Synchrophasor Data Quality

Synchrophasor Data Quality on American Transmission Company's (ATC) Transmission System

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GOALS

- Gain a fundamental understanding of phasor measurement challenges.
- Characterize synchrophasor data quality (error, availability, reliability).
- Identify methods for **detecting** and **correcting** faulty synchrophasor data.
- Attribute defective synchrophasor data to synchrophasor **data generation failure** at the measurement site, **losses in the data transmission** process, or **data-processing errors** at intermediate or final data storage locations.

FUNDAMENTAL QUESTIONS/CHALLENGES

- Smart grid initiatives envision very reliable synchrophasor data, **but…**

  …through early 2013, power system operators report (1) **significant gaps** and (2) **data quality** & **availability issues** with synchrophasor data.

- Inadequate partnerships between industry and researchers to **facilitate synchrophasor data "discovery" research**, specifically regarding access to data with detailed context (e.g., system topology and operating state).
- Our study systematically characterizes synchrophasor data quality, easily recognizing faulty synchrophasor data, and attributing the cause of faults.
- We are developing a list of synchrophasor data signatures for both known and unknown system state changes to generate a **visualization** with **real-time alerts** for operators, and enabling alerts to operators of unusual data patterns that may indicate malicious system attacks.

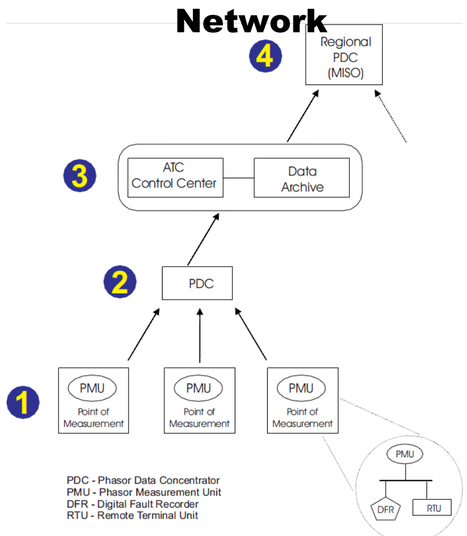
Identified Error Sources and Proposed Error Type Classifications[1]

Error Source	Level(s)	Error Type
Status code errors	1,2,3	data processing
Data streams disordered / shifted in processing	1,2,3	data processing
Loss of PDC configuration	2,3,4	data processing
Improperly configured PMUs (window length/windowing method)	1	digital signal processing
Frequency calculation discrepancies (C37.118.2005)	1	digital signal processing
Quality of metering	1	equipment specification
Accuracy issues (CT/PTs not properly rated for application)	1	equipment specification
Calculation uncertainty – vendor equipment operating differences	1	equipment specification
Metering locations separated by breakers	1	installation
Meters not installed at recorded locations	1	installation
PMU data streams not named as per system policies	1	installation
Asynchronous local behaviors (e.g., DC bias injections during solar storm)	1	measurement
Malformed network packets	2,3,4	network failure
Network data loss	2,3,4	network failure
Mislabeled phasor data streams	1,2,3	PMU configuration
Differences between PMU manufacturer calculation approaches	1	PMU standards

[1] Drawn from Synchrophasor Data Quality activity collaboration with MISO in April 2012 to categorize synchrophasor error types.

