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SuperCalibrator: Expanding Real-Time Information for Power System Operators

Significant penetration of renewable resources, demand response, and distributed generation cause rapid increases in the level of uncertainty in control of electric power systems. This requires a completely new approach to the design of a control system for the future power grid. Current centralized approaches to providing power system operators with the information they need to be aware of their power system's situation (or state) have become highly inefficient and, for all practical purposes, are now considered obsolete. To address this problem, researchers at the Georgia Institute of Technology have developed a game-changing technology called "SuperCalibrator." System visibility to operators has been identified as an important component for power grid reliability. The SuperCalibrator provides unprecedented visibility update rates of 60 times per second thereby reducing the risk of blackouts.

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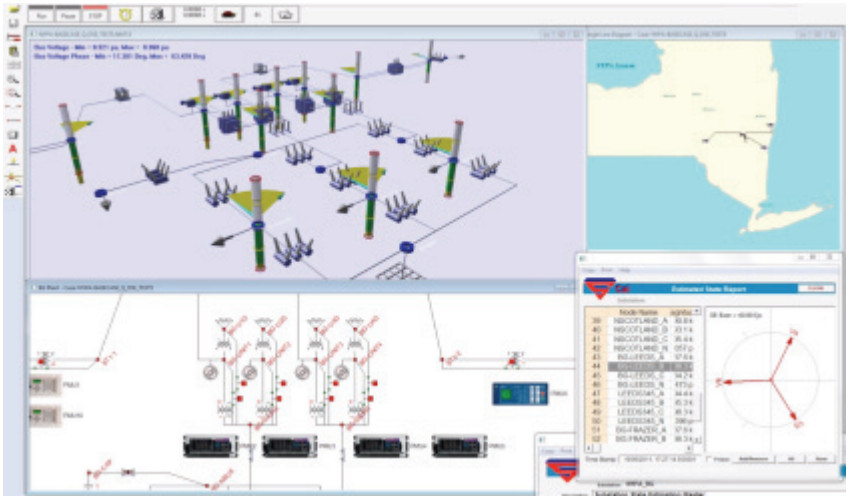
The SuperCalibrator is a distributed state estimator that uses a detailed model of a substation and measurements from all devices in the substation (such as meters and protection relays) for the purpose of extracting a real time model of the substation, identifying and rejecting bad data, identifying and correcting topology errors, and verifying the model parameters. In the presence of at least one valid Global Positioning System (GPS) synchronized measure-

ment, the real time model of the substation is valid for a specific time instant with precision one microsecond. Subsequently, results from each substation (that is, the state of each substation) are transmitted to the control center where all substation real time models are combined to synthesize the real time model (operating state) of the entire system for that instant in time. Synthesis of the entire system model requires minimal computations. The most significant advantages of the SuperCalibrator are: a) high update rates of the system-wide state estimation and solutions (with a demonstrated operation of 60 times per second); b) the accuracy of the real time model; c) scalability that enables high update rates independent of system size; and, d) the model's ability to extract real time model during disturbance conditions.



The SuperCalibrator is a distributed state estimator that uses detailed models of substations and measurements from all substation devices to provide power operators with real-time information that can help them avoid blackouts and improve the efficiency of the grid.

When these characteristics are compared to the present state-of the-art in state estimations, it is clear that the SuperCalibrator is a breakthrough that enables unprecedented speeds for achieving improved system visibility.

The SuperCalibrator has been implemented and demonstrated at several substations (in US Virgin Islands, New York Power Authority, and Pacific Gas and Electric). With the expected massive phasor measurement unit installations across the US, SuperCalibrator will play an important role in the future for both control center applications and substation protection and control.

Economic Impact: The potential economic impacts of SuperCalibrator will result from: 1) elimination of the costly centralized state estimator; 2) operational savings resulting from the accurate real time model that enables avoidance of overly conservative or wrong decisions; and, 3) early (and fast) detection of the danger of cascading power outages (saving on the costs of blackouts). At the individual utility level, this technology can replace the costly centralized state estimator resulting in a savings of several million dollars for each utility. Since the nation's power grid oper-

ational procedures and optimization are based on the system model, a more accurate real time model provided by the SuperCalibrator will favorably impact practically all operations of its power grid. A conservative 0.1% reduction in operating losses will translate in $200 million annual savings for the nation's power grid. That said, the true economic impact of a more visible power grid will remain a topic for speculation. The impacts are believed to be very high because avoidance of just one widespread blackout could result in difficult to document savings of billions of dollars.

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Advanced Power System Visualization Tools

Researchers at PSERC have integrated new visualization techniques with power system modeling methods to create visual insights for the user into the condition of power systems. Using visualization tools, industry can "see" what is happening without disruption of the actual energy production. Using two- and three-dimensional plotting capabilities coupled with power system animation, the technology gives the user a picture of the power system that synthesizes thousands of pieces of information.

With advanced visualization tools, power system operators can be better aware of current operating conditions and prepared to take decisive actions needed to avoid blackouts. The tools are also useful in power system planning, policy analysis, and education of the next generation of electric power engineers.

The visualization technology shortens the time between observing power system problems and identifying appropriate corrective actions, thereby making power systems more reliable. It integrates visualization of economic and engineering data, thereby informing decision-making for economic and reliable power system operation. It is widely used on operational and long-term planning analyses in the electric power industry, allowing engineers to efficiently run and analyze the reliability and economic effects of alternative scenarios. It also enables power systems engineers and operators to better communicate with non-technical audiences that often include business and regulatory policy-makers. It serves as a training tool for technical and non-technical audiences. From either a free download or as run from a CD inserted in a popular power system education book, the tool is improving university education by giving students simulation experiences that give insights into the operation of real power systems so that students can learn about the very complex technology of power systems through simulations. This technology was awarded the Alexander Schwarzkopf Prize for Technological Innovation by the I/UCRC Association in 2005.

Economic Impact: Problems with situational awareness can lead to blackouts, such as the Blackout of 2003 that cost over ten billion dollars. The cost of outages and transmission constraints

leads to some $100 billion in costs nationwide every year, so this tool is directly addressing the need for improved power system reliability. This technology has been successfully commercialized via a new small business. It is being incorporated into software that is sold worldwide. The visualization tool is a spin-off from university research that demonstrably improved power system monitoring, control, analysis, and education in the electric power industry. A small business has installed the tool in some 20 control centers across the US to improve situational awareness for control room operators. It is being used by over 700 engineers and policy-makers worldwide. The technology will be used by the National Electric Reliability Corporation for nationwide reliability monitoring.

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