PNNL-SA-151461

Advanced Sensors and Data Analytics: SynchroPhasors

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Presented to the DOE EAC February 26, 2020

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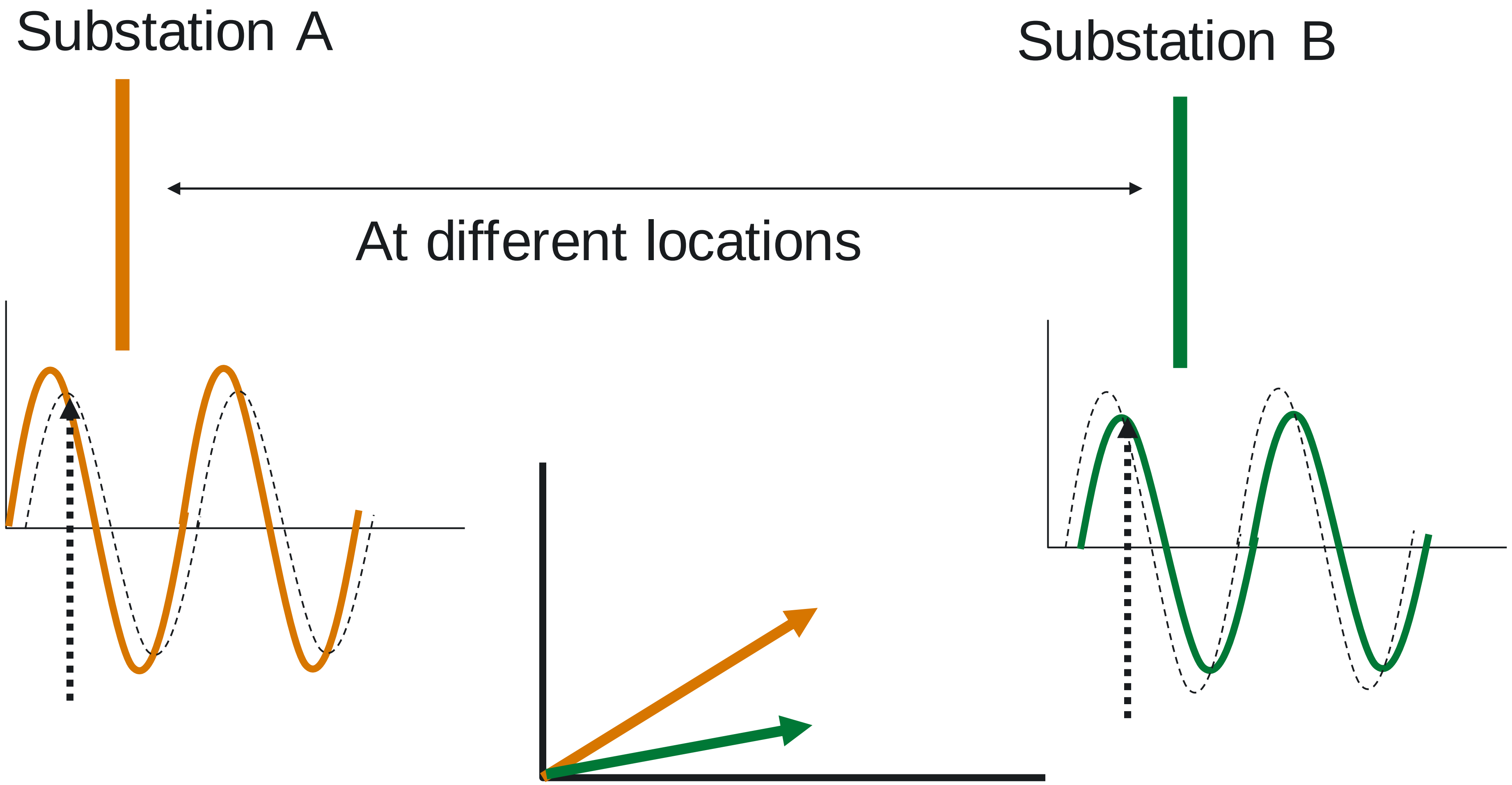
