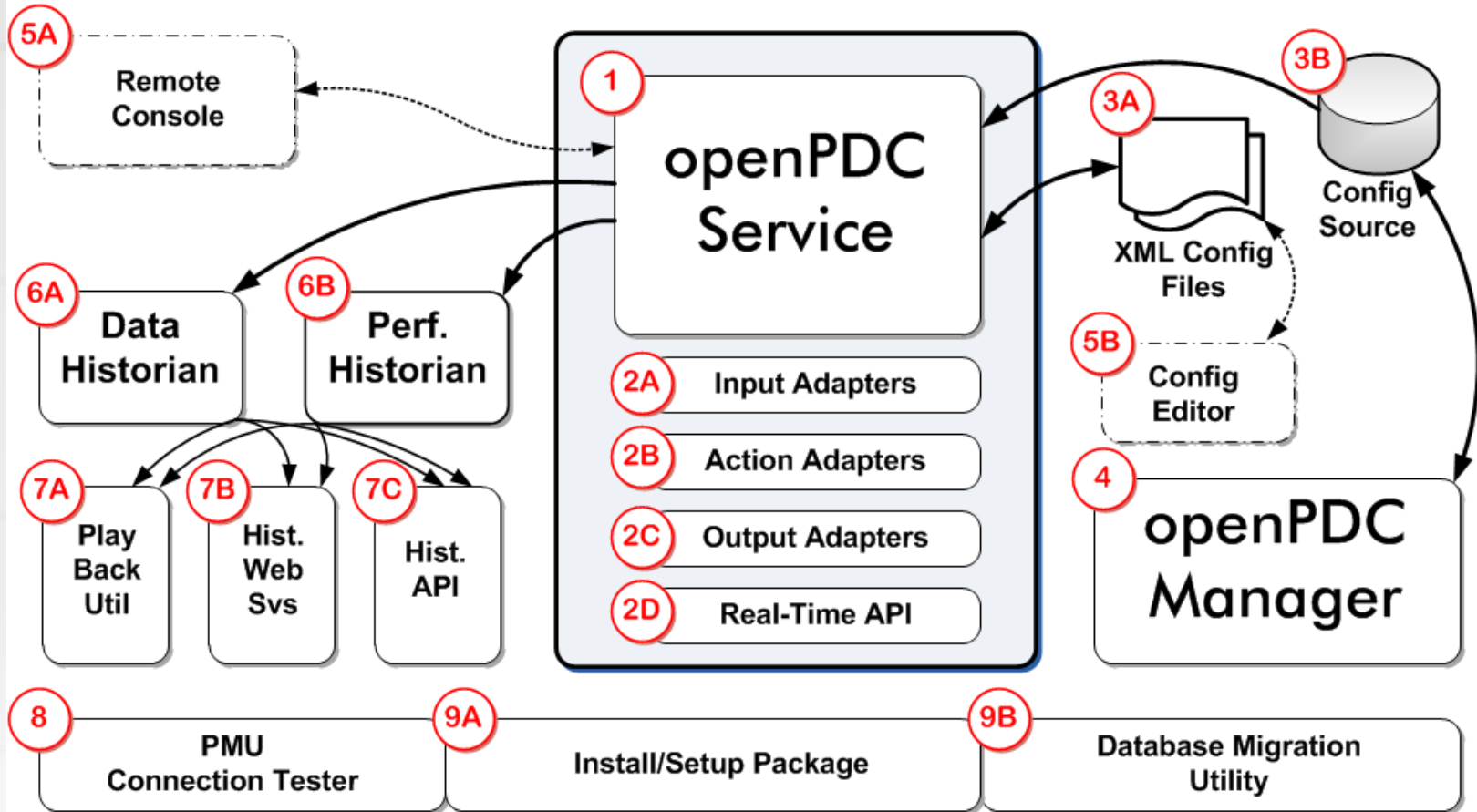
Who are some PDC Vendors?

- GPA – openPDC
- Alstom Grid – openPDC & Psymetrix
- Electric Power Group – ePDC
- Schweitzer
- General Electric
- Kalkitech

openPDC is adapter based



openPDC Components



openPDC Features

- High performance for the largest of installations
- Extreme configuration flexibility
- Preserves data integrity of incoming data streams
- Produces down-sampled real-time data streams
- Independently handles real-time and archival functions
- Horizontally and vertically scalable
- Low-latency, preemptive frame publishing
- Included performance historian logs highly granular operational statistics
- Extensible through the creation of input, action or output adapters
- Many instances can be remotely configured through a single configuration application
- A growing and active open source community

openPDC Specifications

- Input Protocols
 - IEEE C37.118-2005
 - IEEE C37.118-2011 (Beta)
 - IEC 61850-90-5
 - SEL Fast Messaging
 - Macrodyne N and G
 - IEEE 1344-1995
 - BPA PDC Stream
 - UTK FNET
 - DNP3 (Beta)
 - Gateway Exchange Protocol (GEP)
- Output Protocols
 - IEEE C37.118-2005
 - BPA PDC Stream
 - Gateway Exchange Protocol (GEP)
 - Inter-Site Data (ISD) purchased from Alstom Grid

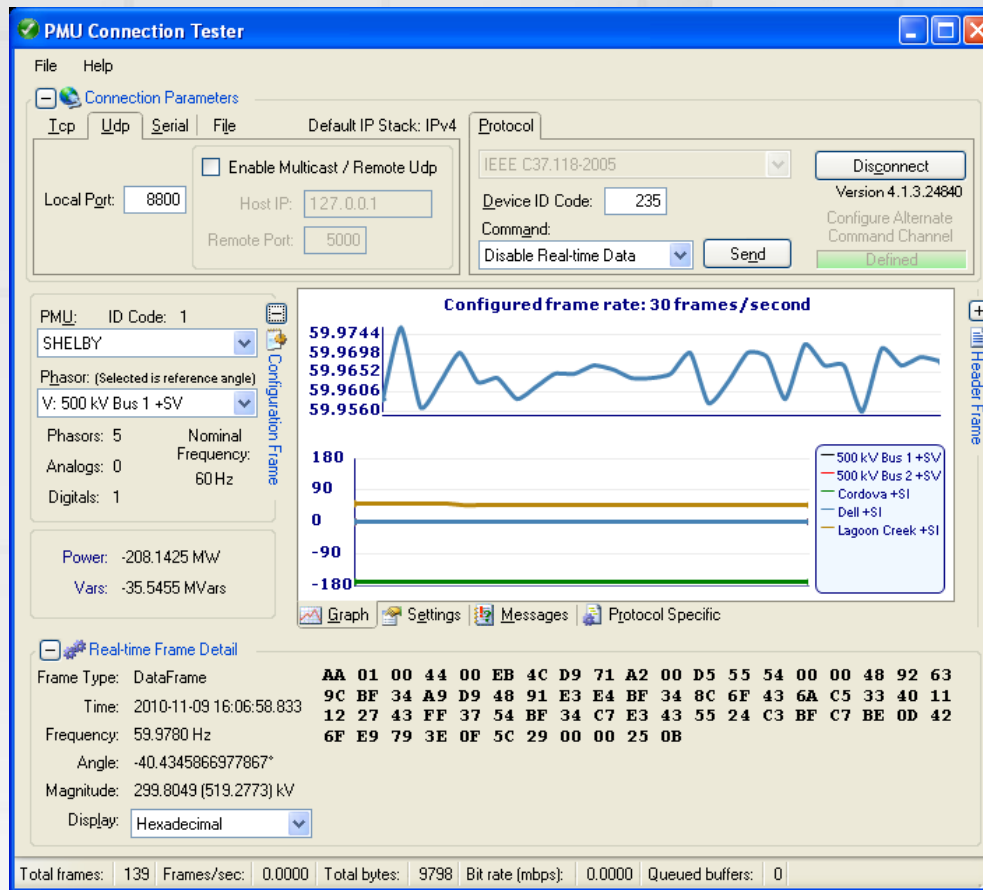
openPDC Specifications

(continued)

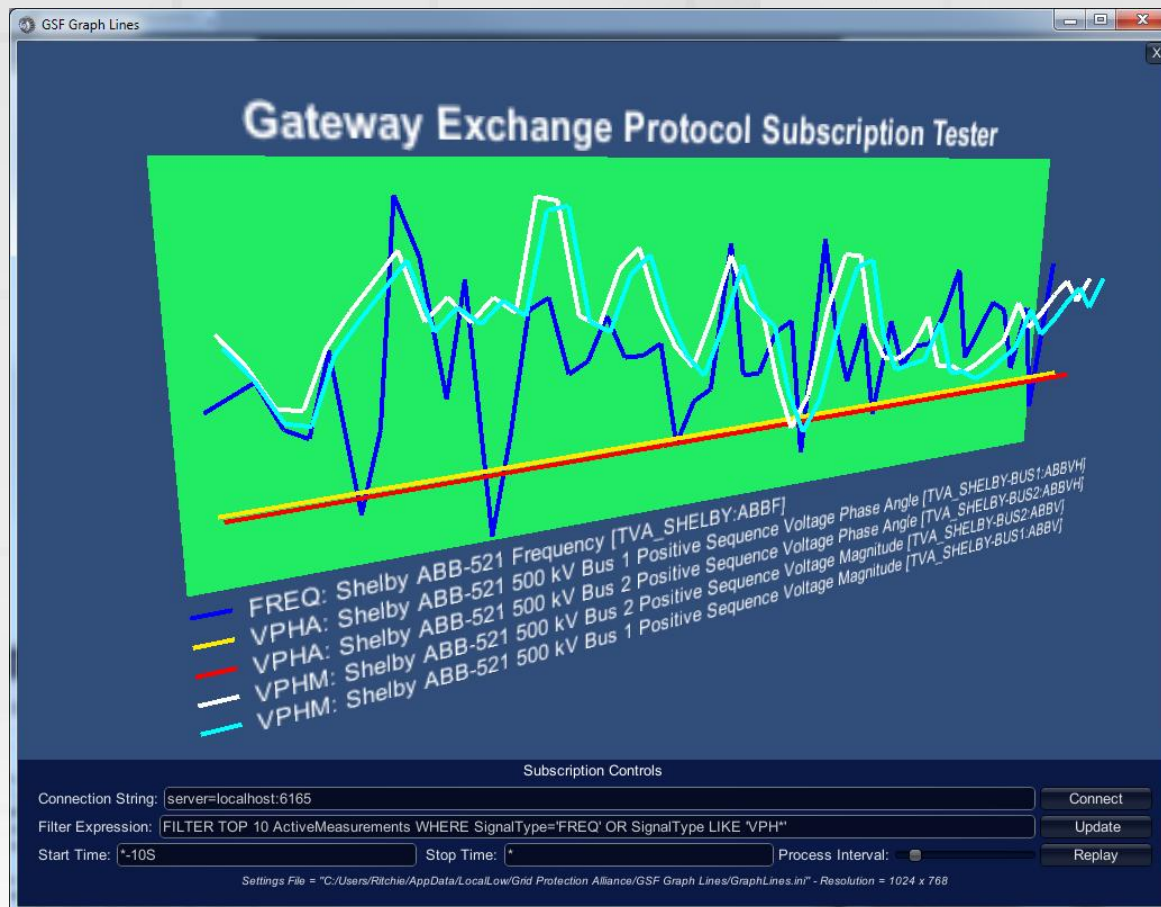
- Communications Standards
 - TCP – IPv4 and IPv6
 - UDP Unicast and Multicast, IPv4 and IPv6
 - Serial (input only)
- Operating System
 - Windows Server 2008, R2 recommended
- Hardware Requirements
 - Multi-processor / multi-core systems recommended
 - Tested on single core, fanless systems with as little as 2 GB of RAM
- Configuration System
 - A relational database is recommended to house configuration data. Supported databases are:
 - MS SQL Server
 - MySQL
 - Oracle
 - SQLite

