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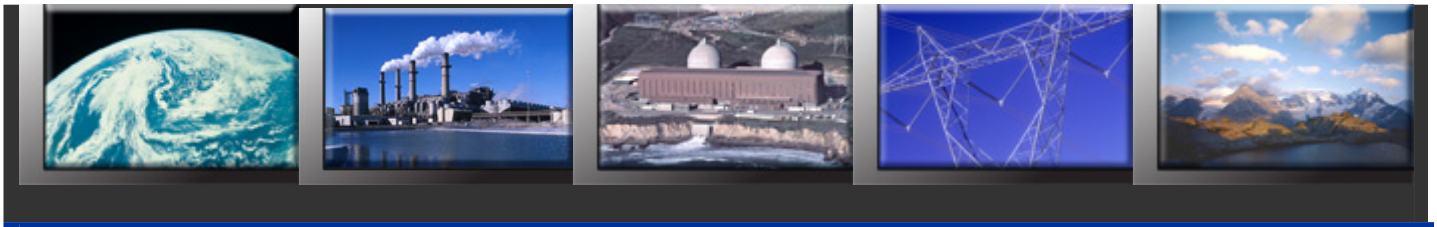
Smarter Transmission



An EPRI Progress Report **May 2011**

ABOUT THE NEWSLETTER

This is the first edition of the "Smarter Transmission" newsletter. The plan is to inform readers about what's happening in the smarter transmission system arena which cuts across a number of the Transmission & Substations, Intelligrid and Grid Operations & Planning research areas at EPRI.on a quarterly basis. The intent is to use this newsletter to update progress related to topics presented in the "A Smarter Transmission Grid" white paper (EPRI Product ID Number 1022305) issued in January 2011. The newsletter will include a short article on a relevant topic of interest, followed by links to recently published information about smarter transmission and a feature article on a timely topic. I appreciate your comments, suggestions, and contributions. Paul Myrda - Smarter Transmission Coordinator. pmyrda@epri.com

WHAT IS SMARTER TRANSMISSION?

Let's start off be defining what is included in Smarter Transmission here at EPRI. Obviously the IntelliGrid program plays a key role and two project sets in particular are Infrastructure for Intelligent Transmission Systems - Project Set 161B and Security Issues for the Power System Communication, Information, and Control Infrastructure - Project Set 161E. A large portion of the Next Generation Sensors work is also included since sensors and the associated algorithms play a pivotal role in understanding "what the grid is doing" at any point in time. Then the Grid Operations, Grid Planning and Integration of Bulk Variable Generation included in Programs 39, 40 and 173 respectively. Lastly at the program level there are a number of activities within Overhead Transmission, Underground Transmission, Substations and HVDC that fall into this arena included in Programs 35, 36, 37 and 162 respectively.

Besides the base program efforts there are supplemental projects such as the Control Center Display of Asset Health Information, Synchrophasor demonstration projects such as the recent multi vendor NASPInet demonstration using the Smart Grid Substations Lab and a new emerging Strategic Technology Innovation work like Grid Transformation project that all contribute to the Smarter Transmission effort.

USEFUL INFORMATION

Recent Publications

"A Smarter Transmission Grid" – White Paper – Product ID 1022305

In January 2011 a white paper was issued to help address the question of "What does a smarter transmission system look like?" since many people in the industry felt that the transmission system was "smart" already.

With guidance from the Transmission Executive Leadership Committee, EPRI prepared a white paper to address this concern. Specifically the paper addressed the need for a smarter transmission grid, global smart grid initiatives, vision of a smarter transmission grid, technology pillars for a smarter transmission grid, key technologies and initiatives, next steps and key factors for success and achieving the smarter transmission grid.

The 21st Century Substation Design – PSERC Report

The purpose of this study is to create a vision of the future substation. To create this vision, various technical, economical and environmental criteria, such as reliability, cost, interoperability, re-configurability, security, controllability and flexibility need to be considered. Those criteria require use of new design methodologies quite different from the existing philosophy. The design strategies are focused on reducing cost while maintaining the performance, or maintaining cost while improving performance.