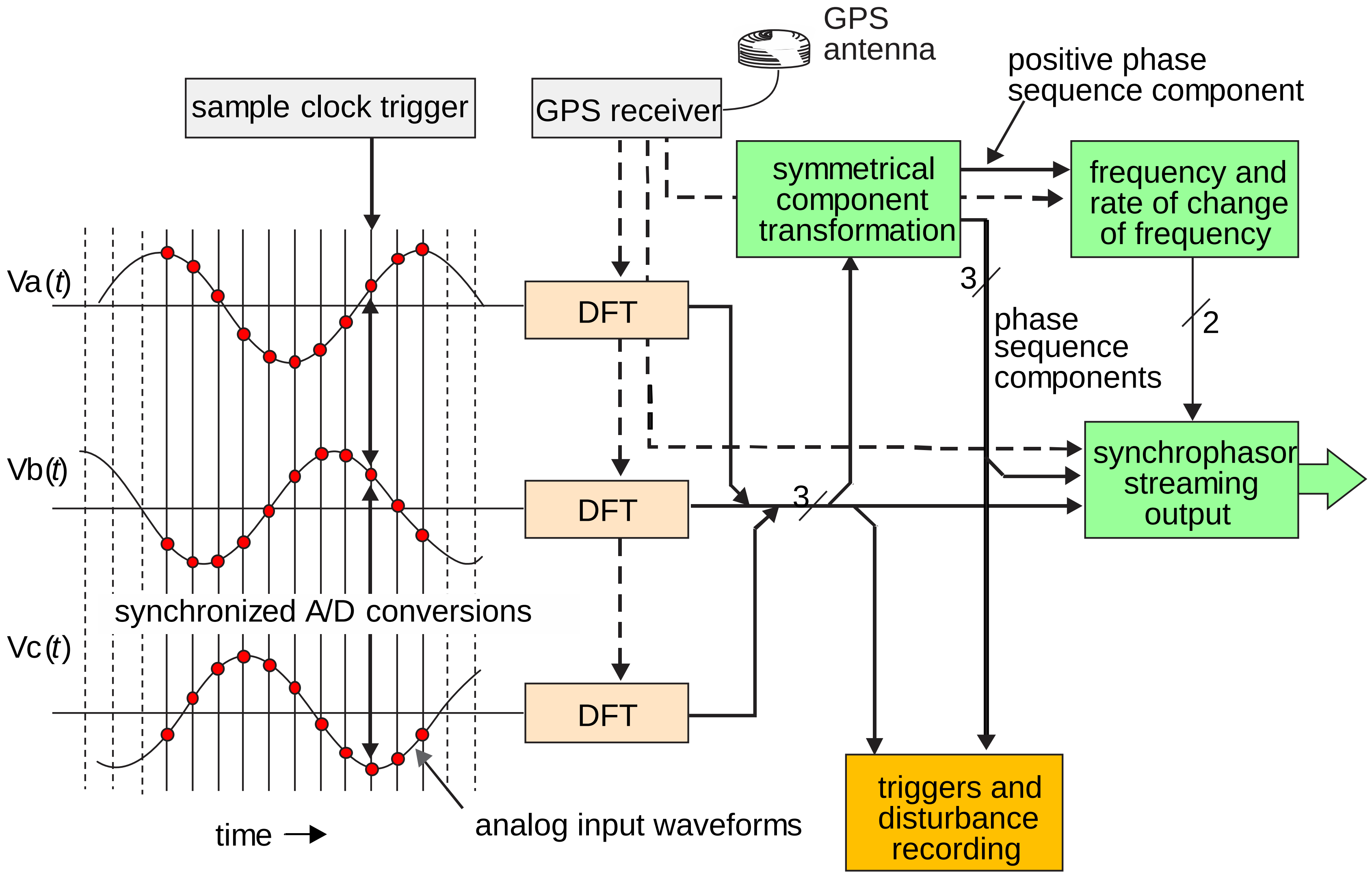
Time Synchronized Measurements



By synchronizing the sampling processes for different signals - which may be hundreds of miles apart, it is possible to put their phasors on the same phasor diagram.