PMU Connection Tester

Included with openPDC



GEP Subscription Tester *Included with openPDC*



Who else uses the openPDC?

- In operational service at TVA since 2004
- Other North American production deployments include WECC, OG&E Dominion, Southern Company, Duke, ISO-NE, FP&L, AESO, PG&E and others
- Large community. There have been over 2,000 downloads of the openPDC since version 1.5 was released.

openPDC Manager Home Screen

openPDC Manager - GPA\arkrohne

openPDC Manager

Current Node: Default

Home Devices Outputs Gateway Adapters Monitoring Manage

System Overview

CORDOVA _CORDOVA:F

Quick Links

- Graph Measurements
- Stream Statistics
- Add New Device
- Manage Devices
- Manage Output Streams
- Remote System Console
- Restart openPDC

Current Configuration

Instance Type 64-bit

Server Time 2012-11-06 16:26:13.045

Local Time 2012-11-06 16:26:13.045

Current User GPA\arkrohne

Version Information

Server 1.5.159.0

Manager 1.5.159.0

Database Information

Type SQLite

Name openPDC.db

System Status

System Health (Last Refreshed: 16:26:13.045)

Counter	Last	Average	Maximum	Units
CPU Utilization	1.21	1.82	10.13	Average % / CPU
I/O Data Rate	16.96	64.22	1840.37	Kilobytes / sec
I/O Activity Rate	279.76	162.08	1035.85	Operations / sec
Process Handle Count	903.00	891.32	931.00	Total Handles
Process Thread Count	60.00	58.82	63.00	System Threads
CLR Thread Count	47.00	45.29	51.00	Managed Threads
Worker Threads	1.00	1.08	2.00	Active in Pool
I/O Port Threads	0.00	0.00	0.00	Active in Pool
Thread Queue Size	0.00	0.00	0.00	Waiting Threads
Lock Contention Rate	0.00	0.01	0.20	Attempts / sec
Process Memory Usage	379.42	323.69	379.42	Megabytes
CLR Memory Usage	33.20	20.82	39.52	Megabytes
Large Object Heap	12.93	7.10	12.93	Megabytes
Exception Count	4.00	2.66	4.00	Total Exceptions
Exception Rate	0.00	0.02	0.40	Exceptions / sec
IPv4 Outgoing Rate	3.60	7.76	32.95	Datagrams / sec
IPv4 Incoming Rate	100.17	98.52	148.93	Datagrams / sec
IPv6 Outgoing Rate	0.20	2.55	23.13	Datagrams / sec
IPv6 Incoming Rate	1.00	0.53	2.39	Datagrams / sec

Statistics calculated using last 120 counter values sampled every 5.0 seconds.

openPDC Manager Home Screen

The screenshot shows the openPDC Manager interface. A green box with the text "Select Instance to Configure" has an arrow pointing to the "Current Mode: Default" dropdown menu. Another green box with the text "Select Point to Display in Real Time" has an arrow pointing to the "_CORDOVA:F" dropdown menu. The main content area displays a line graph with a blue line fluctuating between 59.96 and 60.04. Below the graph is a table of system statistics.

Counter	Units
I/O Activity Rate	Average % / CPU
Process Handle Count	Kilobytes / sec
Process Thread Count	Operations / sec
CLR Thread Count	Total Handles
Worker Threads	System Threads
I/O Port Threads	Managed Threads
Thread Queue Size	Active in Pool
Lock Contention Rate	Waiting Threads
Process Memory Usage	Attempts / sec
CLR Memory Usage	Megabytes
Large Object Heap	Megabytes
Exception Count	Megabytes
Exception Rate	Total Exceptions
IPv4 Outgoing Rate	Exceptions / sec
IPv4 Incoming Rate	Datagrams / sec
IPv6 Outgoing Rate	Datagrams / sec
IPv6 Incoming Rate	Datagrams / sec

Statistics calculated using last 120 counter values sampled every 5.0 seconds.

Connect to a Device

openPDC Manager - GPA\arkrohne
Current Node: Default

Home Devices Outputs Gateway Adapters Monitoring Manage

Manage Device Configuration

Phasors Measurements

Acronym * MULTI
Name
ID Code (Access ID) * 235
Company Select Company
Protocol IEEE C37.118-2005
Connection String transportprotocol=Udp;localport=5000;server=233.123.123.123;remoteport=5000;interface=0.0.0.0;
Data Loss Interval * 5
Allowed Parsing Exception * 10
Delayed Connection Interval * 5
Longitude
Interconnection Select Interconnection
Concentrator Select Device
Time Zone Select Time Zone
Frames Per Second 30
Historian PPA
Device Vendor Select Vendor Device
Alternate Command Channel
Time Adjustment Ticks * 0
Parsing Exception Window * 5
Measurement Reporting Interval * 100000
Latitude
Skip Disable Real-time Data Allow Use Of Cached Configuration Auto Start Data Parsing Sequence Concentrator
Runtime ID 9 Initialize Connect On Demand Enabled
Delete Clear Save

Concentrator Device List

Acronym	Name
BULLRUN	Bullrun
COLLINSVILLE	Collinsville
CORDOVA	Cordova
CUMBERLAND	Cumberland
HENDERSON	Henderson

Connect to a Device

The screenshot shows the 'Manage Device Configuration' window in openPDC Manager. The interface includes a navigation menu (Home, Devices, Outputs, Gateway, Adapters, Monitoring) and a main configuration area. Annotations with green boxes and arrows point to specific fields:

- Name of Connection:** Points to the 'Acronym' field, which contains the value 'MULTI'.
- Connect to another PDC:** Points to the 'Connection String' field, which contains the text: 'transportprotocol=Udp;localport=5000;server=233.123.123.123;remoteport=5000;interface=0.0.0.0;'. A green plus sign icon is visible next to this field.
- Set tolerances for Error Reporting and Reconnection Attempts:** Points to the 'Allowed Parsing Exception' field, which contains the value '10'. Other nearby fields include 'Data Loss Interval' (5), 'Delayed Connection Interval' (5), and 'Parsing Exception Window' (5).

At the bottom of the window, there is a 'Concentrator Device List' table:

Acronym	Name
BULLRUN	Bullrun
COLLINSVILLE	Collinsville
CORDOVA	Cordova
CUMBERLAND	Cumberland
HENDERSON	Henderson

Input Configuration

openPDC Manager - GPA\arkrohne

openPDC Manager

Current Node: Default

Home Devices Outputs Gateway Adapters Monitoring Manage

Input Device Configuration Wizard

- Step 1: Configure Connection Settings
- Step 2: Select Device Configuration Settings
- Step 3: Select Devices to Configure * Device acronym already exists in the database.

<input checked="" type="checkbox"/>	Acronym	Name	Longitude	Latitude	Digitals	Analog
<input checked="" type="checkbox"/>	BULLRUN	Bullrun	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	COLLINSVILLE	Collinsville	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	CORDOVA	Cordova	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0

<input checked="" type="checkbox"/>	Label	Type	Phase
<input checked="" type="checkbox"/>	500 kV Bus 2 +SV	V	+
<input checked="" type="checkbox"/>	500 kV Bus 1 +SV	V	+
<input checked="" type="checkbox"/>	Haywood +SI	I	+
<input checked="" type="checkbox"/>	Shelby +SI	I	+
<input checked="" type="checkbox"/>	Benton +SI	I	+
<input checked="" type="checkbox"/>	Freeport +SI	I	+

<input checked="" type="checkbox"/>	Acronym	Name	Longitude	Latitude	Digitals	Analog
<input checked="" type="checkbox"/>	CUMBERLAND	Cumberland	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	HENDERSON	Henderson	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	LOWNDES	Lowndes	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	MARSHALL	Marshall	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	RIDGEDALE	Ridgedale	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	SHELBY	Shelby	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	VOLUNTEER	Volunteer	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/>	CALLAWAY	Callaway	-98.6	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0

Previous Finish

Input Configuration

openPDC Manager - GPA\arkrohne

openPDC Manager

Current Node: Default

Home Devices Outputs Gateway Adapters Monitoring Manage

Input Device Configuration Wizard

Step 1: Configure Connection Settings

Step 2: Select Device Configuration Settings

Step 3: Select Devices to Configure

Click on Row to Expand

Can Edit (override) C37-118 Labels

Acronym	Latitude	Digitals	Analogs
<input checked="" type="checkbox"/> BULLRUN	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/> COLLINGSVILLE	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0
<input checked="" type="checkbox"/> CORDOVA	37.5	<input type="checkbox"/> 0	<input type="checkbox"/> 0

Label	Type	Phase
<input checked="" type="checkbox"/> 500 kV Bus 2 +SV	V	+
<input checked="" type="checkbox"/> 500 kV Bus 1 +SV	V	+
<input checked="" type="checkbox"/> Haywood +SI	I	+
<input checked="" type="checkbox"/> Shelby +SI		
<input checked="" type="checkbox"/> Benton +SI		
<input checked="" type="checkbox"/> Freeport +SI		