Three design approaches to meet different scenarios' requirements and needs are considered: Retrofit existing substation design, Implement new substation design, and Green field design.
The full report can be found at [The 21st Century Substation Design]

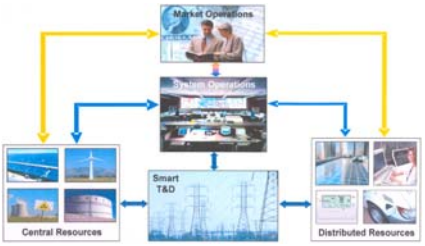
Using PMU Data to Increase Situational Awareness

With the large-scale deployment of PMUs in the U.S. and worldwide, a recurring theme has been the question of how to best extract useful "information" or "knowledge" from the very voluminous data that PMUs provide. While the direct control center display of PMU-based data is certainly important, particularly bus voltage angle values, this project focused on techniques that go beyond direct display of the raw PMU data. That is, the project focused on how information could be extracted from the PMU data, and then how this information could be used to improve power system situational awareness. Five different aspects of the problem are considered.
The full report can be found at [Using PMU Data to Increase Situational Awareness]

Technology Innovation

Grid Transformation

A new Strategic Technology Innovation project called Grid Transformation was recently authorized by EPRI. The project addresses the fact that the existing Supervisory Control and Data Acquisition (SCADA), Energy Management Systems (EMS) and Protection and Control (P&C) systems used today to manage electric energy across the grid and protect the grid from faults is essentially built upon decades old technology. In the case of EMS the computational algorithms are essentially the same while numerical techniques and computational capability has increased by orders of magnitude. Similarly, P&C systems are essentially digital adaptations of the old electromechanical functions. Rethinking these functions using modern approaches could yield tremendous operational improvements in power system planning, operations and protection.



EPRI's focus will be on developing the functional requirements for these next generation systems by engaging with the national laboratories, Department of Energy, universities, and others through collaborative technology development, integration, and application focused on opportunities for the electric utility industry. Essentially, EPRI proposes to bridge the gap between the organizations and become the catalyst between utilities, vendors, universities, etc. to facilitate the future visioning required to develop the conceptual approaches needed to design and transition to the new systems platforms. Four core research areas are being proposed: seamless geospatial three phase power system model requirements concept, seamless power system analytics requirements development, integrated energy management system coupled with the above analytics and grid measurements and also a setting-less protection method. A white paper is in the final stages of publication and will elaborate on the concepts further but suffice it to say this project is targeting some of the core "limiting" technology principles used by the power industry today with an eye toward simplification and extensive integration.

Upcoming Events

North American SynchroPhasor Initiative - NASPI

The next North American SynchroPhasor Initiative - Working Group Meeting is scheduled for June 8-9, 2011 - Toronto Airport Marriott, Toronto (Mississauga), Ontario, Canada This NASPI work group meeting will feature success stories of synchrophasor technology use by system owners and operators. The meeting will be co-located with the North American Electric Reliability Corporation's Operations Committee and Planning Committee meetings (scheduled for June 7-8), to enable OC and PC attendee to stay over for the NASPI meeting as well. Planned topics include: End-to-end Testing Your Synchrophasor System, Oscillation Detection and Mode Meter Tools, PMU Models and Testing, Operator training panel, Owner-Operator Synchrophasor Success Stories, PDCs, Data Archiving and Retrieval.
http://www.naspi.org/meetings/workgroup/workgroup.stm

IEEE Power System Relaying Committee - PSRC

The IEEE Power System Relaying Committee (PSRC) will meet in Asheville, NC on May 16-19, 2011. The PSRC has a number of sessions that are dealing with a number of transmission related smart grid standards activities. Some of these topics are IEEE/IEC Phasor Measurement standard, The Role of Protective Relaying in the Smart Grid, IEEE 1588 Profile for Power System Applications (PC37.238), Synchrophasor Data Transfer for Power Systems, Considerations for "Aurora" Protection, Cyber Security for Protection Related Data Files C37.118 Power Systems Synchrophasors Standard Harmonization with IEC 61850 and Guide for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units. Many of these activities are driven by the NIST Priority Action Plans activity. http://pes-psrc.org/

IEC 61850 Training and Workshop

EPRI will host an IEC 61850 training and workshop in New York, NY on August 3-5, 2011. The one day training will provide the latest update and an overview of the IEC 61850 standard. The following one and a half day workshop will address the "real world" issues and challenges in field deployment of IEC 61850 standard. In the workshop, participated utilities will be encouraged to make presentations and share project experiences. The goal of the workshop is to enhance awareness of IEC 61850 among utility users and to provide a forum to exchange knowledge, share experiences and lessons-learned. The new EPRI supplemental project "Testing Guidelines and Utility Practices for Multi-vendor Equipment and Systems based on IEC 61850 Standard" will be kicked off in the workshop. The workshop will also provide needed guidance on ongoing and future EPRI R&D on this topic. http://www.cvent.com/events/iec-61850-training-and-workshop/event-summary-c2278262e3ef4e71abc0cea44a9dd10e.aspx?i=151cf138-b353-4718-8254-b23c0346c9b5

