

# **openPDC Specifications**

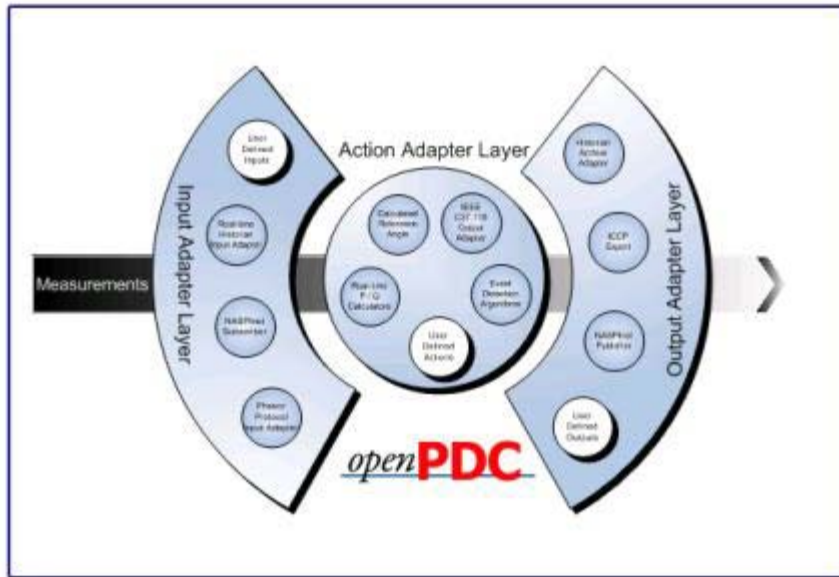
NASPI Work Group Meeting

February 25, 2010

J. Ritchie Carroll

# openPDC

Phasor Data Concentrator



- TVA's original SuperPDC is now an open source project called the openPDC
- Objective is to better support Stimulus/DOE plans to accelerate use of synchrophasors in the US
- Source code is released under a very liberal open source agreement that supports vendor commercialization
- Key design element is the ability for others to easily extend the openPDC at the input, action or output layers
- TVA's hope is that this code will be an enabling technology for the industry and vendors at the international level

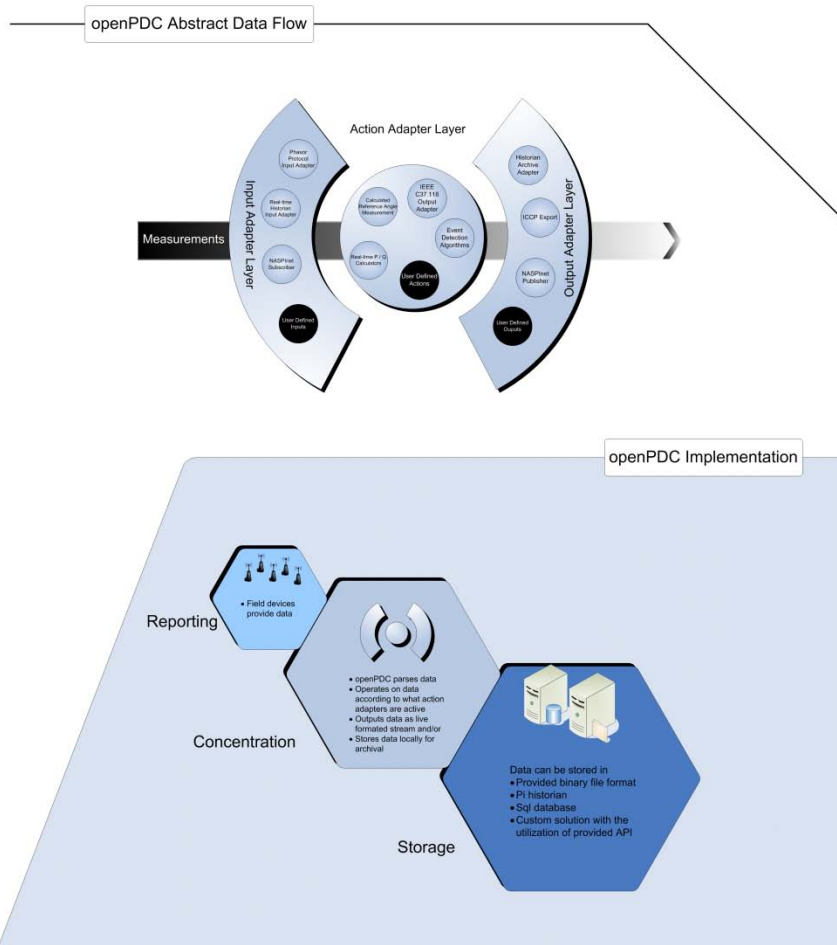
<http://openpdc.codeplex.com>



# openPDC Vision



The Open Source Phasor Data Concentrator



The openPDC is a foundational adaptive technology that can be used for streaming, analyzing and processing any kind of time-measured data.

It is our hope that this code will be used to support the development of the smart grid and facilitate the Department of Energy plans to accelerate the use of synchrophasors in the U.S. as part of the federal economic stimulus programs.

We believe this code will be an enabling technology for both vendors and the electric power system industry as billions are invested to modernize the power grid over the next several years.

# What's Included...

- TVA Code Library
- openPDC synchrophasor projects
  - All phasor data concentration components
  - Web based openPDC management system
  - PMU Connection Tester
- An experimental *prototype* implementation of NASPInet

# Commercialization and Support



- AREVA is now offering a commercial implementation of the openPDC with 24x7 support.
- Please contact Jay Giri for more information:

***[jay.giri@areva-td.com](mailto:jay.giri@areva-td.com)***

- AREVA benefits from and contributes to ongoing development of the open source PDC.
- I like to think of this like the Linux / Red Hat relationship

# Source Code Status

- Based on TVA's SuperPDC that has been used since 2004.
- Based on .NET 3.5 and written almost exclusively in C#.
- Has over 300,000 lines of fully documented code spanning 630+ classes.
- Includes detailed API help files
- Allow users to create their own operational PDC
- Being continually updated and improved – but ONLY by approved participants and NO UPDATES are committed to the official source code unless they are reviewed for security.