Label	Type	Phase
<input checked="" type="checkbox"/> CUMBERLAND	Cumberland	
<input checked="" type="checkbox"/> HENDERSON	Henderson	
<input checked="" type="checkbox"/> LOWNDES	Lowndes	
<input checked="" type="checkbox"/> MARSHALL	Marshall	
<input checked="" type="checkbox"/> RIDGEDALE	Ridgedale	
<input checked="" type="checkbox"/> SHELBY	Shelby	
<input checked="" type="checkbox"/> VOLUNTEER	Volunteer	-98.6 37.5 <input type="checkbox"/> 0 <input type="checkbox"/> 0
<input checked="" type="checkbox"/> CALLAWAY	Callaway	-98.6 37.5 <input type="checkbox"/> 0 <input type="checkbox"/> 0

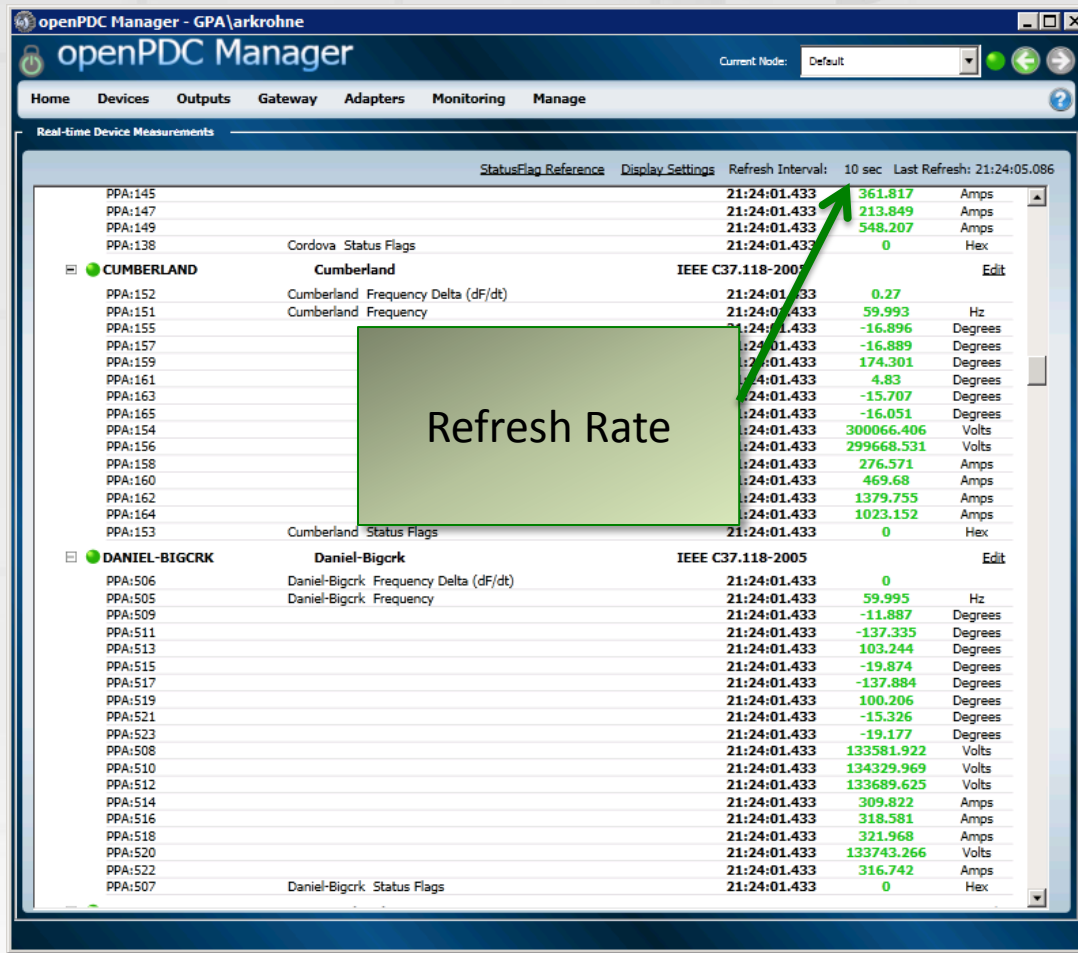
Previous Finish

Review Real Time Values

The screenshot displays the 'openPDC Manager' interface. The title bar shows 'openPDC Manager - GPA\arkrohne'. The main menu includes 'Home', 'Devices', 'Outputs', 'Gateway', 'Adapters', 'Monitoring', and 'Manage'. The 'Monitoring' section is active, showing 'Real-time Device Measurements'. The interface includes a 'StatusFlag Reference', 'Display Settings', 'Refresh Interval: 10 sec', and 'Last Refresh: 21:24:05.086'. The data is organized into two main sections: 'CUMBERLAND' and 'DANIEL-BIGCRK', each with a sub-section for 'IEEE C37.118-2005' and an 'Edit' button. The table lists various PPA units with their corresponding real-time values and units.

PPA ID	Measurement	Value	Unit
PPA:145		361.817	Amps
PPA:147		213.849	Amps
PPA:149		548.207	Amps
PPA:138	Cordova Status Flags	0	Hex
CUMBERLAND			
Cumberland			
IEEE C37.118-2005			
PPA:152	Cumberland Frequency Delta (df/dt)	0.27	
PPA:151	Cumberland Frequency	59.993	Hz
PPA:155		-16.896	Degrees
PPA:157		-16.889	Degrees
PPA:159		174.301	Degrees
PPA:161		4.83	Degrees
PPA:163		-15.707	Degrees
PPA:165		-16.051	Degrees
PPA:154		300066.406	Volts
PPA:156		299668.531	Volts
PPA:158		276.571	Amps
PPA:160		469.68	Amps
PPA:162		1379.755	Amps
PPA:164		1023.152	Amps
PPA:153	Cumberland Status Flags	0	Hex
DANIEL-BIGCRK			
Daniel-Bigcrk			
IEEE C37.118-2005			
PPA:506	Daniel-Bigcrk Frequency Delta (df/dt)	0	
PPA:505	Daniel-Bigcrk Frequency	59.995	Hz
PPA:509		-11.887	Degrees
PPA:511		-137.335	Degrees
PPA:513		103.244	Degrees
PPA:515		-19.874	Degrees
PPA:517		-137.884	Degrees
PPA:519		100.206	Degrees
PPA:521		-15.326	Degrees
PPA:523		-19.177	Degrees
PPA:508		133581.922	Volts
PPA:510		134329.969	Volts
PPA:512		133689.625	Volts
PPA:514		309.822	Amps
PPA:516		318.581	Amps
PPA:518		321.968	Amps
PPA:520		133743.266	Volts
PPA:522		316.742	Amps
PPA:507	Daniel-Bigcrk Status Flags	0	Hex

Review Real Time Values



openPDC Manager - GPA\arkrohne

Current Node: Default

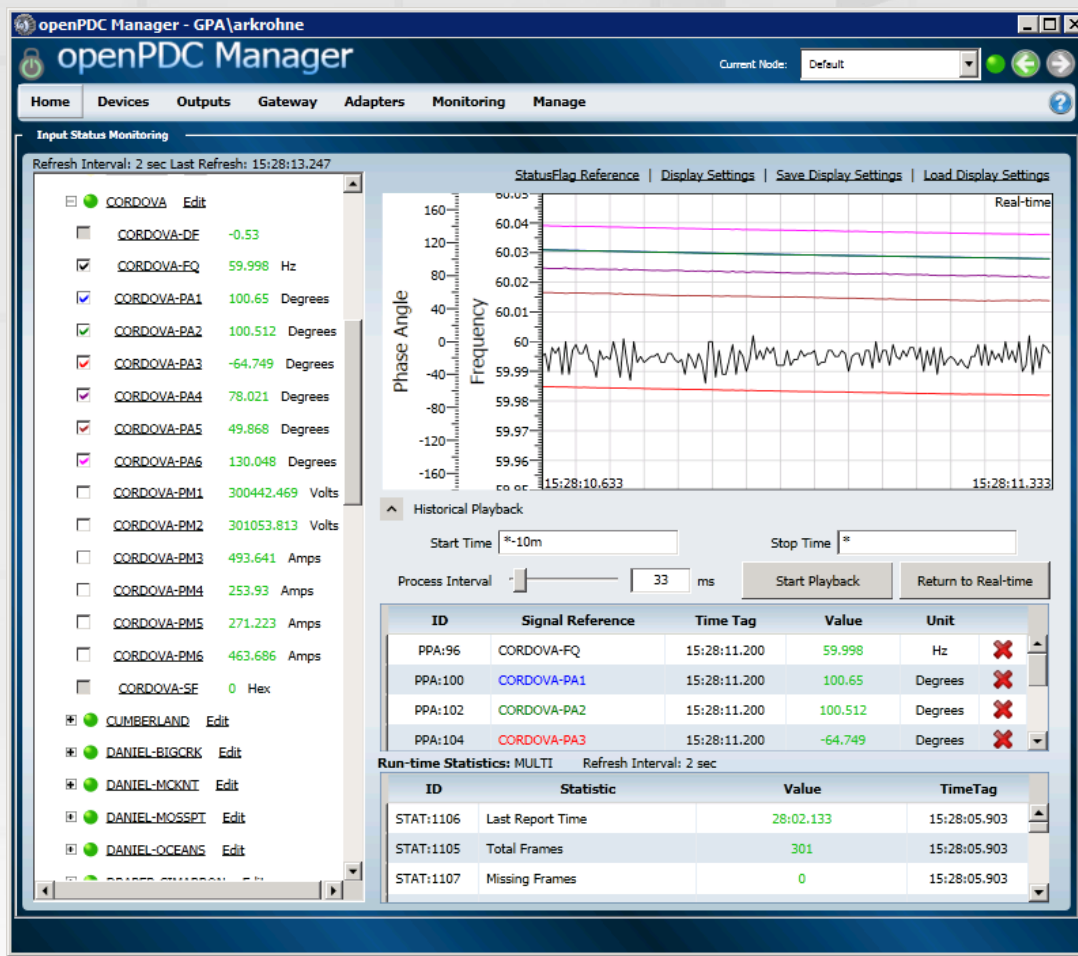
Home Devices Outputs Gateway Adapters Monitoring Manage