RESEARCH PLAN

Nominal Synchrophasor Data Network

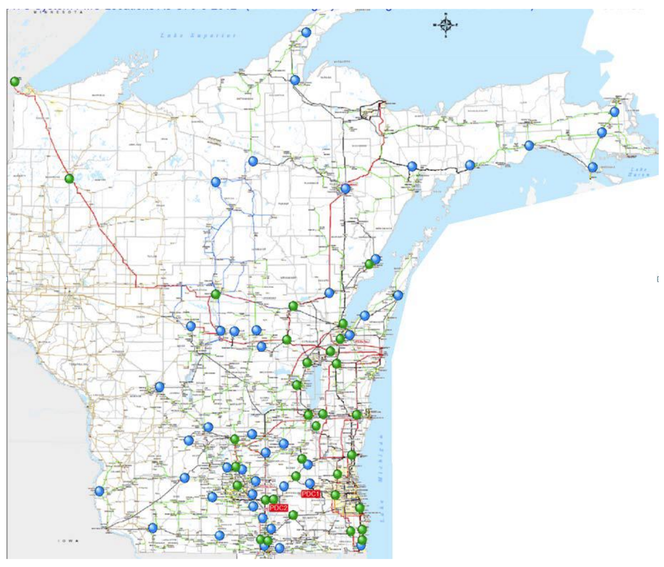


LEVEL 1 – POINT OF MEASUREMENT

LEVEL 2&3 – NETWORK TRANSMISSION

LEVEL 4 – CONTROL CENTER/POINT of USE

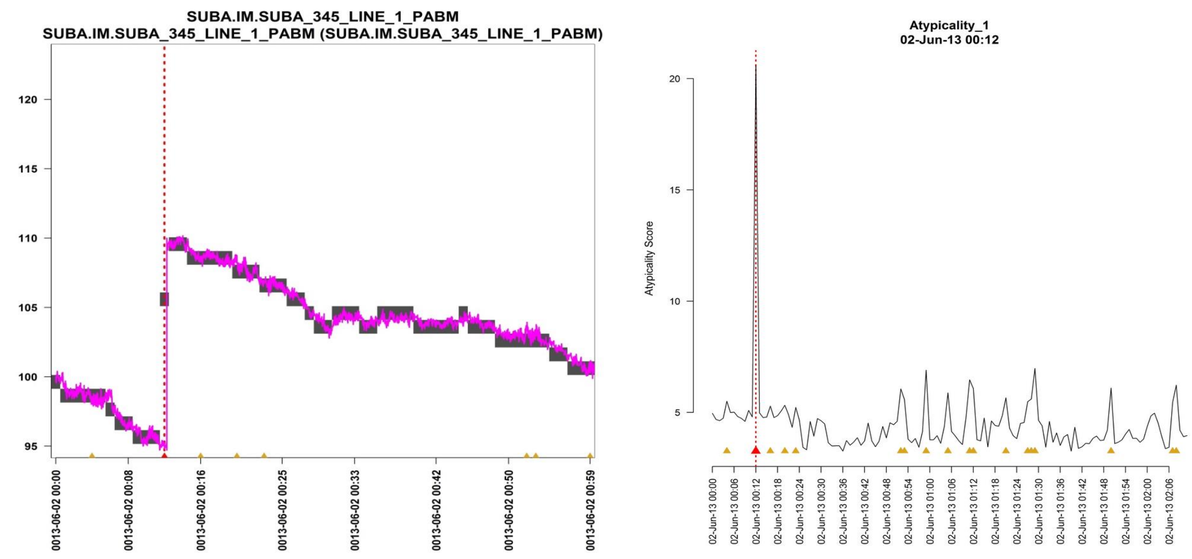
ATC PMU Installations



- Build robust 3-way collaboration including ATC, Pacific Northwest National Laboratory (PNNL), and TCIPG
- Renew/revise UIUC-ATC nondisclosure agreement to facilitate synchrophasor data and contextual information sharing
- Cross-correlate data collected at each network level to characterize data losses (> 2 seconds) between point of measurement and point of use
- Use PNNL-developed data tool (Situational Awareness and Alerting Report, SitAAR) to screen archived ATC data

RESEARCH RESULTS (ANALYSIS)

- Sample data from ATC have been received and analyzed through the use of SitAAR (Situational Awareness and Alerting Report) developed by Brett Amidan (Statistics Dept., PNNL)
- Kenta Kirihara has interned at Hitachi America, Big Data Lab on Big Data Analysis
- Yang Liu (new undergraduate research assistant) has worked on creating a real-time FFT computation of the synchrophasor data