## New Updates: *Simplified System Configuration*

- Web based management system “openPDC Manager” – allows automated device configuration
- Configuration editor allows low-level system settings to be updated from a simple to use application.
- Phasor concentrator is remotely manageable with a secured system console that allows monitoring and control of system.

# openPDC Management System

The screenshot displays the openPDC Manager interface for the TVA PCS Node. The top navigation bar includes Home, Devices, Adapters, Manage, Help, and a Node dropdown menu set to TVA PCS Node. The main content area is divided into two sections. The left section, titled 'Currently processing PMU data from the following companies', features a table with columns for Company Name, Measured Lines, and Total. The right section, titled 'Vendor Device Distribution', shows a pie chart and a legend with various vendor names.

Company Name	Measured Lines	Total
American Electric Power	18	13
Ameren	16	7
American Transmission Company	1	1
ConEdison	2	3
Duke Energy	6	7
Entergy Energy Services	20	20
First Energy	2	2
Florida Power & Light Company	6	7
International Transmission Company	2	2
MidAmerican Power	1	1
Minnkota Power Collective	1	1
Manitoba Hydro	2	1
New England ISO	9	2
New York Power Authority	9	9
Oklahoma Gas & Electric	7	8
PPL Electric Utilities	1	1
Southern Company	18	23
Tennessee Valley Authority	48	19
Virginia Tech	5	5

**Vendor Device Distribution Legend:**

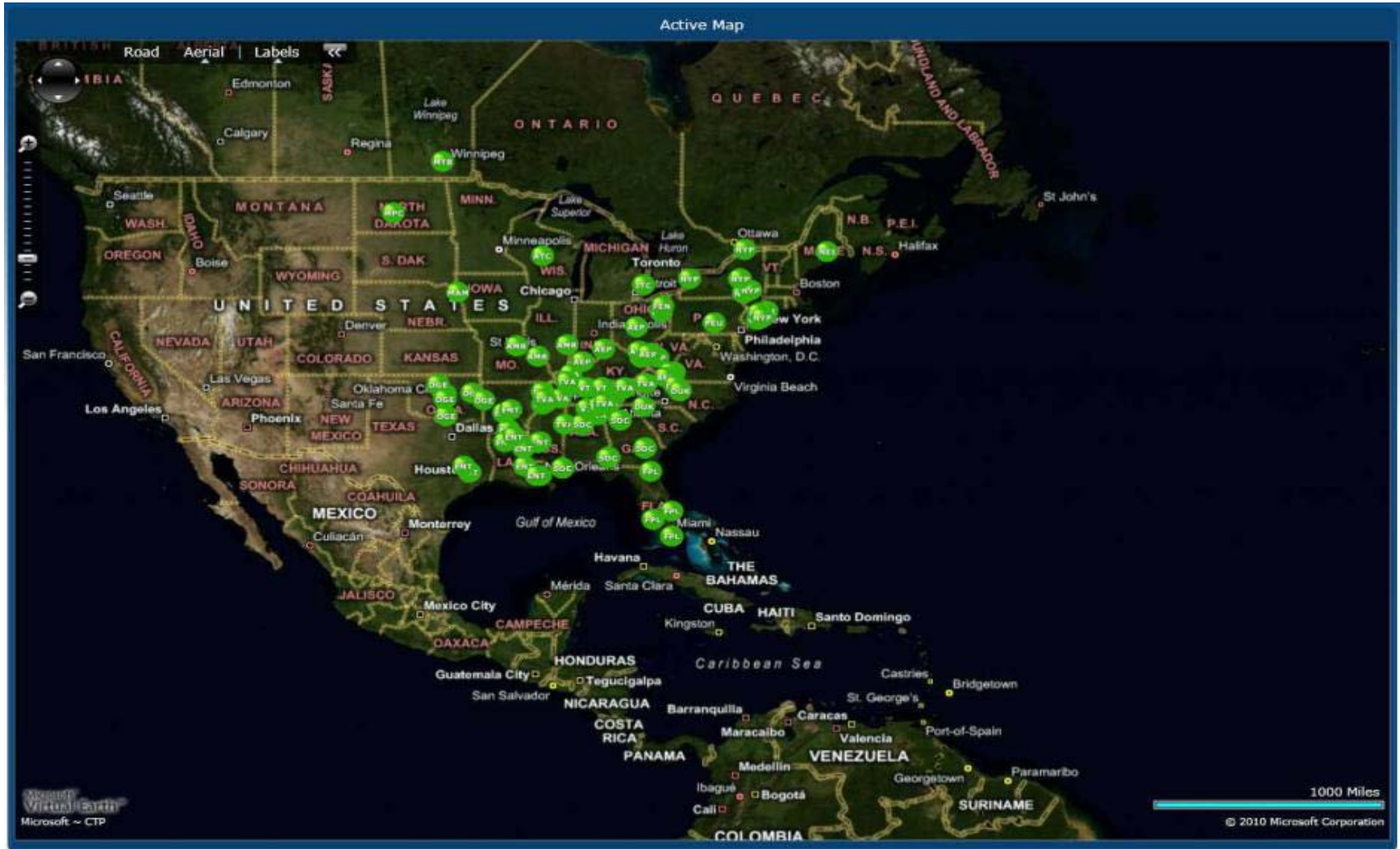
- ABB
- Ametek
- Arbiter
- Bonneville Power Administration
- ERLPhase
- General Electric
- Hathaway
- Macrodyne
- Mehtatech
- Other
- Schweitzer
- Virginia Tech

Simple Menu Driven System Allows Access to System Configuration

Single web based system allows management of multiple instances of the openPDC called "nodes"