Real-time Device Measurements

StatusFlag Reference Display Settings Refresh Interval: 10 sec Last Refresh: 21:24:05.086

Device ID	Measurement	Value	Unit
PPA:145		361.817	Amps
PPA:147		213.849	Amps
PPA:149		548.207	Amps
PPA:138	Cordova Status Flags	0	Hex
CUMBERLAND			
IEEE C37.118-2005			
PPA:152	Cumberland Frequency Delta (df/dt)	0.27	
PPA:151	Cumberland Frequency	59.993	Hz
PPA:155		-16.896	Degrees
PPA:157		-16.889	Degrees
PPA:159		174.301	Degrees
PPA:161		4.83	Degrees
PPA:163		-15.707	Degrees
PPA:165		-16.051	Degrees
PPA:154		300066.406	Volts
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PPA:153	Cumberland Status Flags	0	Hex
DANIEL-BIGCRK			
IEEE C37.118-2005			
PPA:506	Daniel-Bigcrk Frequency Delta (df/dt)	0	
PPA:505	Daniel-Bigcrk Frequency	59.995	Hz
PPA:509		-11.887	Degrees
PPA:511		-137.335	Degrees
PPA:513		103.244	Degrees
PPA:515		-19.874	Degrees
PPA:517		-137.884	Degrees
PPA:519		100.206	Degrees
PPA:521		-15.326	Degrees
PPA:523		-19.177	Degrees
PPA:508		133581.922	Volts
PPA:510		134329.969	Volts
PPA:512		133689.625	Volts
PPA:514		309.822	Amps
PPA:516		318.581	Amps
PPA:518		321.968	Amps
PPA:520		133743.266	Volts
PPA:522		316.742	Amps
PPA:507	Daniel-Bigcrk Status Flags	0	Hex

View Real Time Data



View Real Time Data

openPDC Manager - GPA\arkrohne

Current Node: Default

Home Devices Outputs Gateway Adapters Monitoring Manage

Input Status Monitoring

Refresh Interval: 2 sec Last Refresh: 15:28:13.247

CORDOVA Edit

- CORDOVA-DF -0.53
- CORDOVA-FQ 59.998 Hz
- CORDOVA-PA1 100.65 Degrees
- CORDOVA-PA2 100.512 Degrees
- CORDOVA-PA3 -64.749 Degrees
- CORDOVA-PA4 78.021 Degrees
- CORDOVA-PA5 49.868 Degrees
- CORDOVA-PA6 130.048 Degrees
- CORDOVA-PM1 300442.469 Volts
- CORDOVA-PM2 301056.613 Volts
- CORDOVA-PM3 493.641 Amps
- CORDOVA-PM4 253.93 Amps
- CORDOVA-PM5 271.223 Amps
- CORDOVA-PM6 463.686 Amps
- CORDOVA-SF 0 Hex

CUMBERLAND Edit

DANIEL-BIGCRK Edit

DANIEL-MCKNT Edit

DANIEL-MOSSPT Edit

DANIEL-OCEANS Edit

Phase Angle

Frequency

Real-time

Real Time

Select Points to Display

Historical Playback

Start Time *-10m Stop Time *

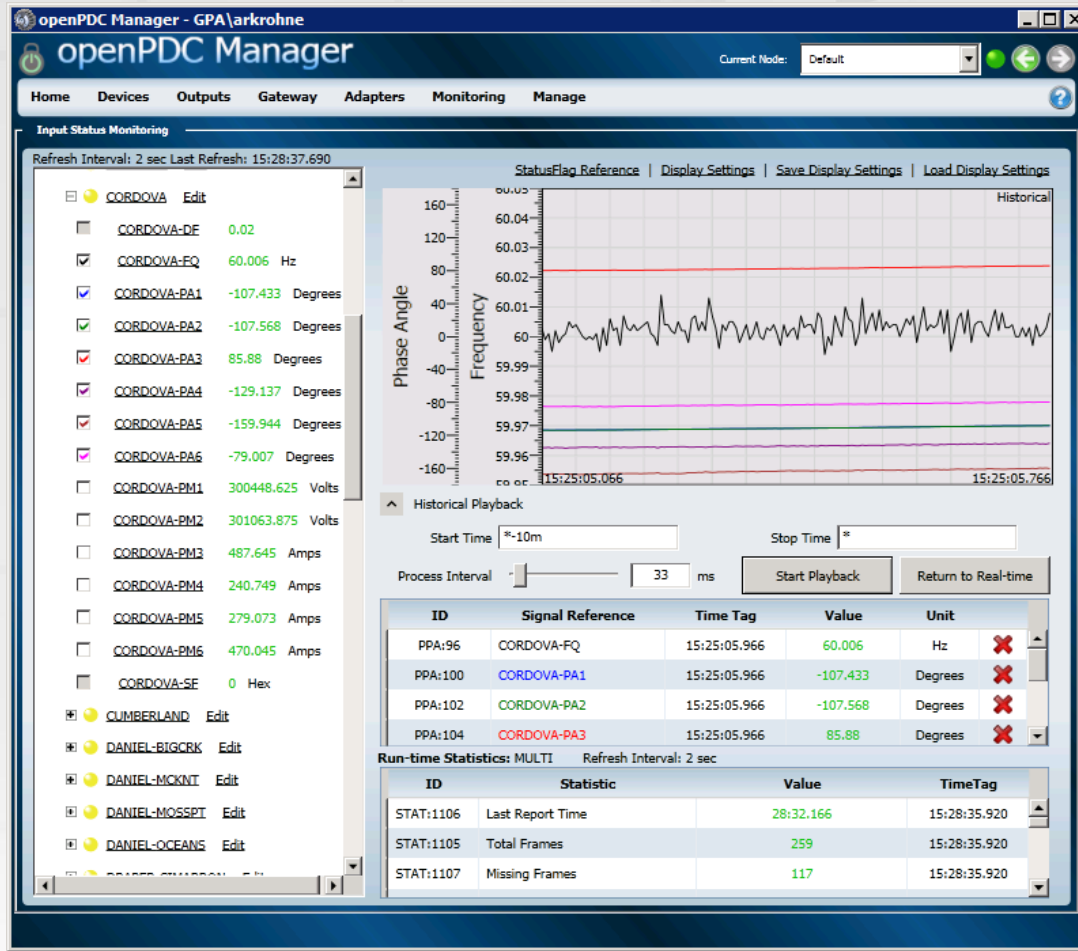
Start Playback Return to Real-time

Time Tag	Value	Unit
15:28:11.200	59.998	Hz
15:28:11.200	100.65	Degrees
15:28:11.200	100.512	Degrees
15:28:11.200	-64.749	Degrees

Run-time Statistics: MULTI Refresh Interval: 2 sec

ID	Statistic	Value	TimeTag
STAT:1106	Last Report Time	28:02.133	15:28:05.903
STAT:1105	Total Frames	301	15:28:05.903
STAT:1107	Missing Frames	0	15:28:05.903

View Historical Data



View Historical Data

openPDC Manager - GPA\arkrohne

Current Node: Default

Home Devices Outputs Gateway Adapters Monitoring Manage

Input Status Monitoring

Refresh Interval: 2 sec Last Refresh: 15:28:37.690

StatusFlag Reference | Display Settings | Save Display Settings | Load Display Settings

CORDOVA Edit

- CORDOVA-DF
- CORDOVA-FQ
- CORDOVA-PA1
- CORDOVA-PA2
- CORDOVA-PA3
- CORDOVA-PA4
- CORDOVA-PA5 -159.944 Degrees
- CORDOVA-PA6 -79.007 Degrees
- CORDOVA-PM1 300448.625 Volts
- CORDOVA-PM2 301063.875 Volts
- CORDOVA-PM3 487.645 Amps
- CORDOVA-PM4 240.749 Amps
- CORDOVA-PM5 279.073 Amps
- CORDOVA-PM6 470.045 Amps
- CORDOVA-SF 0 Hex

CUMBERLAND Edit

DANIEL-BIGCRK Edit

DANIEL-MCKNT Edit

DANIEL-MOSSPT Edit

DANIEL-OCEANS Edit

Historical

Start Time *-10m Stop Time *

Process Interval 33 ms Start Playback Return to Real-time

ID	Signal Reference	Time Tag	Value	Unit	
PPA:96	CORDOVA-FQ	15:25:05.966	60.006	Hz	✗
PPA:100	CORDOVA-PA1	15:25:05.966	-107.433	Degrees	✗
PPA:102	CORDOVA-PA2	15:25:05.966	-107.568	Degrees	✗
PPA:104	CORDOVA-PA5	15:25:05.966	85.88	Degrees	✗

Run-time S

ID	Value	TimeTag
STAT:110	166	15:28:35.920
STAT:1105	Total Frames 259	15:28:35.920
STAT:1107	Missing Frames 117	15:28:35.920