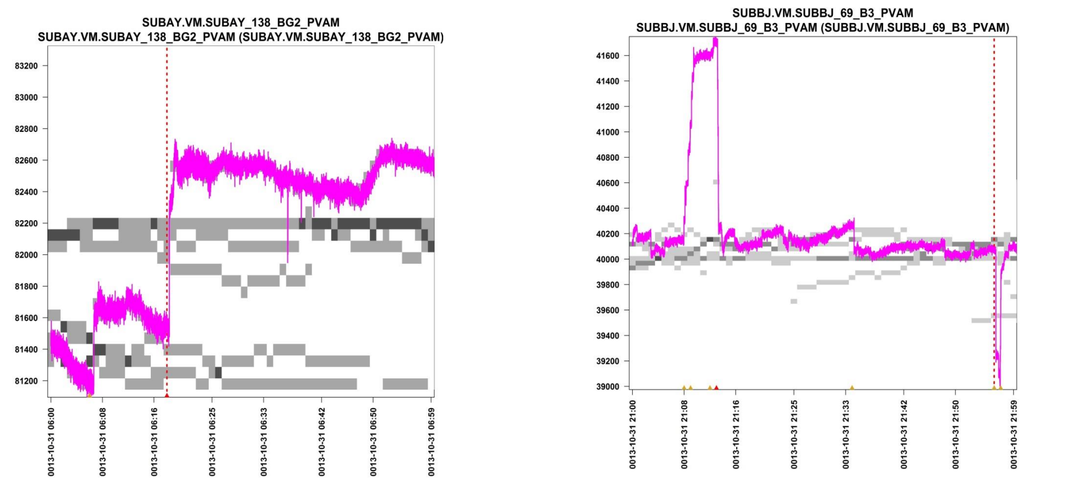


Sample SitAAR Information: Line current data (left) and corresponding "Atypicality Score" (right)

Signature Identified:

Figures below show two example signatures that were detected.

The two signatures both exhibit a sudden change in voltage, but are caused by different behaviors in the system. Being able to differentiate between the two shows the effectiveness of the detection method.



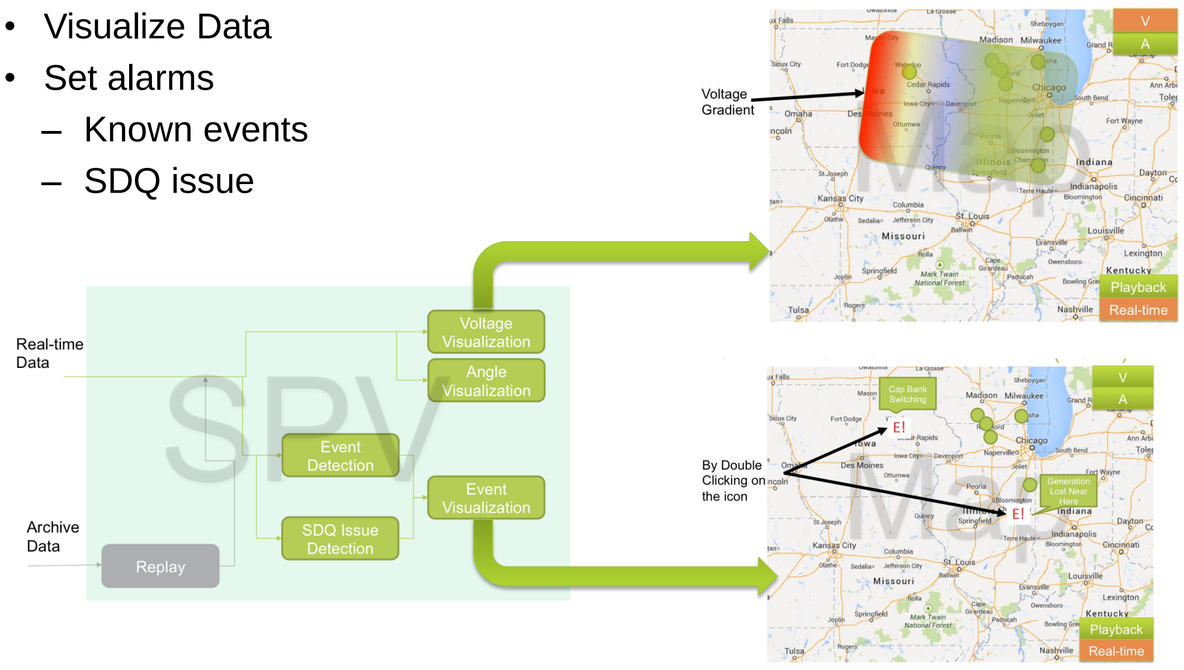
Atypical Events Captured: double capacitor bank switching (left) and tap changer switching (right)

RESEARCH RESULTS (VISUALIZATION)

Synchrophasor Visualizer (SPV)*

Java-based Application:

- Visualize Data
- Set alarms
  - Known events
  - SDQ issue



FUTURE EFFORTS

- Pursue progressively comprehensive complex "Signature Discovery" research
- Refine statistical analysis methods and tools
- Categorize types of detection criteria
- Develop real-time operations center alarms with visualization

FUNDING SUPPORT PROVIDED BY DOE-OE AND DHS S&T