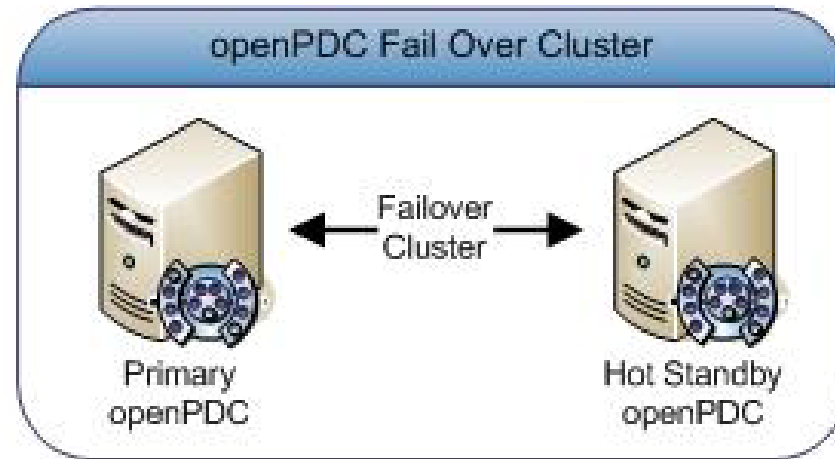


# Geospatial View of all Configured Devices

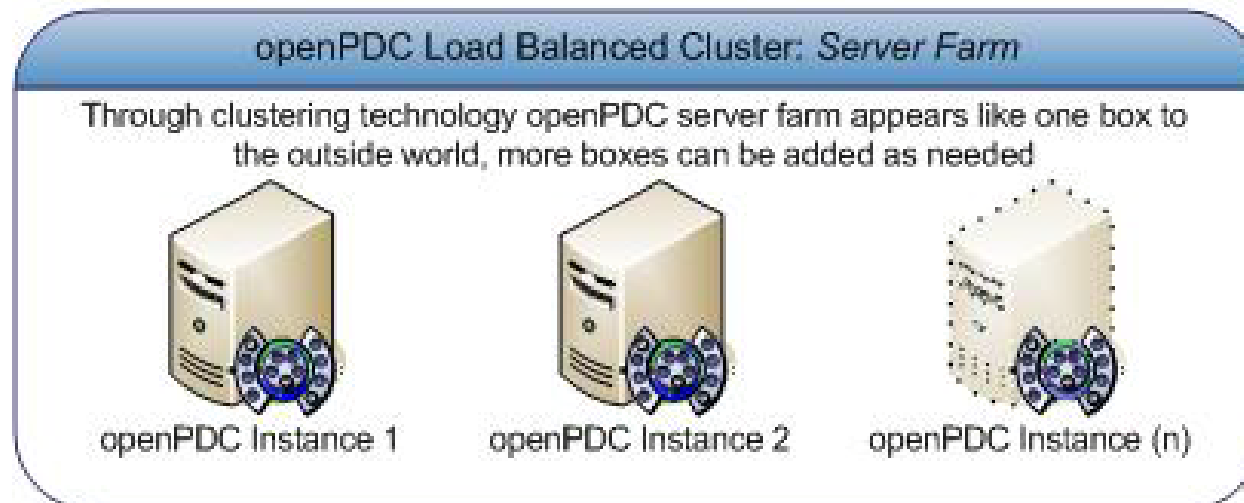


# openPDC Redundancy Options

## ***Fail Over Cluster:***