Credit: A.G. Phadke

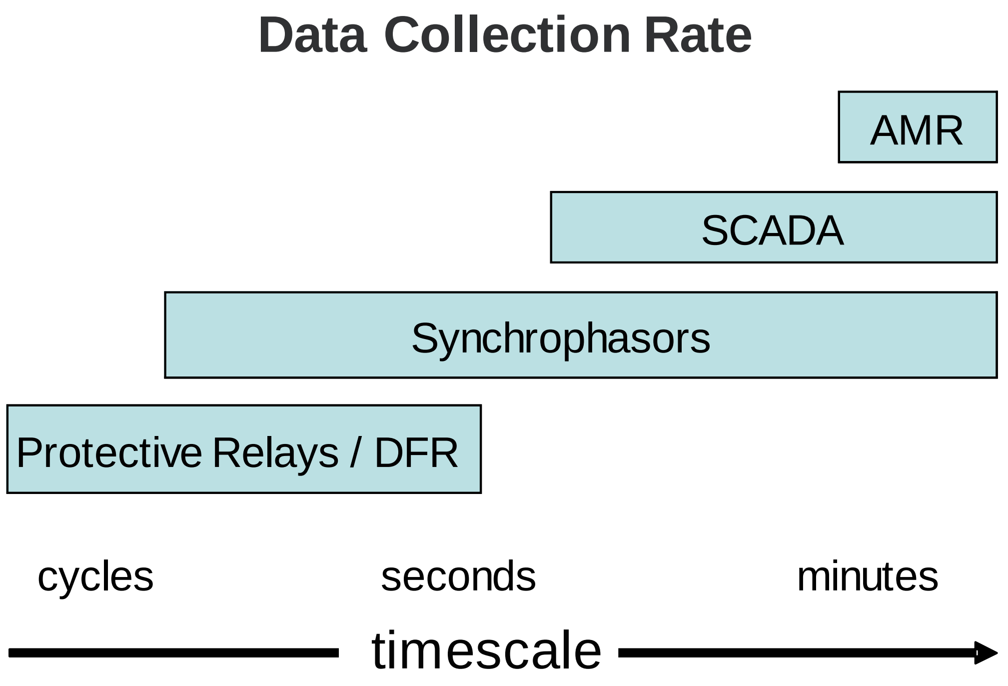
Phasor Measurement Unit



Credit: A.G. Phadke

Technology to Meet Emerging Industry Needs

- Synchrophasors are being rapidly deployed by several utilities throughout the world and across North America
- Both on-line and off-line applications are emerging, particularly those that require faster time synchronized measurements than are available from existing technology
- The measurement infrastructure is tailored to the requirements of the installation
- Vendors are providing new solutions including measurement technology, networking, and applications



Time synchronized synchrophasor data is gathered at sample rates much faster than SCADA systems, and provide the missing link between localized digital fault recorders (DFR) and SCADA systems, which are much slower.

