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 **significant gaps** and **data quality** & **availability issues** with synchrophasor data.
- Anemic 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 and attributing faulty synchrophasor data.
- We are developing understood synchrophasor data signatures for system state changes to generate **real-time alerts** for operators, and enabling alerts to operators of unusual data patterns that may indicate malicious system attacks.

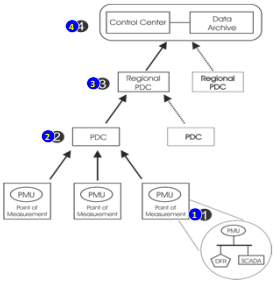
Identified Error Sources and Proposed Error Type Classifications[1]

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

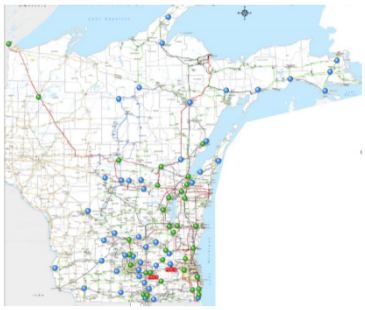
[1] Drawn from Synchrophasor Data Quality activity collaboration with MISO in April 2012 to categorize synchrophasor error types.

RESEARCH PLAN

Nominal Synchrophasor Data Network



ATC PMU Installations



LEVEL 1 – POINT OF MEASUREMENT

LEVELS 2 & 3 – NETWORK TRANSMISSION

LEVEL 4 – CONTROL CENTER / POINT of USE

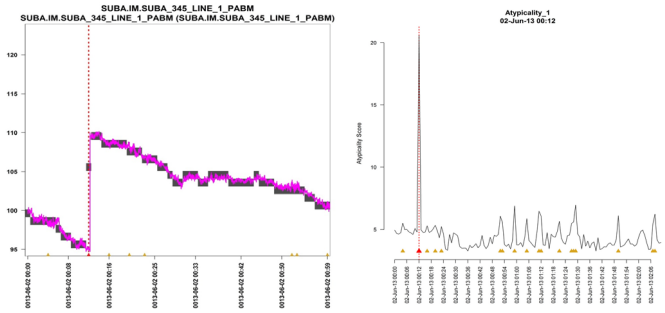
- Build robust 3-way collaboration including ATC, Pacific Northwest National Laboratory (PNNL), and TCIPG.
- Renew/revise UIUC-ATC nondisclosure agreement to facilitate synchrophasor data and contextual information sharing.
- Receive, secure, and use archived ATC synchrophasor and context data.
- Cross-correlate 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 PLAN (CONT.)

- ATC has proposed preliminary event analysis categories.
  - Unit trips and/or loss of significant loads.
  - System fault.
  - Capacitor bank failures.
  - Predecessor events to trips.
  - Imbalanced line phase angles differences (i.e., differing from 120°).
  - Etc.…
- We will analyze synchrophasor data to ID and characterize signatures.
- We will also screen ATC data for known signatures and identify other unusual data streams for investigation.

RESEARCH RESULTS

- Kenta Kirihara set conditions for productive research (data identification, sharing, system context) as ATC intern, Summer '13.
- Sample data from ATC have been received.
- Brett Amidan, Statistics Dept., PNNL, modified his "R-Project" based SitAAR (Situational Awareness and Alert Report) to accept and process ATC data.



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

BROADER IMPACT

- ATC benefits:
  - Improved ATC system situational awareness.
  - Rapid fault-condition location and identification – $$ savings.
  - Set the stage for future real-time PMU data applications.
  - Enable system instability condition forecasting.
  - Derived information will support the business cases for system improvements.
- PNNL benefits:
  - Side-by-side interaction with TCIPG power systems expertise.
  - SitAAR improvement recommendations from informed users.
  - Apply insights gained to parallel research efforts.
- TCIPG gains access to synchrophasor data with contextual information to facilitate research addressing project goals.

INTERACTION WITH OTHER PROJECTS

- Open Box Phasor Measurement Unit Development.
- Partner with PNNL (Brett Amidan) DOE/CERTS-sponsored synchrophasor data analysis projects.

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.

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