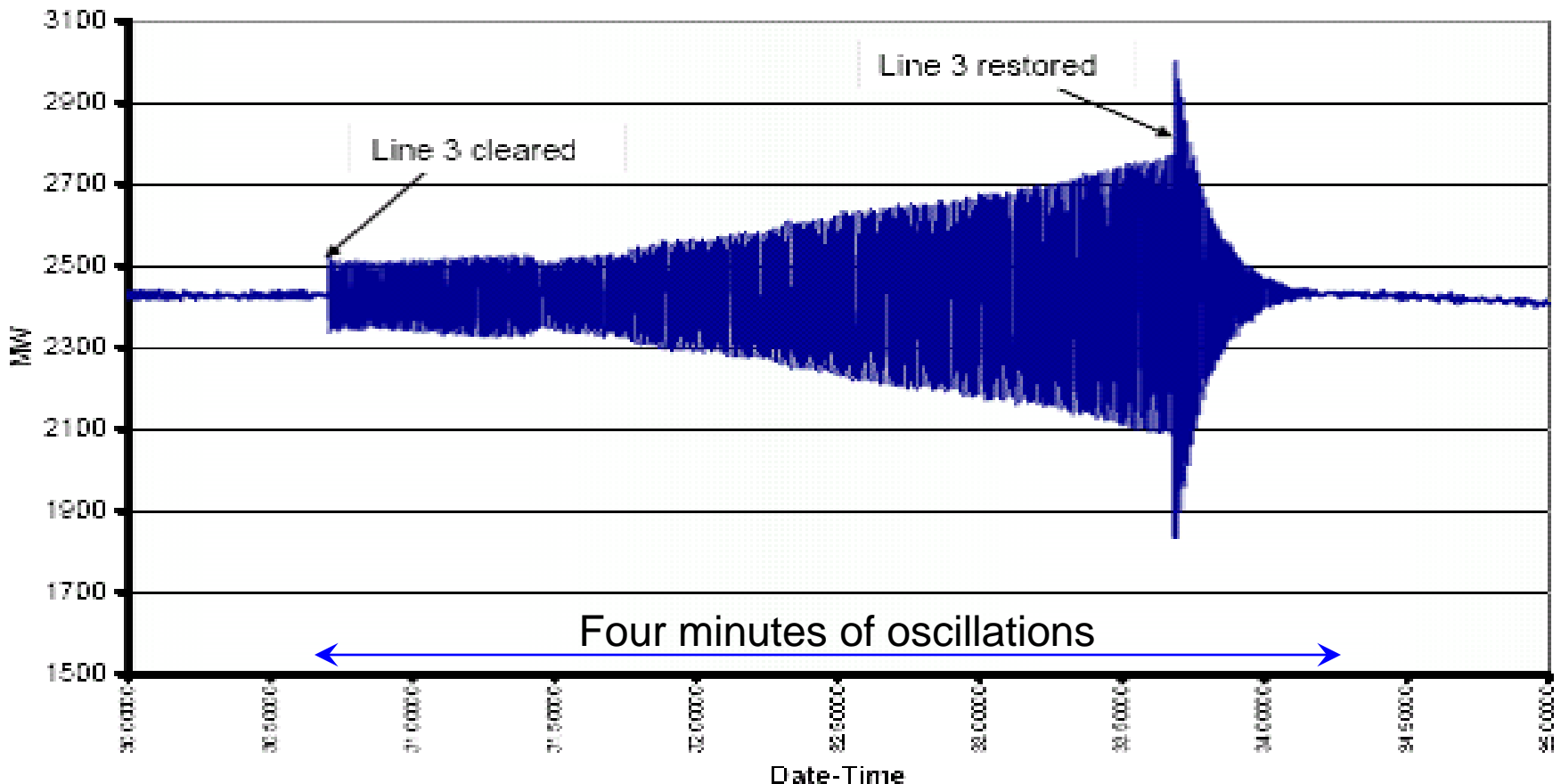
## ***Load Balanced Cluster:***



# Extensible with Event Detection and Alarming

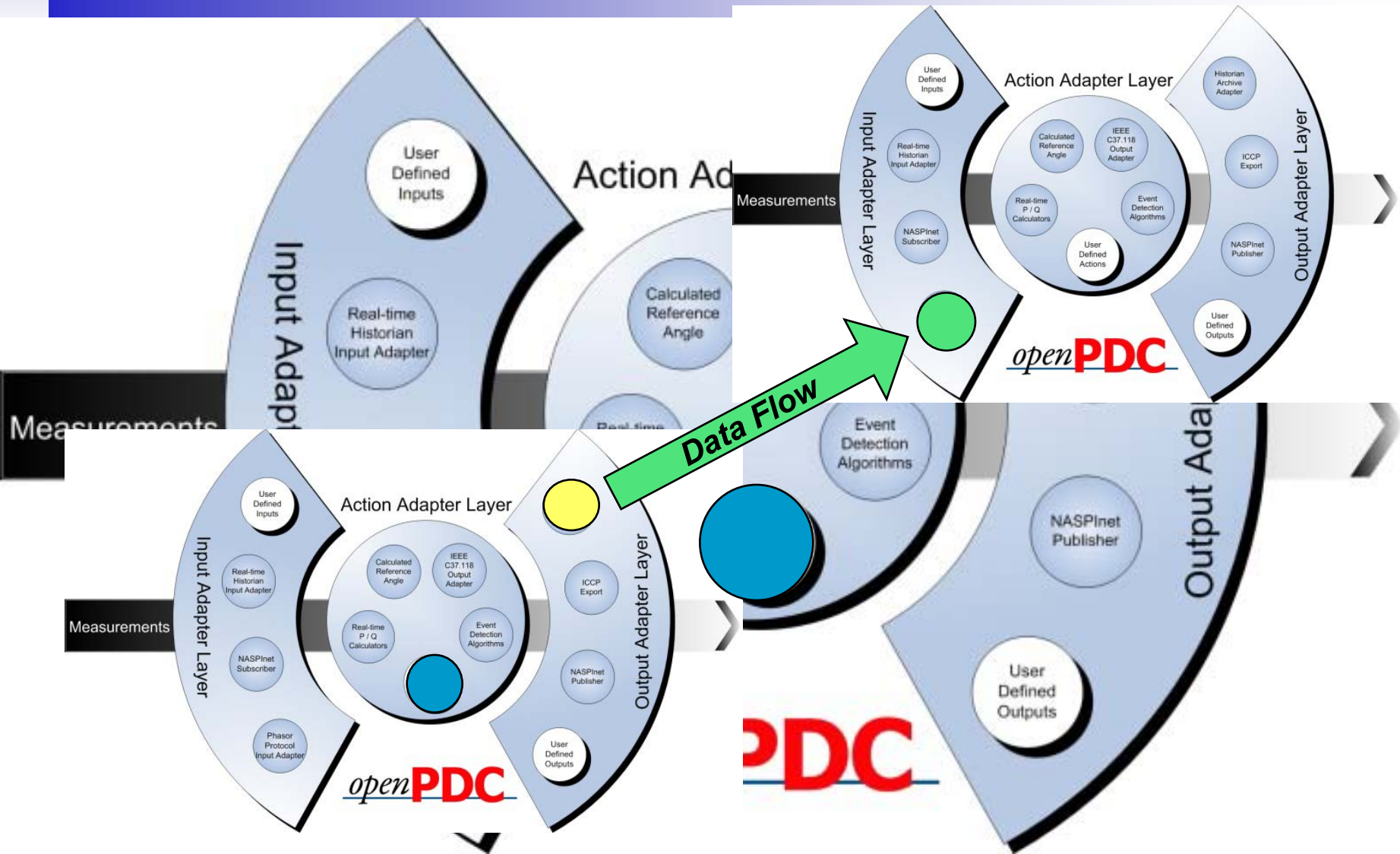
9/18/2006  
MW Oscillations on Generators