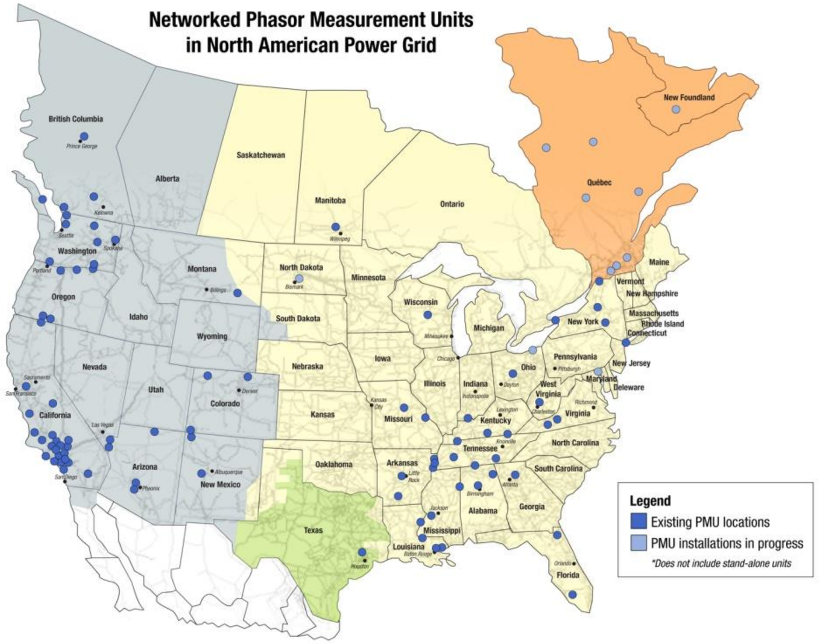
The North American SynchroPhasor Initiative (NASPI)

The U.S. Department of Energy (DOE) and EPRI are working together closely with industry to enable wide-area time-synchronized measurements that will enhance the reliability of the electric power grid through improved situational awareness and other applications.

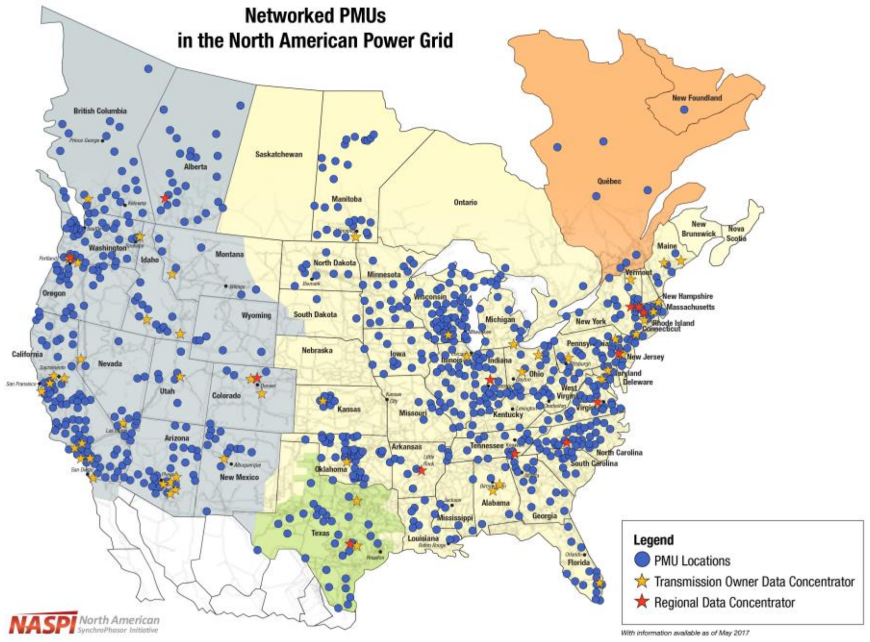
Current and emerging areas of emphasis/focus for NASPI:

- Networking and communications technologies (advanced architectures)
- Statistical analysis and deep learning for extracting actionable information from large datasets
- High-speed sensor measurements to characterize the transient behavior of inverter-based resources and other fast-acting phenomena

April 2007



May 2017



"Better information supports better - and faster - decisions."