FEATURE ARTICLE

NASPInet Demonstration at North American SynchroPhasor Initiative

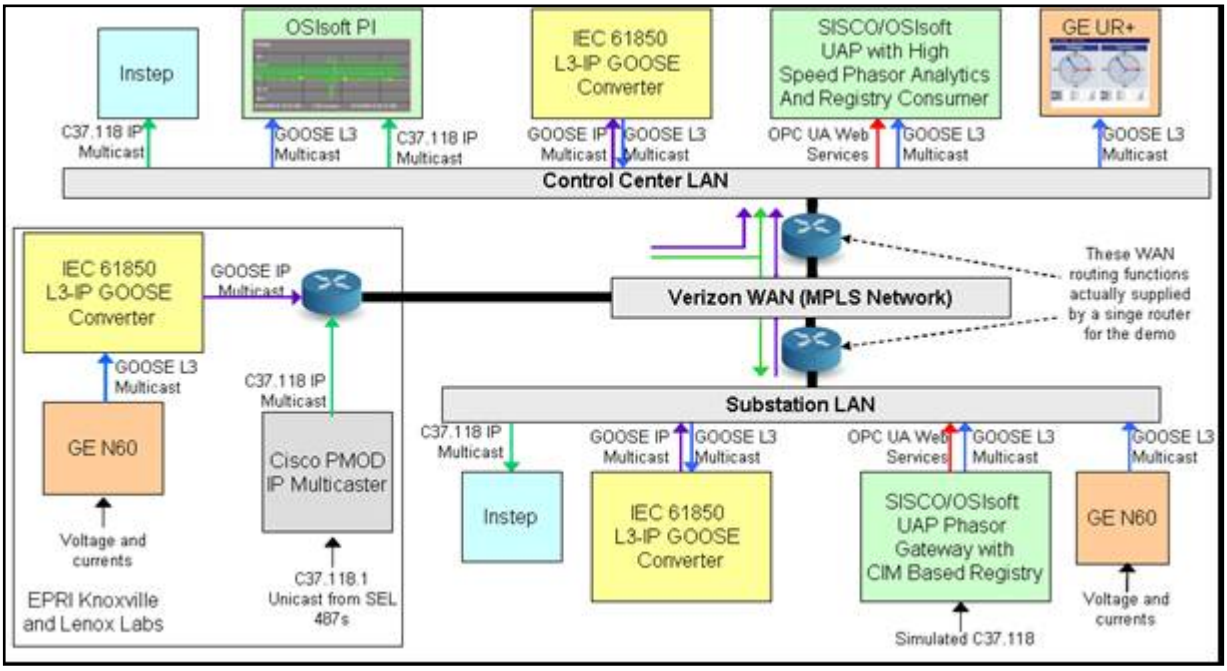
In late 2009, $3.4 billion in grant awards were made under the American Reinvestment and Recovery Act. A significant portion of that amount went towards the installation of more than 850 phasor measurement units (PMU's). At the time, there were about 150 units installed in the US & Canada. Synchrophasors make it possible for grid operators to better manage the grid through improved awareness of grid disturbances and help better integrate renewable energy resources like wind and solar power.

While synchrophasor technology has been around for over 20 years, adoption has been limited. One of the biggest obstacles has been the lack of high speed communications links necessary to transport the synchrophasor measurements to a data or operations center. Today, most of the data channels tend to be implemented through virtual private network (VPN) tunnels over dedicated communications paths. Also currently synchrophasors mainly benefit transmission operators, which further complicate the situation since these communication paths need to comply with NERC Critical Infrastructure Protection standards.

Synchrophasor technology is the singular focus of the North American SynchroPhasor Initiative (NASPI). The mission of the North American SynchroPhasor Initiative is to improve power system reliability and visibility through wide area measurement and control. The organization is made up of an Executive Steering Group, Leadership Team and five task teams. A few years ago the Data and Networking Task Team developed the concepts behind a synchrophasor network that would provide for secure transport of synchrophasors outside a single utility. This network is called NASPInet and the specifications describing this network (http://www.naspi.org/naspinet.stm) were published in 2008. At the most recent NASPI meeting in Fort Worth, TX on February 24, 2011 the Data and Networking Task Team organized a multi vendor demonstration of one approach to the implementation of NASPInet for transporting synchrophasor data. The participants in the demonstration were CISCO, GE Digital Energy, OSIsoft, EPRI, InStep Software, SISCO, Space Time Insight, and Verizon. The features of the demo were to:

- Illustrate how IEC 61850 can be used to transport synchrophasor data over a wide area
- Demonstrate the efficient routing of synchrophasor data across the Wide Area Network using IP Multicast
- Identify the value of a common Application Program Interface (API) that supports C37.118 and IEC 61850-90-5
- Illustrate the benefits of an IEC 61970 Common Information Model (CIM) based synchrophasor registry using set of secure, cross-platform web services that support model driven exchange

Architectural Schema Used in the Demonstration



IEC 61850-90-5 based phasor data exchange

The IEC 61850-90-5 standard specifies how to transmit synchrophasor data and has been published as draft Technical Report (57/1086/DC). A significant aspect of this draft standard is that it defines how high speed protection oriented IEC 61850 messaging can be used for wide area communication.