openPDC Console

- The openPDC console can be used to remotely monitor the details of openPDC operation
- It can be run independently of the openPDC Manager
- Typical Commands
 - **Clients** Shows list of connections to service
 - **Health** Shows health report
 - **List** Displays list of devices connections
 - **Help** Displays list of commands

```
C:\Program Files\openPDC\openPDCConsole.exe
State of process "HealthMonitor" has changed to "Processing".
State of process "HealthMonitor" has changed to "Processed".

Counter                Last          Average       Maximum       Units
-----
CPU Utilization        0.23          3.60          7.55          Average % / CPU
I/O Data Rate          14.17         427.52        2262.70       Kilobytes / sec
I/O Activity Rate      854.55        19439.51      31276.70      Operations / sec
Process Handle Count   1000.00       996.69        1149.00       Total Handles
Process Thread Count   66.00         68.85         89.00         System Threads
CLR Thread Count       51.00         53.57         73.00         Managed Threads
Worker Threads         7.00          6.05          12.00         Active in Pool
I/O Port Threads      0.00          0.00          0.00          Active in Pool
Thread Queue Size      0.00          0.00          0.00          Waiting Threads
Lock Contention Rate   0.00          0.00          1.00          Attempts / sec
Process Memory Usage   699.86        600.34        752.81        Megabytes
CLR Memory Usage       31.78         42.25         186.93        Megabytes
Large Object Heap      5.28          5.70          13.92         Megabytes
Exception Count        152.00        78.66         152.00        Total Exceptions
Exception Rate         0.00          0.23          4.20          Exceptions / sec
IPv4 Outgoing Rate     10.78         7.28          105.56        Datagrams / sec
IPv4 Incoming Rate     26.14         90.01         254.86        Datagrams / sec
IPv6 Outgoing Rate     0.00          2.08          25.58         Datagrams / sec
IPv6 Incoming Rate     0.20          0.32          2.80          Datagrams / sec

Statistics calculated using last 120 counter values sampled every 5.0 seconds.

[Input Adapter Collection]
Process statistics for 14 hours 6 minutes 14 seconds total runtime:
Time span      Measurements      Per second
-----
Entire runtime  12,746,161        251
Last minute    375,366           6,254

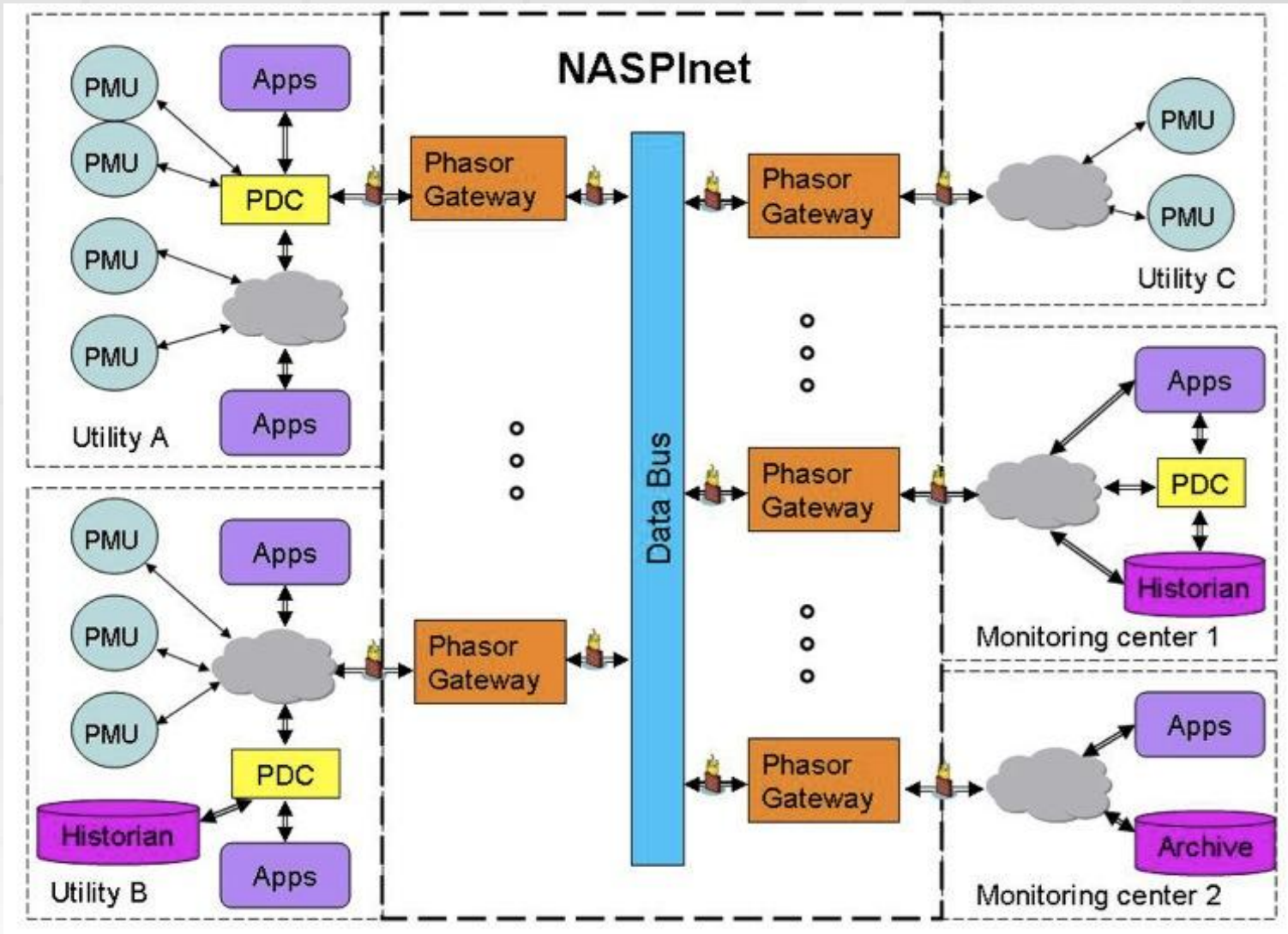
[Output Adapter Collection]
Process statistics for 14 hours 6 minutes 14 seconds total runtime:
Time span      Measurements      Per second
-----
Entire runtime  33,177,141        653
Last minute    376,764           6,277

[PPA] 32,900,437 measurements have been processed so far...
[MULTI] 12,800,152 measurements have been processed so far...
```

Secure Information Exchange Gateway

SIEGate

The term "Gateway" came from NASPInet



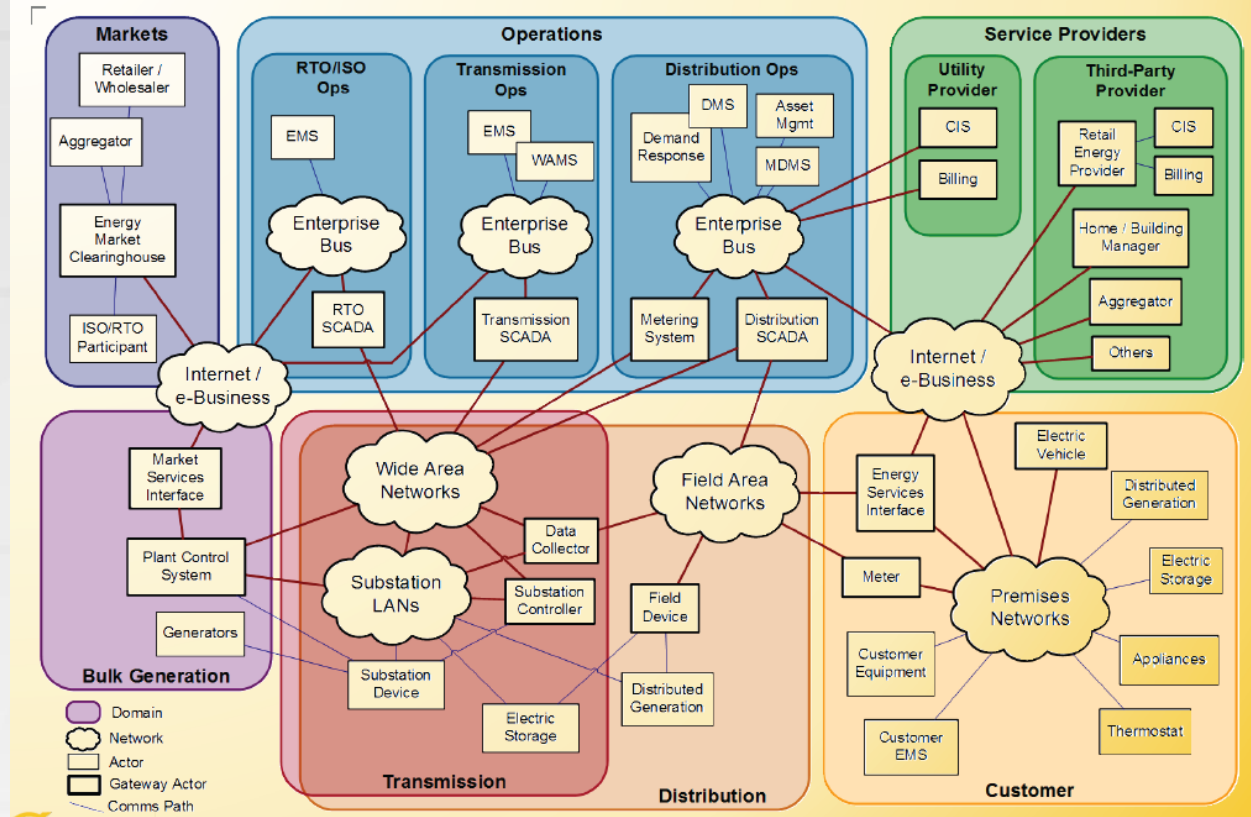
Taken from NASPInet Specification, 2007

What is a gateway?

- Creates a hardened security buffer between critical internal systems and external ones
- Protects the confidentiality and integrity of reliability and market sensitive BES data
- Facilitates and reduces the cost of BES data exchange, including synchrophasor data -- both the actual data and the supporting metadata information for this data as well