— Line summation = Unit 1 + Unit 2 MW

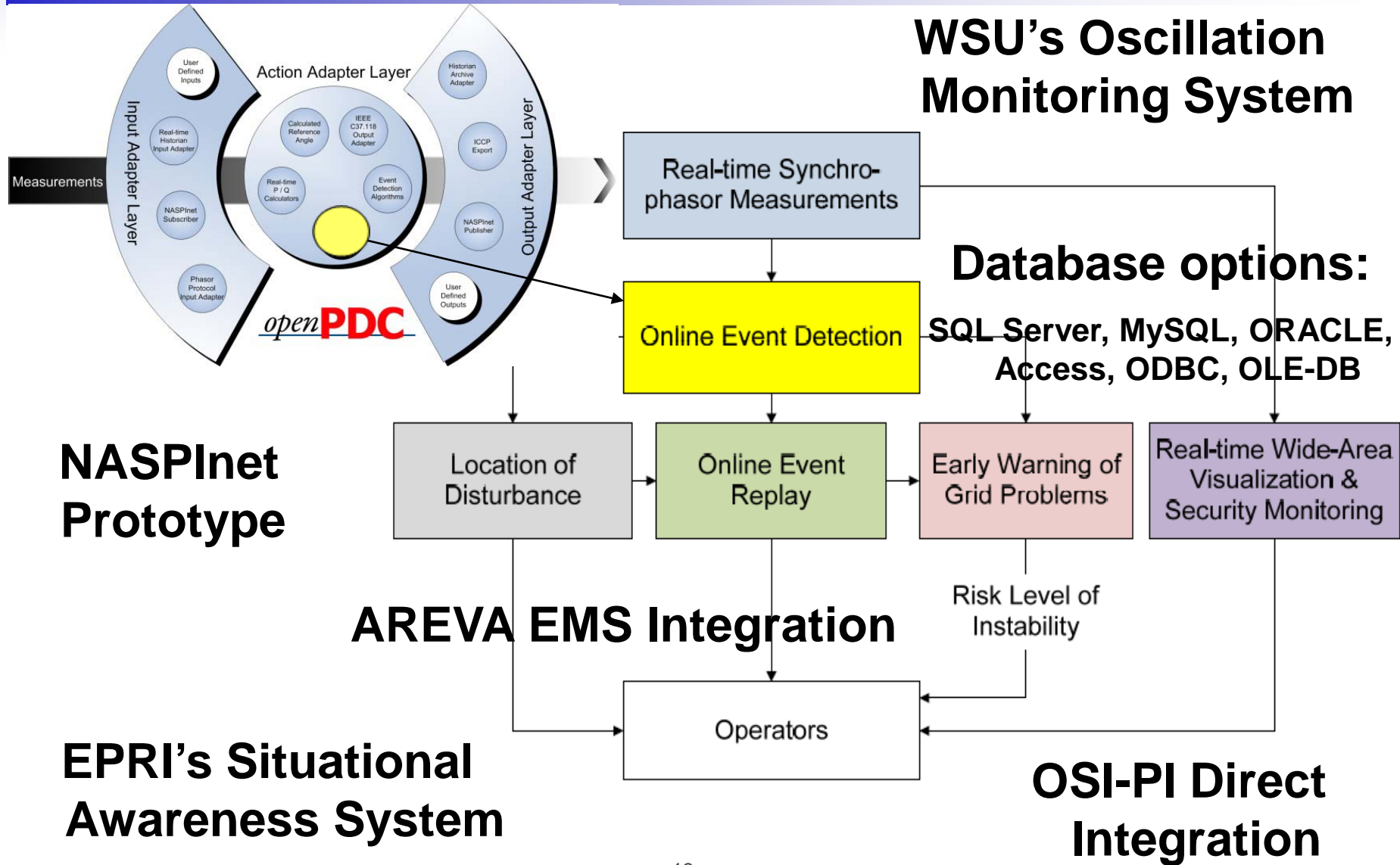


***This kind of event is why synchrophasors matter***

# openPDC Scalability Options

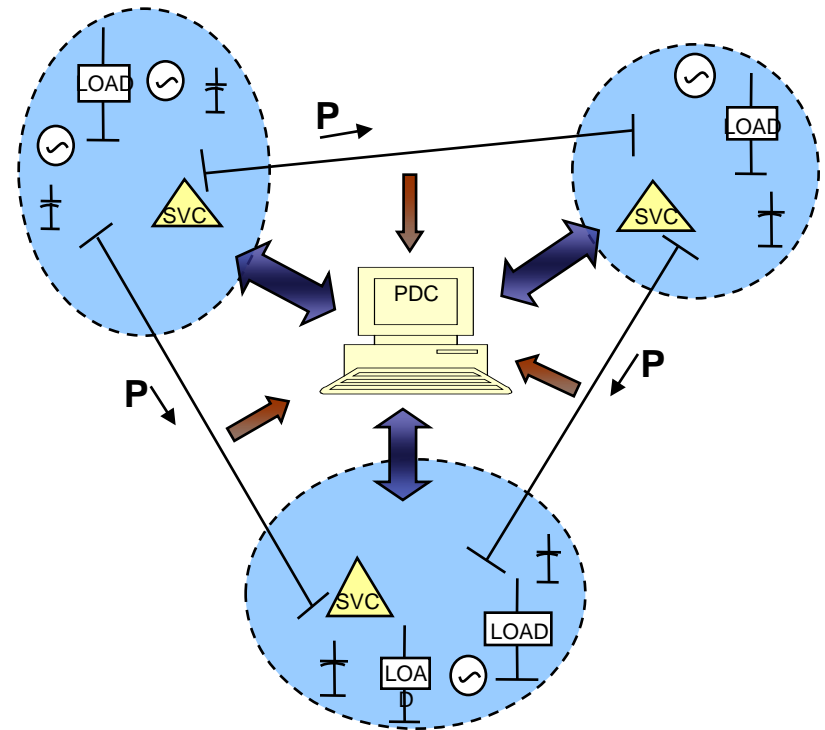


# openPDC Extensibility Options:

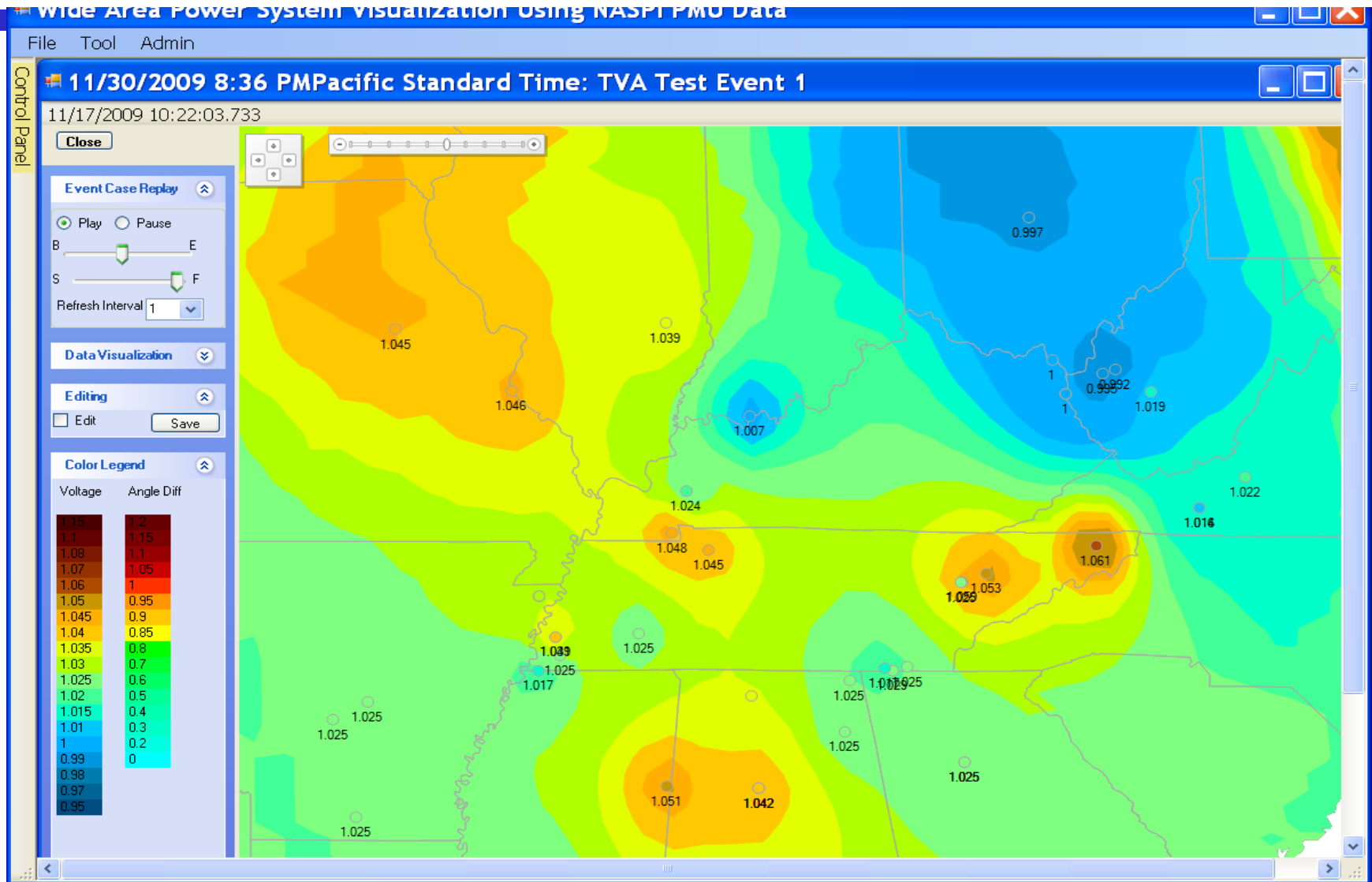


# WSU Oscillation Monitoring System

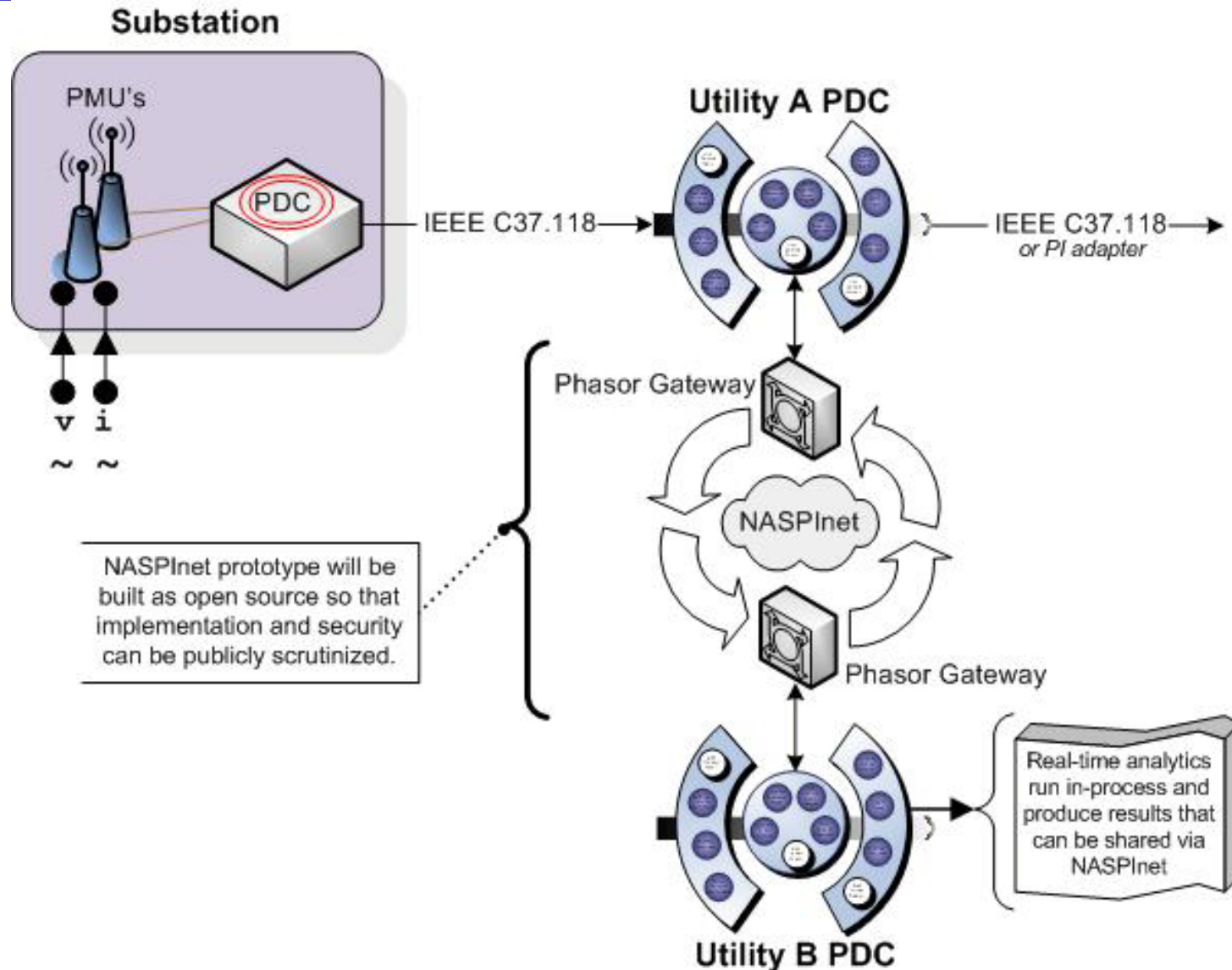
- **Goal of Oscillation Monitoring System (OMS)**
  - Early detection of poorly damped oscillations as they appear
  - Trigger warning or control signals
- **OMS is made possible by Wide Area PMU Measurements**
  - Growing numbers of PMU's across the power grid
  - Fast algorithms available for online measurements
  - Rule based automatic analysis of PMU measurements
  - Prototype implementation running in openPDC at TVA