The demonstration illustrated how IEC 61850-90-5 can be used to transport synchrophasors over a wide area and enable subscription to specific synchrophasor data streams using multiprotocol labeled switching (MPLS) and IP Multicast. The benefits of this approach are:

- Increased visibility and reliability of the power system
- Enablement of wide area protection and control

- Simplification of substation design engineering
- Reduced telecommunication cost

While not demonstrated this architecture supports secure synchrophasor transport

- IEC 61850-90-5 for transport encryption
- GDOI key exchange protocol (under review in IEC)

Demonstrate IP Multicast

Another goal of the demo was to show how the routing of synchrophasors across the Wide Area Network could be accomplished efficiently using IP Multicast, as opposed to using IP Unicast. This approach allows the interested receiving entities (Subscribers) to specify which synchrophasor data (Publisher's) they wish to receive; the network automatically builds a single data distribution tree to support all receivers of the same data. Data replication (i.e. IP Multicast packet replication) is done efficiently within the network routing layer. Use of IP Unicast requires that a separate data stream be created by the PMU for every receiver that wishes to receive the synchrophasor. This is neither scalable nor efficient, and leads to overly complex architectures with latency-inducing Phasor Data Concentrator (PDC) stacking approaches to make data available to all interested subscribers. All of the IP Multicast-related routing technologies used in the demonstration have been in use in various industries (eg. live video distribution) for many years and have well proven track records and are implemented with off-the-shelf equipment and open standards. Examples of subscribers can include PDCs, historians, protection and control systems, analytics and visualization systems, other devices and applications that receive IP Multicast. The demonstrated architecture can scale to support synchrophasor distribution within a single utility network as well as between utility networks. The benefits of this approach are:

- Simpler PMU network structure
- Eliminates the need for PDC stacking, so improves latency
- Reduces PMU processing burden– only a single source stream is needed
- Dramatically expands the number of potential receivers (subscribers) for any PMU with no incremental burden on the source device (PMU)
- Provides reliable data receipt modes
- Handles both C37.118 and 61850-90-5 traffic
- Supports extensive security measures

Demonstrate Common API Support by Phasor Applications

The OPC API was used by PMU applications to access local PMU data. Using an OPC API simplifies migration of legacy protocols and devices and enables integration of synchrophasor data with CIM and PMU registry. The benefits of the OPC API are:

- Reduces migration cost for utilities that already have some PMUs deployed
- Supports both IEC 61850 and C37.118 protocols simultaneously
- Eliminates the need for wholesale upgrades
- Provides a unified environment for a model driven application development
- Widely supported by existing off-the-shelf applications

Demonstrate Wide Area Access to a CIM-based Synchrophasor Registry

The IEC Common Information Model is a well thought-out power system data model easily adapted to support the synchrophasor registry. The OPC Unified Architecture (UA) standard provides a cohesive, secure and reliable cross platform mechanism for access to historical data and events across a wide area. OPC UA Web Services enables a secure exchange of connected power system models with current and historical synchrophasors; support also is available for alarms and events. The benefits of a CIM-based Synchrophasor Registry accessed using OPC UA are:

- Simplifies controlled registration and subscription of data across utility boundaries
- Enables secure power system model synchronization between utilities
- Provides support for wide area system analysis for power system event response and post analysis
- Future support for coordinated alarm handling across a wide area

Actual Geography Involved

The demonstration utilized live synchrophasor measurements that were streamed across Verizon-provided communications links between three EPRI labs in Lenox, MA, Charlotte, NC and Knoxville, TN and the demo presentation site in Fort Worth, TX. The Knoxville site also simulates a utility operations center and was also sending data to Fort Worth, TX. The demo also included a local area network in Fort Worth with a local PMU generating synchrophasor data locally.

In summary

A successful demonstration of key technologies took place at the NASPI meeting that included:

- Interoperable IEC 61850 90-5 based phasor data exchange over a wide area.
- IP Multicast routing of phasor data across the WAN
- Common OPC API support for C37.118 & IEC 61850-90-5
- CIM-based PMU Registry data exchange using secure OPC UA web services over a wide area.

The team is currently looking to expand the demonstration foundation to include cyber security features, system performance measurement, network management, and other features necessary to implement the full NASPInet architecture.
