TIP 305: Data Integrity and Situational Awareness Tools (DISAT)

Context

The recent increase in the deployment of high-speed time-synchronized measurement devices such as phasor measurement units (PMU) provides a great challenge and opportunity to the power grid community.

Synchronized phasor measurements provide an opportunity to monitor dynamic behavior of a power system in real time. PMUs measure synchronized voltage and current phasors, frequency, and other data. Typical application areas of phasor measurements in power systems include state estimation, stability analysis, security assessment, event identification and fault location, and others. Among the applications, rapid and accurate detection and identification of transient events is increasingly important to the reliable operation of the system.

Significant challenges include managing the substantial amounts of data, cleaning that data, and then creating insightful analyses and displays. There is a great opportunity to provide system engineers real-time tools that increase their understanding of the current state of the grid and refine predictions of future grid behavior.

Pacific Northwest National Laboratory (PNNL) undertook a substantial research effort investigating these challenges in collaboration with utilities and the Department of Energy (DOE).

Description

The DISAT system is a prototypical collection of algorithms that provides interactive displays and results in a web browser, delivering situational awareness insight into PMU data. This project focused on PMU data management architecture, identifying and correcting data errors, and building real-time situational awareness tools to enhance grid visualization. These tools can increase power system engineers' understanding of the wide-area dynamic state of the grid, predictions of future grid behavior (potential types of violations, their probability, critical contingencies, and time to violation), as well as facilitating development of actionable advisory information tools and responsive controls to help manage potential problems such as grid instability.

TIP 305 created databases capable of supporting both real-time analysis of recent data records and offline analysis of large historical data sets.

Data-mining techniques applied to this data identified unusual events that were mapped to BPA logs establishing atypical baseline behavior. There were also a significant number of atypical events that did not map to known events.

Data cleaning filters were developed or adapted and then applied to data to help define the true meaning of the contained information.

As data was determined to be missing or bad, new and existing algorithms were applied to identify suspect data values as unavailable for all future analyses. New types of data filters were developed to confidently synthesize a corrected data value.

The project employed two tools that have been developed at PNNL: 1) SitAAR (Situational Awareness and Alerting Report), a data-driven multivariate approach to situational awareness; and 2) WAMN (Wide-Area Multidimensional Nomogram tool) which is combined with a characteristic ellipsoid (CELL) tool providing a wide-area, predictive, and actionable view of a power system.

Interactions with power system engineers will allow the project team to tune these algorithms and improve their usefulness, robustness, and predictability of the system behavior.

Benefits

PMUs produce large quantities of data that must be of high quality and reliability to be used for real-time decision making. The full value of these investments will only be realized if a data infrastructure is created, with data quality filters and analytical abilities.

The DISAT system shows promise as a situational awareness tool capable of finding un-envisioned atypical events. The data quality filters and methods developed promise to greatly increase the usability and application-related value of the PMU data.

Accomplishments

As currently developed, the DISAT system performs the following functions:

- Reads and processes streaming PMU data;
- Cleans the PMU data to provide useful and reliable data for analyses;
- Calculates and stores signatures which extract important features found in the data to be used in the analysis;
- Groups the data into mathematically defined patterns to help define what is typically seen;
- Detects atypical events using a mathematically and data driven focus; and
- Displays plots and tables graphically, providing insight into the analytical results.

Further work can be done to insert domain knowledge, creating even better insight. As domain experts investigate these atypical events, their experience can be used to build a classification system, in which the type and importance of the events is determined. This would provide a domain-driven reason for the event and possibly describe its relative importance and indicate possible corrective actions. This insight could also be useful in adding prediction capability to DISAT to warn of probable future atypical events.

PNNL and BPA will continue to collaborate to refine and tune the event detection filters. This will be accommodated largely as part of normal workload, as BPA continues to generate and analyze PMU data, and PNNL will continue to evolve the DISAT product. Based on experience gained with the tool, the need for or advantage of additional large scale features may be revealed. If so, PNNL may again submit a BPA Technology Innovation Proposal to create a formal Project.

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Project Start Date: October 1, 2013

Project End Date: January 31, 2015

Total BPA Project Cost $250,000

Deliverables

Final Report
Prototype DISAT tool

Participating Organizations

Pacific Northwest National Laboratory
United States Department of Energy (DOE)

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