NASPI North American SynchroPhasor Initiative | U.S. DEPARTMENT OF ENERGY | Office of ELECTRICITY | EPRI ELECTRIC POWER RESEARCH INSTITUTE

Big Data Analysis of Synchrophasor Data
DE-FOA-0001861

- Derive additional value from the vast amounts of sensor data already being generated

- Provide actionable information from the use of Machine Learning and Artificial Intelligence methods on large PMU data sets

- Enable faster grid analytics and modeling and better grid asset management through new tools

Press Release:
https://www.energy.gov/articles/department-energy-announces-20-million-artificial-intelligence-research

Fact Sheet:
https://www.energy.gov/sites/prod/files/2019/04/f61/Big%20Data%20Awards%20Fact%20Sheet%20FINAL_1.pdf

FOA Award Recipients

Prime Recipient	Team Members	Project Title
Iowa State University of Science & Technology	Electric Power Group, Google Brain, IBM	Robust Learning of Dynamic Interactions for Enhancing Power System Resilience
Schweitzer Engineering Laboratories, Inc.	Oregon State University	Machine Learning Guided Operational Intelligence from Synchrophasors
The Regents of the University of California	Electric Power Group, Michigan Technological University	Discovery of Signatures, Anomalies, and Precursors in Synchrophasor Data with Matrix Profile and Deep Recurrent Neural Networks
Board of Regents, NSHE obo University of Nevada, Reno	Arizona State University, IBM, Virginia Tech	A Robust Event Diagnostics Platform: Integrating Tensor Analytics and Machine Learning Into Real-time Grid Monitoring
General Electric Company	GE Grid Solutions	PMU-Based Data Analytics using Digital Twin and PhasorAnalytics Software
Siemens Corporation, Corporate Technology	Siemens Digital Grid, Siemens Industries and Drives (Mindsphere), Southern Methodist University, Temple University	MindSynchro
Ping Things, Inc.	N/A	Combinatorial Evaluation of Physical Feature Engineering and Deep Temporal Modeling for Synchrophasor Data at Scale
Texas A&M Engineering Experiment Station	Temple University, Quanta Technology LLC, OSIsoft, LLC	Big Data Synchrophasor Monitoring and Analytics for Resiliency Tracking (BDSMART)

PMU Data for FOA 1861

DOE and PNNL have worked to create a dataset that:

- Covers a significant number of PMUs and substations in each of the three US interconnections
- Covers multiple years and includes event logs
- Is real field data from a variety of sources that includes a variety of errors, inconsistencies, quality levels, and flaws
- Is anonymized, to reduce the data’s value in exposing potential information about power system operational vulnerabilities

FOA Analysis Objectives

1. Identify key events within each interconnection-specific dataset
2. Identify unusual or anomalous events and patterns not in the event log.
3. Catalogue the “signatures” (identifying patterns) including events that can be used to identify and diagnose events and grid conditions.
4. Identify precursor conditions that warn about forthcoming events.
5. Identify patterns that reveal the condition of power system equipment and insights into equipment modeling.
6. Identify apparent ground-induced currents (GIC) relating to geomagnetic disturbances.
7. Predict performance of power plants and other assets.
8. Identify actual load event and patterns, potentially including detection of DERS.
9. Identify factors that can improve wind integration and solar integration.
10. Identify factors that reflect weather and seasonality without the use of site-specific weather data.
11. Identify anomalies that may reflect cyber security issues and events rather than grid performance.

Conclusions

- Precise timing is widely used to support synchrophasor applications in the electric power sector
- Synchrophasors have long been used for important applications, such as validating power system dynamic models
- There are emerging applications being deployed that utilize synchrophasors for operational applications
- Various research initiatives are underway that will continue to introduce advanced technology to solve planning and operational challenges
  - One key example highlighted today is the application of machine learning technology on large datasets
- There is an emerging need to support additional high-speed "*point on wave*" measurements to characterize the behavior of inverter-based resources during off-normal conditions

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NASPI North American SynchroPhasor Initiative

https://www.naspi.org/

Thank you