# EPRI Voltage Magnitude Visualization Display Real-time SynchroPhasor Measurements

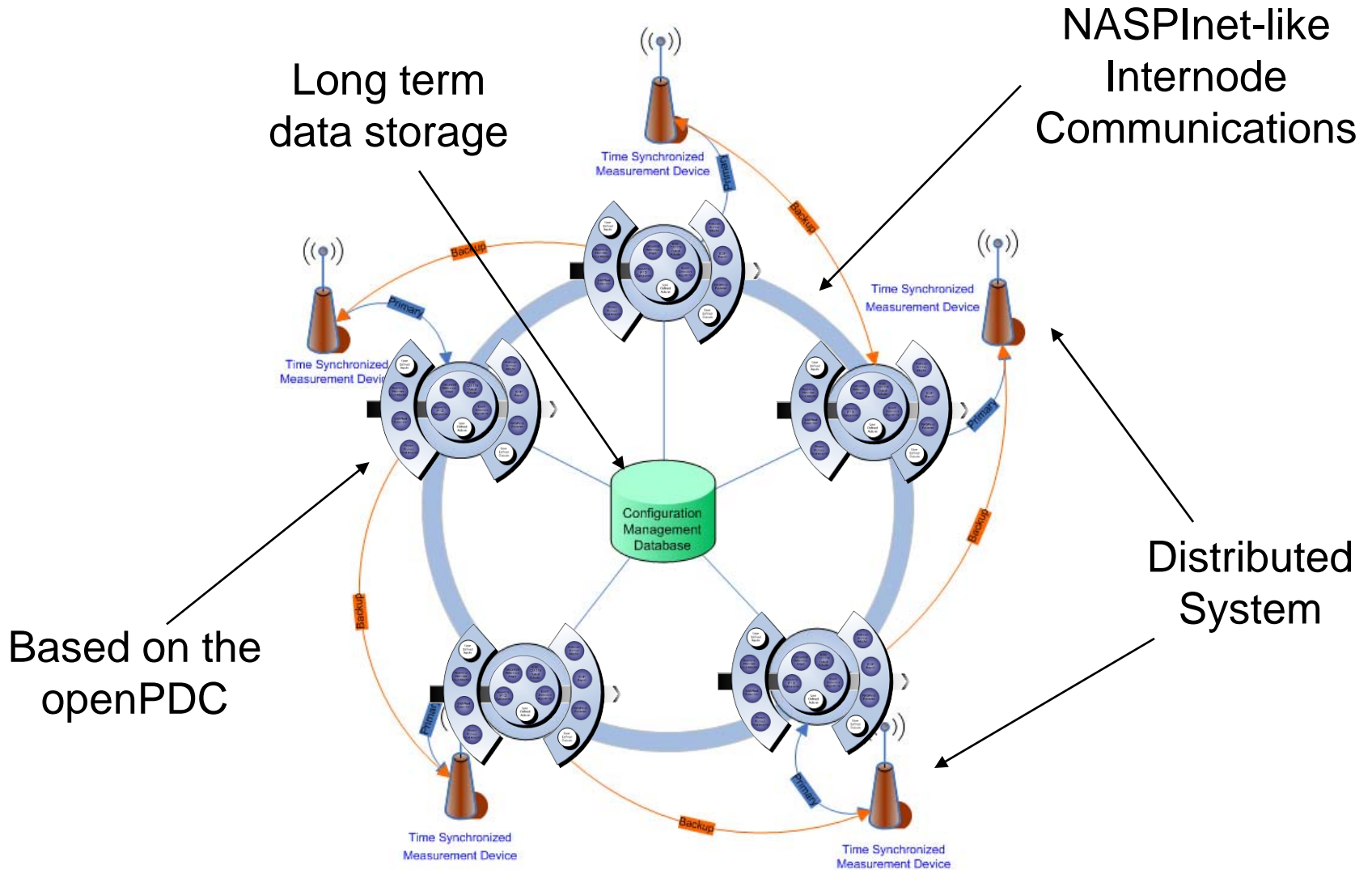


# openPDC NASPInet Prototype

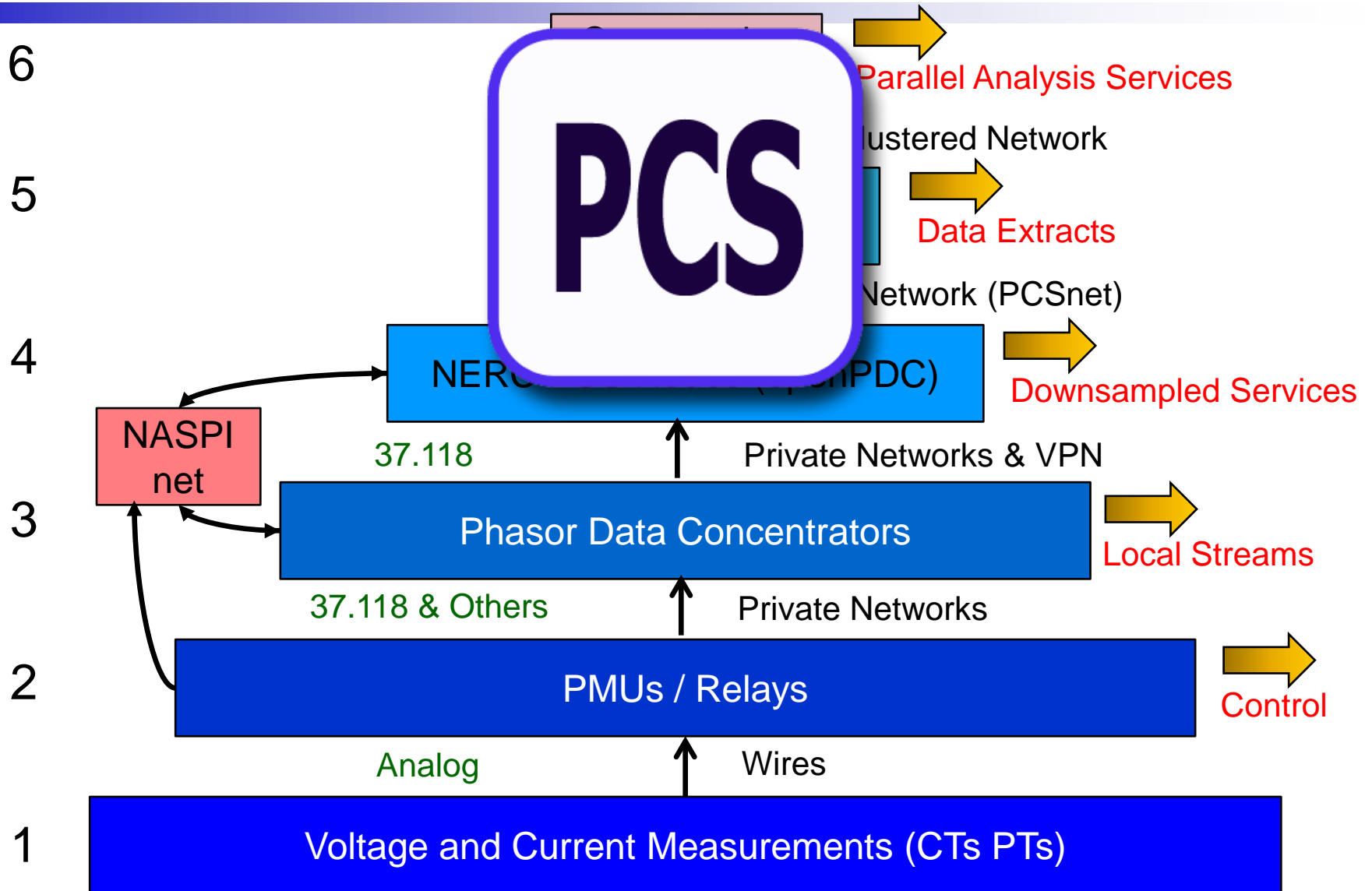




# NERC Phasor Concentration System



# The technology layers



# See website for more information...

### openPDC The Open Source Phasor Data Concentrator

<http://openpdc.codeplex.com>

**Abstract Data Flow**

**Implementation**

**Source Code**

- Over 300,000 lines of code in 630+ object oriented C# classes spanning 21 projects in 3 solutions
- Over 6% of code is structured development comments used to create help files that are integrated within Visual Studio
- Full source code for the PMU Connection Tester included

### NERC Phasor Concentration System

**Measurement**

**Concentration**

**Storage**

NERC Regional Nodes installed around the country serve as storage locations for specified geographic areas.

A Central Data Archive accepts the trickle down of all data via a scheduled roll-off from each regional node data storage repository. The schedule is variable depending upon each regional node's storage capabilities.

**Capability for High Data Availability**

- Each PMU will have two possible storage locations
- Backup concentrator will be the geographically closest to cut down on communication path length