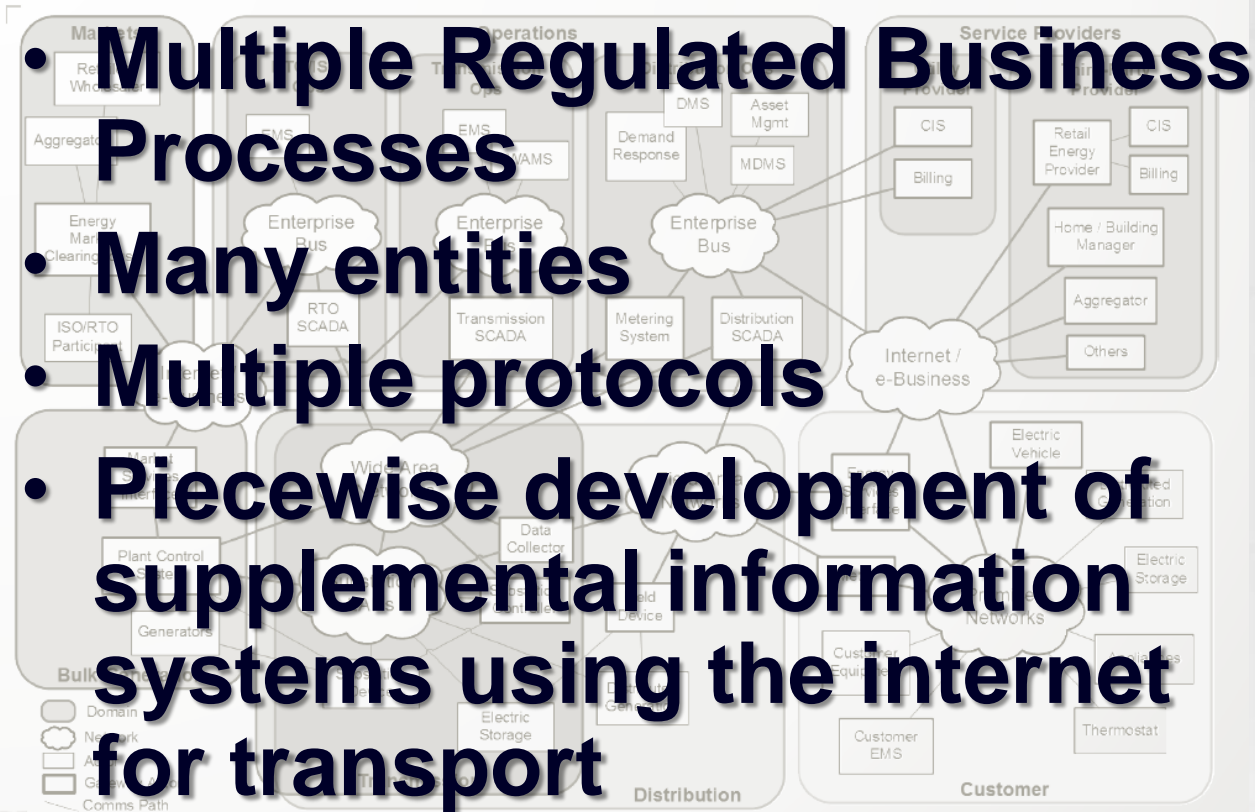
Current State of BES Data Exchange is Complex

Smart Grid Architecture (Source: NIST)



Current State of BES Data Exchange is Complex

Smart Grid Architecture (Source: NIST)



PDC vs. SIEGate

Distinguishing Features

- PDC – optimized for time-alignment of many inputs
 - Accepts inputs from PMUs and other IEDs using the broadest range of formats and protocols
 - Provides time-alignment of data (with delays and loss after time-out)
 - Allows implementation of adapters that require rapid access to time-aligned data
 - Publishes multiple time-concentrated streams
 - Reports and alarms on quality of measurements (signals) and input device status
- SIEGate – optimized for directed data transfer of granular information that facilitates a security-layered network design
 - Manages asynchronous communication of specific measurements (signals) with other SIEGate nodes
 - Relays data upon receipt without further delay
 - Can effectively manage the joining of two semantic models
 - Reports and alarms on status of communication of data with other gateways

SIEGate Project Objective

To develop and commercialize a flexible appliance to enable the secure exchange of all types of real-time reliability data among grid operating entities.

SIEGate will be a security-centric edge-device that

- Resists cyber attacks
- Preserves data integrity and confidentiality

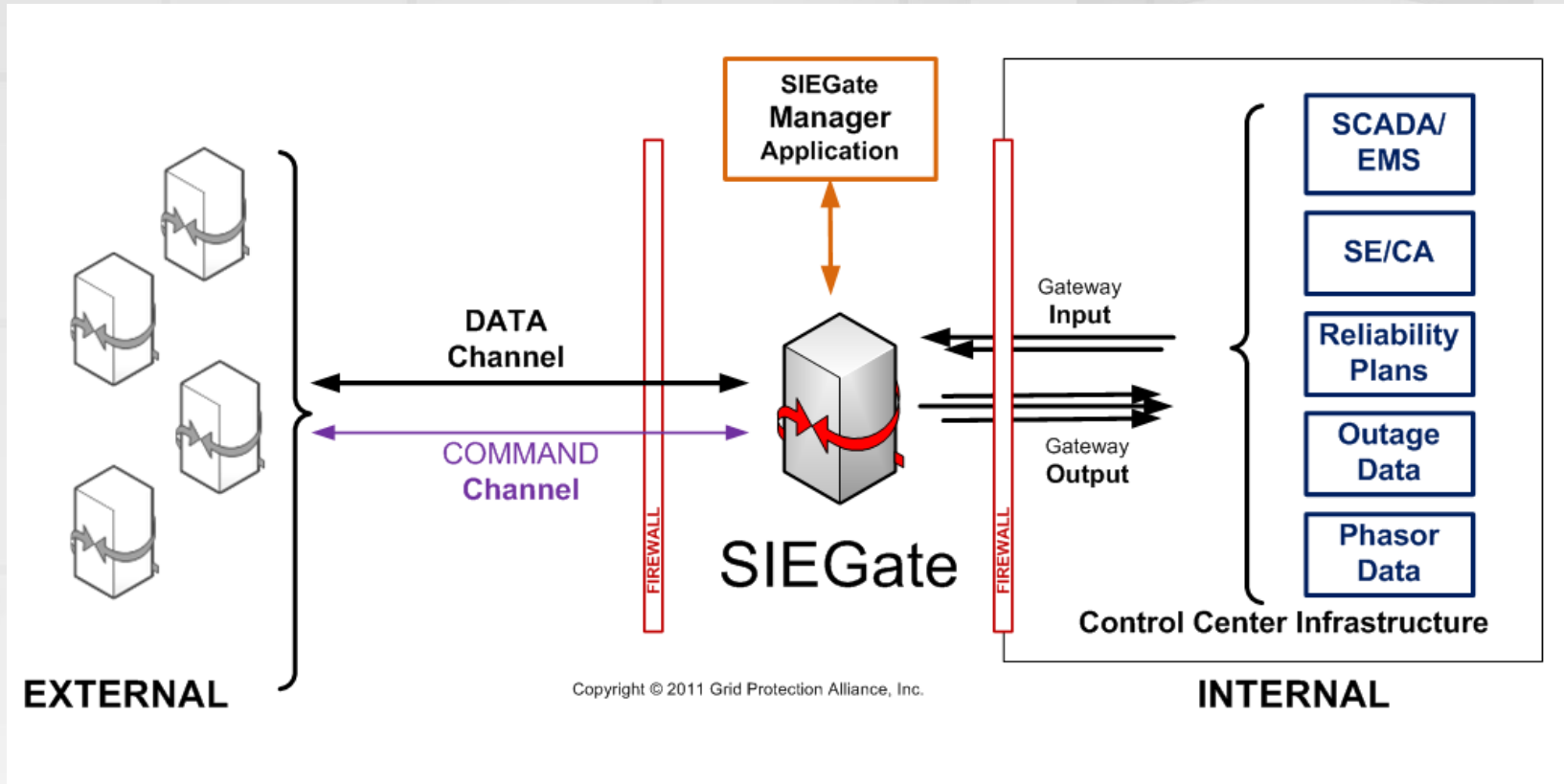
and that integrates and interoperates easily with existing control room technology.

SIEGate Version 1.0

High Level Requirements

- Security Throughout
 - At multiple levels: hardware, OS, application
- High Performance
 - Meet real-time requirements
 - Scalable to meet growing capacity needs
- Support for subset of power protocols
 - DNP3, IEEE C37.118, IEC 61850-90-5, also Modbus, ICCP and SDX expected

SIEGate Implementation



SIEGate Core Functionality

- Reliably exchange high-sample rate signal values and timestamps (measurements) with other gateways so that this information moves between with minimum time delay
- Enable gateway administrators to easily select the measurement points which are to be made available to owners of other gateways
- Enable gateway administrators to easily select the points that they chose to consume (i.e., the subset of the points made available to them) from other gateways

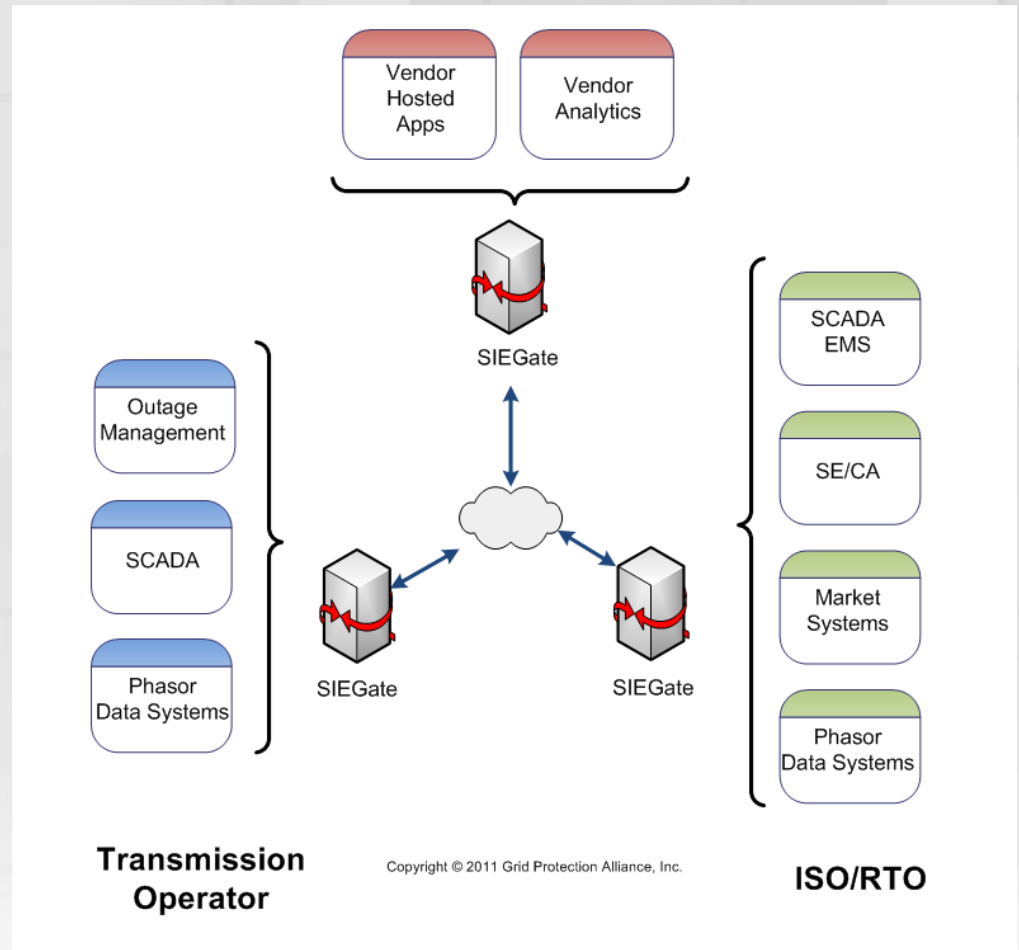
SIEGate Core Functionality

(continued)

- Detect, log and **alarm** on communications issues
- Be implementable as a **high-availability** solution that can meet NERC **CIP compliance** requirements
- Support **encrypted communication** among gateways as well as **minimize bandwidth** requirements for gateway-to-gateway data exchange
- Utilize **standard communications, networking and server hardware**
- Be **easily extensible** to support the development of custom interfaces to the gateway owner's internal infrastructure and/or new phasor data protocols

SIEGate Uses

- Case 1
 - RC to RC
- Case 2
 - TOp to RC
 - BA to RC
- Case 3
 - TOp to Distribution Ops
 - BA to BA
 - TOp to TOp
- Case 4
 - RC/Top/BA to Wide Area Service Provider (SANFR)



SIEGate Data Classes

- Real Time Measurements
 - Phasor Data
 - SCADA Data
- Batch Data
 - Disturbance Data
 - Planning Data

Possible Future Classes:

- Emergency Data (*extremely important data*)
- Control Commands

SIEGate Security Profile

- Availability – HIGH
- Integrity – VERY HIGH
- Confidentiality -- MODERATE

Alarming and Notifications

- Bad data quality
- Security exceptions
 - E.g., Integrity failures, connection failures, access control
- Attestation failures
- Configuration changes
- System health

Who “touches” a SIEGate?

