TIP 251: Implementation of a Full-Topology, Three-Phase, Robust, and Generalized State Estimator

Context

The need for more frequent system analysis is growing due to increasing use of more distributed energy resources (such as wind generation), which results in a more variable transmission system state. In addition, more stringent NERC requirements may now demand more frequent analysis. To meet these requirements, a flexible state estimation tool is of paramount importance. State estimation is an essential tool for real-time power system monitoring and is a fundamental requirement for all real-time security analysis and advanced control tools. Access to a refined and accurate description of the current state of controlled devices and subsystems in the transmission grid is a necessity for any real-time wide-area control and for the development of any software tools that help improve system performance and online real-time transmission grid operation.

Description

This project is meant to revolutionize the state estimation algorithms used within a control center. The first major change will be to write the state estimation algorithms to utilize the full-topology (node-breaker) power system models contained within control center energy management systems (EMS). Present state estimators must make use of a cumbersome two-model approach that maps data between the full-topology model and a reduced bus/branch model on which state estimation is performed. This mapping has detrimental ramifications for software development as well as the use of output from a state estimation algorithm. In addition, present technology used in commercial state estimators does not fully take advantage of advances in algorithms made over the past 20 years, such as topology error detection and parameter error detection (largely because of the problems with maintaining two models).

Why It Matters

The wider adoption of full and consolidated representations of the power system available in the same format, model, and GUI will have the following advantages:

1. Offline tools, such as contingency analysis and dynamic security assessment, can be directly used in the real-time production environment without requiring changes to EMS modeling.
2. Seamless exchange of cases between real-time and planning environments facilitates comparing the actual operating outcome with the planned operation and correcting model discrepancies. This also allows development of a centralized model for the power system.
3. The project will greatly simplify maintenance and operation, allowing data managers and engineers to deal with a single format. There will be no need to understand multiple models with diverse data structures that should represent the same physical system.
4. A unified set of applications and interfaces can be presented to operators, engineers, and planners. Learning and usage become much easier, faster, and cheaper.
5. Unification of power system models will help enhance operating practices, increasing the capability to predict insecure conditions in the system and making better tools available to identify economic opportunities in the electricity market.

The impact of the proposed project on areas of benefit (in order of most obvious to least) will be as follows:

1. <u>Lower operation and maintenance costs</u>: Better modeling yields better situational awareness yields better system utilization.
2. <u>Reduced cost of power interruptions</u>: Better situational awareness means fewer costly blackouts.
3. <u>Lower electricity costs</u>: Better grid utilization means lower operation and maintenance costs.

Goals and Objectives

The State Estimator must meet the following objectives:

1. Include integrated topology error detection
2. Perform parameter error identification and correction
3. Handle three-phase modeling and measurements
4. Operate on a single power system model representing full-topology modeling

Technology Innovation Project

Project Brief

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Deliverables

1. A PowerWorld Simulator/Retriever version that includes an orthogonal factorization built on QR factorizations using Givens rotations.
2. A PowerWorld Simulator/Retriever version that includes expanded state estimation algorithms to utilize full-topology Models.
3. A PowerWorld Simulator/Retriever version that includes full implementation of topology error detection in the full-topology framework.
4. A PowerWorld Simulator/Retriever version that includes expansion of the network model and equations to a three-phase representation.
5. PowerWorld Simulator/Retriever version that includes investigation of parameter error identification and correction.
6. A final report detailing the completed tasks and updated software.

Project Start Date: December 2011

Project End Date: September 2012

Participating Organizations

PowerWorld

Funding

Total Project Cost:	$772,500
BPA Share:	$387,500
External Share:	$385,000
BPA FY2012 Budget:	$387,500

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