- A heartbeat signal will indicate whether the backup PDC should continue to discard received data or begin to archive due to primary PDCs failure (lack of heartbeat pulse)

Legend:  
 = Binary ".d" formatted archive file  
 = Local concentrator  
 = PMU  
 = openPDC

### NERC PCS Central Data Archive

**Requirements**

- Petabyte Scale
- "Big Data" Warehousing
- "Big Data" Processing
- Fault Tolerant Platform
- Scalable
- Focus on Results

**Hadoop**

- Petabyte Scale
- Robust / Decentralized
- Commodity Hardware
- Self Healing
- Open Source / Open Platform
- Highly Cost Effective
- Commercial Support Available
- Strong Developer Ecosystem
- Broad Use, Rapidly Growing

**Map Reduce Data Flow**

**Map Phase**

**Reduce Phase**

**Processing with Hadoop**

- Double redundancy (three copies of the data) allows use of low commodity hardware for physical storage
- Processes are able to multiple distributed copies of the data, processing in parallel in nature, which means no special parallel programs are required
- Most logical processing algorithms can be applied to massive amounts of historical data
- Designed specifically for petabyte scale data analysis

**Companies using Hadoop**

- Yahoo
- Amazon
- Facebook
- Microsoft (Bing.com using PowerSet)
- University of Nebraska (Large Hadron Collider)
- VISA
- Rackspace

<http://openpdc.codeplex.com>