- The SIEGate application is like an ICCP node in a control center
- As a back-office tool, SIEGate is administered by specialists, and likely to become part of critical infrastructure
- For security and compliance, change is tightly managed

Who uses SIEGate?

- Entergy and TVA are active current users with MISO, PJM and Southern Company scheduling installations
- WECC has installed and tested the openPG (the predecessor of SIEGate)
- Dominion and Duke have expressed a desire to install to examine capabilities

open Historian

GRID PROTECTION ALLIANCE

What is a data historian?

- A non-relational database that is optimized for handling time-based process data
 - Data must be in the form of (time, value)
- Effectively handles very large volumes of data
- High performance read/write operations
- Easy migration of older data to less expensive, second tier storage media

Why install a historian?

- Relational systems are not a good fit for phasor data
 - Do not scale well (record overload & retrieval responsiveness)
 - Cost - higher storage consumption per point
 - Data backup processes can be problematic (outages and network congestion)
- Typical Historian uses in a Control Room Architecture
 - SCADA/EMS Data Storage
 - Primary Phasor Data Storage
 - Second Tier Phasor Data Storage

Who are historian vendors?

- **GPA**
- **OSIsoft PI**
- **eDNA**
- **Honeywell Uniformance PHD**
- **GE Proficiency Historian**
- **Industrial SQL Server Historian**

Who “touches” a data historian?

- A historian is like an enterprise-wide relational system (e.g., work management) that’s just for operational, or process control, data. It requires diligent administration to enable enterprise-wide use
- A historian is used as the common point for systems to consume operational data in near-real-time; i.e., within about 1 second of real-time
- Many engineers and analysts interact directly with a historian to obtain historical operating data

openHistorian 1.0 vs. 2.0

Version 1.0

- ▶ Two instances of the archiver are embedded in the openPDC and openPG
 - Data Historian
 - Performance Historian
- ▶ Configuration managed through openPDC or openPG Manager
- ▶ Includes two tools for data extraction/display
 - Data Extraction Tool
 - Data Trending Tool

Version 2.0

- ▶ Includes both archiver and server components
- ▶ Completely redesigned storage engine
 - Broader range of data types
 - Greater time precision
 - Improved storage efficiency
 - Improved performance
- ▶ Flexibility in implementation with integrated support for other open storage systems
- ▶ Includes an integrated suite of tools for data extraction and display

openHistorian 2.0 Design Goals

- **Complete redesign of current historian to enable the openHistorian to be the nexus for operational data at all sampling rates**
 - ACID protects data integrity
Atomicity, Consistency, Isolation, Durability
 - High Performance
 - Maximum storage efficiency
 - High-availability
 - Compliant
 - Flexibility in deployment for rapid integration

Planned openHistorian 2.0 Components

- Archival Services
- Extraction Services and API
- Administrator's Console
- Web-based graphing/trending display
- Engineer's Trending Tool and Screen Builder
- Operator's Display
- Alarming / Notification Services

openHistorian 2.0 Features

- Optimized for management of process control and other time-series data
- Very large volumes of data can be efficiently stored and be made available on line
- Both lossless and swinging-gate compression options available
- Real-time data streams can be exported for both the provided web-based display or other application needs
- Horizontally scalable
- Easy to install, easy to configure
- Low cost of ownership
- Performance logging and alarming

openHistorian 2.0 Features

(continued)

- Condition-based collection
- Data scaling on extract based on a set of scaling factors that apply over a time range
- Name (tag) translation and support for 61850 naming
- COMTRADE file exports

openHistorian is ACID Compliant

- **Atomicity** - requires that database modifications must follow an "all or nothing" rule. Each transaction is said to be atomic
- **Consistency** - ensures that any transaction the database performs will take it from one consistent state to another
- **Isolation** - refers to the requirement that no transaction should be able to interfere with another transaction at all
- **Durability** - that once a transaction has been committed, it will remain so

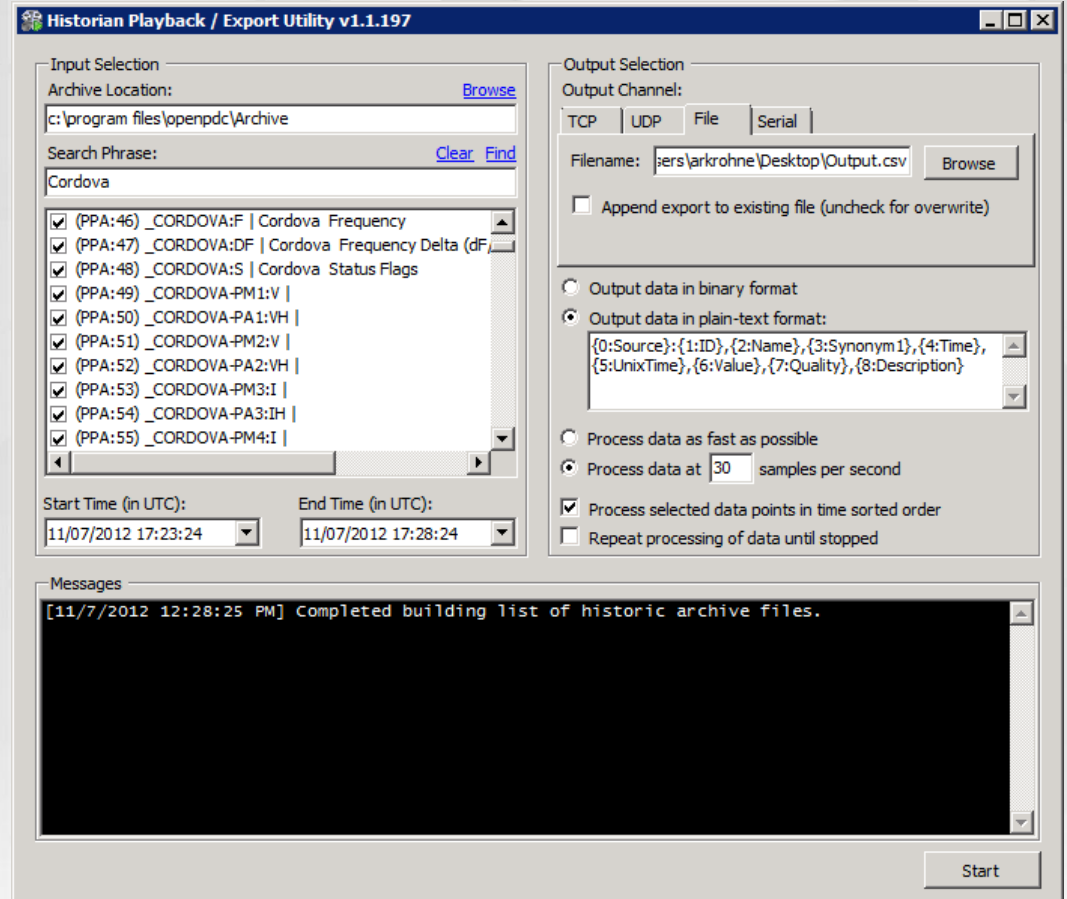
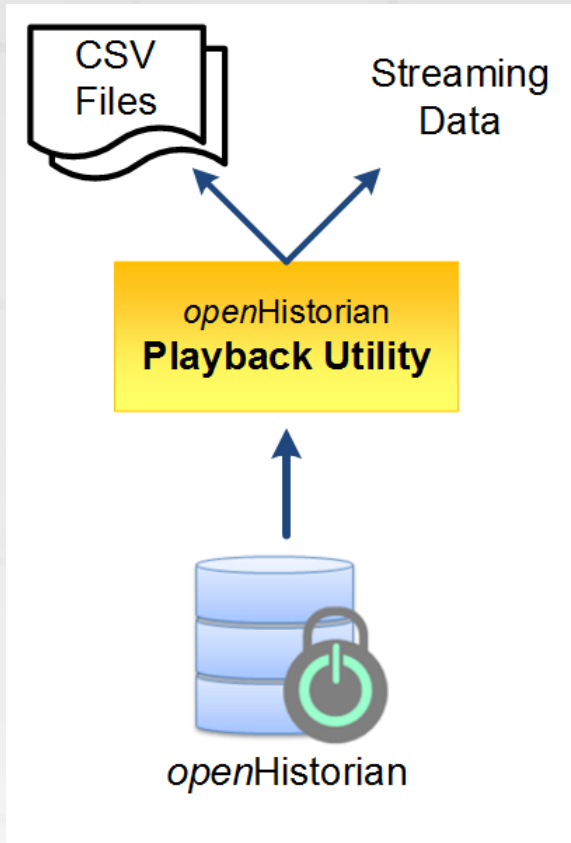
ACID protects data integrity.

Who else uses the openHistorian?

