Advanced Real-Time Situational Awareness Sourced from Synchrophasor Data

“Faster than the Eye, not faster than PI”

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BPA Business Challenge

Leverage new Phasor Measurement Units (PMUs) deployment to provide wide-area situational awareness for grid stability.

Harden and build out the PI Data Historian beyond SCADA

Create a reusable infrastructure for analysis and alarming
Technical Challenges

PMUs are new devices

• newer interface protocol
• Expect 1.0 behavior

Fast data means:

• Network constraints
• Computer processing and storage constraints

Emerging science on new data set

• Calculations will change/evolve
BPA Goals for Situational Awareness (SA) Applications

• Create a reusable architecture, that allow new SA applications (calculations) to be easily implemented
SA Applications Developed

**ODM**
- Low Frequency (e.g. 0.25 Hz) Oscillation Detection of devices on Power Grid*

**MMM**
- Detection of Poor Inner Area Oscillation Dampening (Mode Meter)*

**AAM**
- Excessive Phase Angle Alarm +

**IDM**
- Power System Island Detection +

* WECC/MontanaTech  + BPA Developed
Sample Displays
Oscillation Detection (ODM)
ODM Detail-Inputs
Angle Alarm Analysis (AAM)
Power Islanding Detection (IDM)
PI System Architecture

2 month data retention

PMU

PDC

C37.118

SA PI Server

1 year+ data retention

Corp PI Server

SA Apps Server

AF-SDK

PI-SDK (buffered)
SA PI Server Details

- 24 Core Windows server, 32G physical memory
- 1 GB Archive fills every hour
- 2 months of online data for Situational Awareness (SA) PI (2TB Storage)
Historian PI Details

- 24 Core Windows server, 32G physical memory
- 1 year of high resolution (60 sps) data online
- All event data online
- All low-speed data (outputs from calculations every 5 to 10 seconds) online
SA Application servers

- 2 servers
  - 24 Core Server
  - 64 GB Physical Memory
  - Windows 2008 R2
## Current Event Rates

<table>
<thead>
<tr>
<th>C37118 Interface</th>
<th>Events/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>From WISP PMUs stream 1</td>
<td>2,336,544</td>
</tr>
<tr>
<td>From WISP PMUs stream 2</td>
<td>2,590,145</td>
</tr>
<tr>
<td>From WISP PMUs stream 3</td>
<td>1,071,036</td>
</tr>
<tr>
<td>From WISP PMUs stream 4</td>
<td>809,655</td>
</tr>
<tr>
<td>From WISP Partner PMU steams</td>
<td>32,357</td>
</tr>
</tbody>
</table>

Current Event Rate: 113,966 Events/second
SA Apps Architecture

SA PI Server

AF-Server (configuration)

SA PI Server

Corp PI Server

SCADA

Client-Side Data Queue Of Real PMU measurements

SAWrapper

Loaded Calculation

Output values

Output Alarm triggers
Re-Assembling IEEE C37.118 (PMU Communications Protocol)

- Analyses require time aligned data
Windows Services

- Each calculation runs as its own service (similar to ACE)
AF Database

PI Data References

Meta Data for PMUs.

Calculation Definition
AF Database – Calculation Definition

Extensible Calculations

Configurable Tuning and monitoring
Re-Assembly Rules

• Per block time: count of events must match rule

\[
\text{Data Rate } \times \text{ Block Time}
\]

60 events \times 5 \text{ seconds}

• Any block not matching the rule is counted as bad.
BPA Synchrophasor SA Deployment
Kudos and Cautions!

- PI Server 2012 is rock solid!
- Fast Interface patch turnaround
- PI-SDK… Watch threading!
- AF-SDK 2012 – looking good!
SA Wrapper Requirements

- IData – sends and retrieves data from the calculation
- ILog – enables logging out of the calculation
Looking Ahead: PMU Deployment Goals

- Currently deployed PMUs -- 82 (42 stations)
- Target deployment 2014 – 104
- Partner data integration – 41
Looking Ahead: Analysis

Increase geographic data models

- + CA
- + Montana
- + Alberta
- + Nevada

Add Analyses

- Geospatial Frequency Analysis
- Generation Insertion Efficiency
BPA Situational Awareness

Advanced Real-Time Situational Awareness using Synchrophasor data.

Business Challenge
- Turn Real-Time PMU data into Operator Awareness
- Leverage latest in high speed Phasor Measurement Analysis
- Prepare for future calculations

Solution
- PI AF based analysis plugin architecture
- PI Server 2012 using PI-AF 2012 data access

Results and Benefits
- Online displays show abnormal system behavior.
- Replay of real event data shows event identification, ready and waiting!
- Potential of early warning for system instability
Forum Developing!

BPA working with Casne and MontanaTech to maintain analysis and solution code.

Expand functions, unify event definitions

Share data, ideas, test cases

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