Synchrophasor Data Quality

Overview and Problem Statement

Synchrophasor data are envisioned to be a key enabler for real-time power grid situational awareness and control.

More than 1,000 phasor measurement units (PMUs) have been installed across North America and are generating synchrophasor data. However, the efforts to aggregate and process the synchrophasor data to produce consistently available, reliable, and actionable information have been challenging. Power system operators widely report synchrophasor data availability and trustworthiness issues as significant obstacles to realizing the envisioned capabilities and benefits.

Research Objectives

- Investigate the sources, effects, and implications of absent or erroneous synchrophasor data.
- Seek a fundamental understanding of real-time synchrophasor measurement challenges, as well as synchrophasor data quality measures (error, availability, and reliability).
- Characterize the sources of synchrophasor data quality shortfalls in the utility system from point of measurement to point of use.
- Identify and distinguish data quality issues due to system errors, system events, and maliciously altered data.
- Understand the implications of defective or absent synchrophasor data for system situational awareness.
- Develop methods for detecting and remedying defective synchrophasor data.
- Investigate next-generation phasor measurement device requirements.
- Develop and implement algorithms for next-generation PMUs.
- **Smart Grid Application Area:** Experiment-based trust assessment.

Technical Description and Solution Approach

- Establish collaborative research partnerships with power industry entities that collect synchrophasor data to classify synchrophasor data error sources, characterize the frequency of data errors, and identify strategies for improving synchrophasor data quality. Characterize the errors, availability, and reliability of field measurements and phasor measurement devices.
- Participate in and contribute to North American Synchrophasor Initiative (NASPI) working group meetings and research activities.
- Build and test an “open-box” PMU compliant with industry standards; understand the challenges of measuring, processing, synchronizing, and integrating synchrophasor data.

Results and Benefits

- The activity has established partnerships with the American Transmission Company (ATC) and the Statistics Department of Pacific Northwest National Laboratory (PNNL), laying the groundwork for “discovery” analysis of synchrophasor data being measured on ATC’s system.
- We are working with Jim Kleitsch, System Operations Engineer with the American Transmission Company (ATC), to investigate synchrophasor data quality using ATC synchrophasor data from 90+ PMUs. Kleitsch is the operations lead for the ATC DOE Synchrophasor Project, which involves the addition of 45 PMUs on the ATC system, and helps manage the 40 operational PMUs that ATC already has up and scanning at sites scattered across their footprint.
- In coordination with Brett Amidan, Statistics Department, PNNL, the team has adapted PNNL’s Situational Awareness and Alerting Report (SitAAR) tool to ingest and analyze ATC’s archived synchrophasor data. SitAAR uses the “R” statistical computing environment. The SitAAR tool enabled the identification of several event signatures within a small ATC data set.

- Using a small ATC sample synchrophasor data set, the team has written signal-processing algorithms to investigate methods for screening synchrophasor data in real-time for signatures of transmission system events.
- The activity has demonstrated a PMU developed using National Instruments' LabVIEW software and C-RIO hardware (compact reconfigurable I/O (RIO) architecture). The PMU is being integrated with an uninterruptible power supply to enable transient measurements during power outages on the power distribution system. Synchrophasor data are buffered and transferred hourly to a remote Linux web server via an FTP connection.
- The activity has evolved its PMU design to reduce per-unit cost from ~$1,000 to ~$250.
- The activity has been investigating ways to visualize power system cyber security relationships detailed in NISTIR 7628, Guidelines for Smart Grid Cyber Security. Early development efforts used MATLAB as the visualization platform; the team's poster describing this effort earned 3rd place recognition in the 2014 IEEE Transmission and Distribution Conference student poster session. Recent efforts have pursued creation of a web-based HTML application.
- **Technology Readiness Level:** Technology concept and/or application formulated.

Researchers

- Karl Reinhard, reinhrd2@illinois.edu
- Bogdan Pinte, bpinte2@illinois.edu
- Michael Quinlan, quinlan4@illinois.edu
- Kenta Kirihara, kirihar1@illinois.edu
- Daniel A. Long, dalong2@illinois.edu
- Brianna Drennan, bdrenna2@illinois.edu
- Yang Liu, yliu160@illinois.edu
- Peter Sauer, psauer@illinois.edu

Industry Collaborators

- American Transmission Company, Jim Kleitsch
- Pacific Northwest National Laboratory, Brett Amidan
- National Instruments

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