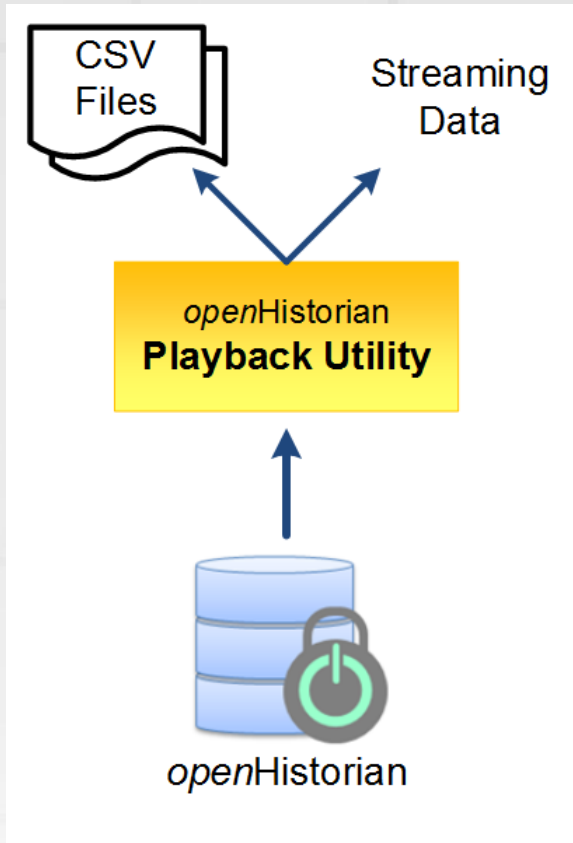
- 1.0 Implementations:
 - TVA has been a long term user (since 1995)
 - Dominion
 - PG&E
 - Entergy
 - Anyone hosting an openPDC
- 2.0 Alpha Implementations:
 - OG&E

openHistorian Screenshots

Data Extraction



Data Extraction



Historian Playback / Export Utility v1.1.197

Input Selection

Archive Location: c:\program file

Search Phrase: Cordova

Output Selection

Output Channel: TCP | UDP | File | **Serial**

Filename: jers\arkrohne\Desktop\Output.csv

Output data in plain-text format:

```
{0:Source},{1:ID},{2:Name},{3:Synonym1},{4:Time},{5:UnixTime},{6:Value},{7:Quality},{8:Description}
```

Start Time (in UTC): 11/07/2012 17:23:24

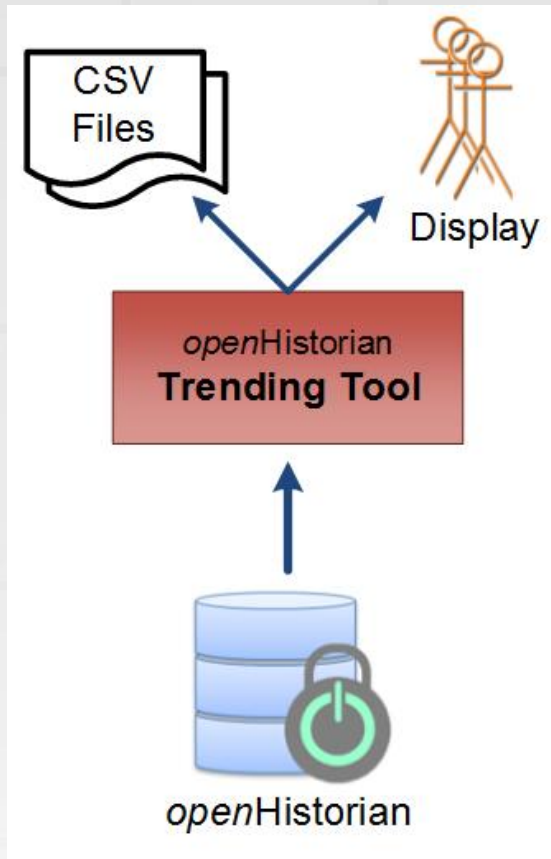
End Time (in UTC): 11/07/2012 17:28:24

Messages

```
[11/7/2012 12:28:24 PM] Completed building list of historic archive files.
```

Start

Data Display



Historian Data Viewer

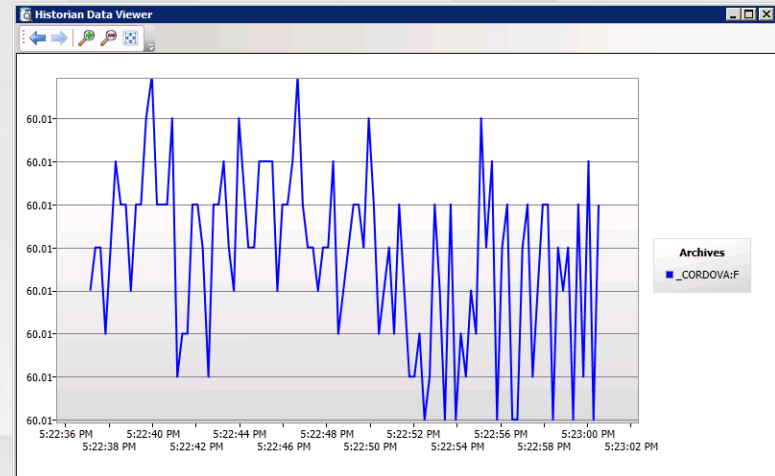
File Options

Search: Cordova Select All Deselect All

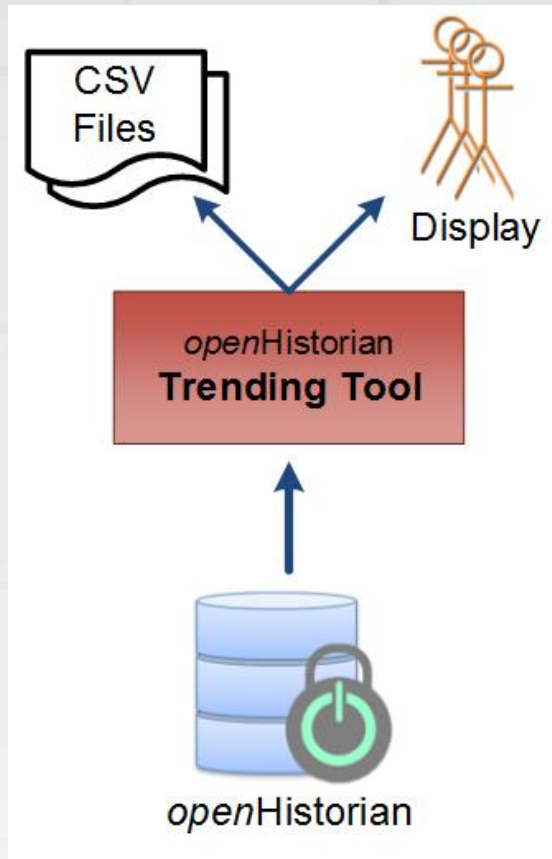
Export	Display	Pt.#	Name	Description
<input type="checkbox"/>	<input type="checkbox"/>	46	_CORDOVA:F	Cordova Frequency
<input type="checkbox"/>	<input type="checkbox"/>	47	_CORDOVA:DF	Cordova Frequency Delta (df/dt)
<input type="checkbox"/>	<input type="checkbox"/>	48	_CORDOVA:S	Cordova Status Flags
<input type="checkbox"/>	<input type="checkbox"/>	49	_CORDOVA-PM1:V	
<input type="checkbox"/>	<input type="checkbox"/>	50	_CORDOVA-PA1:VH	
<input type="checkbox"/>	<input type="checkbox"/>	51	_CORDOVA-PM2:V	
<input type="checkbox"/>	<input type="checkbox"/>	52	_CORDOVA-PA2:VH	
<input type="checkbox"/>	<input type="checkbox"/>	53	_CORDOVA-PM3:I	
<input type="checkbox"/>	<input type="checkbox"/>	54	_CORDOVA-PA3:IH	
<input type="checkbox"/>	<input type="checkbox"/>	55	_CORDOVA-PM4:I	
<input type="checkbox"/>	<input type="checkbox"/>	56	_CORDOVA-PA4:IH	
<input type="checkbox"/>	<input type="checkbox"/>	57	_CORDOVA-PM5:I	
<input type="checkbox"/>	<input type="checkbox"/>	58	_CORDOVA-PA5:IH	
<input type="checkbox"/>	<input type="checkbox"/>	59	_CORDOVA-PM6:I	
<input type="checkbox"/>	<input type="checkbox"/>	60	_CORDOVA-PA6:IH	

Last 5 minutes Chart resolution: 100 samples

Choose an interval relative to current time



Data Display



Historian Data Viewer

File Options Search: Cordova Select All Deselect All

Export	Display	Pt.#	Name	Description
<input type="checkbox"/>	<input type="checkbox"/>	46	_CORDOVA:F	Cordova Frequency
<input type="checkbox"/>	<input type="checkbox"/>	47	_CORDOVA:DF	Cordova Frequency Delta (df/dt)
<input type="checkbox"/>	<input type="checkbox"/>	48	_CORDOVA:S	Cordova Status Flags
<input type="checkbox"/>	<input type="checkbox"/>	49	_CORDOVA-PM1:V	
<input type="checkbox"/>	<input type="checkbox"/>	50	_CORDOVA-PA1:VH	
<input type="checkbox"/>	<input type="checkbox"/>	51	_CORDOVA-PM2:V	
<input type="checkbox"/>	<input type="checkbox"/>	52	_CORDOVA-PA2:VH	
<input type="checkbox"/>	<input type="checkbox"/>	53	_CORDOVA-PM3:I	
<input type="checkbox"/>	<input type="checkbox"/>	54	_CORDOVA-PA3:IH	
<input type="checkbox"/>	<input type="checkbox"/>	55	_CORDOVA-PM4:I	
<input type="checkbox"/>	<input type="checkbox"/>	56	_CORDOVA-PA4:IH	
<input type="checkbox"/>	<input type="checkbox"/>	57	_CORDOVA-PM5:I	
<input type="checkbox"/>	<input type="checkbox"/>	58	_CORDOVA-PA5:IH	
<input type="checkbox"/>	<input type="checkbox"/>	59	_CORDOVA-PM6:I	
<input type="checkbox"/>	<input type="checkbox"/>	60	_CORDOVA-PA6:IH	

Last 5 minutes Chart resolution: 100 samples
 Choose an interval relative to current time

Select Points

