New approach to modeling power system aims for better monitoring and control of blackouts

January 12 2011

Major power outages are fairly infrequent, but when they happen they can result in billions of dollars in costs – and even contribute to fatalities. Now research from North Carolina State University has led to the development of an approach by which high-resolution power-system measurements, also referred to as Synchrophasors, can be efficiently used to develop reliable models of large power systems, which would help us keep an eye on their health.

Synchrophasors are real-time measurements of voltages and currents that provide a very high-resolution view of various complex events occurring in a power system. They are measured by sophisticated digital recording devices called phasor measurement units (PMUs). "PMUs are comparable to surveillance cameras that continuously monitor the complex dynamics of groups of people in busy places, and indicate how different people respond and interact with each other," says Dr. Aranya Chakrabortty, lead author of a paper describing the research and an assistant professor of electrical and computer engineering at NC State.

"This research is a major step toward helping us understand how Synchrophasor technology can be used to model the complex behavior of any large, geographically distributed power system, especially taking into account the system's interconnected nature," Chakrabortty says.

"We need to have a better understanding of how a disturbance entering one generation cluster – or localized group of nodes – may spread across the entire system, creating havoc in its neighboring clusters as well," Chakrabortty says. "More importantly, we need to investigate if the speed of this spread is dictated by the way these clusters are connected to each other." The North American power grid is divided into four distinct operating zones, each of which has several such generation pockets, Chakrabortty explains, across which a disturbance can disseminate very easily.

For example, during the 2003 Northeast Blackout, generating units in Ohio and New England appeared to be functioning smoothly. However, there was significant disparity between the two regions when it came to reactive power – which is a byproduct of generating electricity. That disparity created a cascading series of "voltage collapse" events – which cut off power to approximately 50 million people, was linked to multiple fatalities and cost an estimated $4 to 10 billion. The event highlighted the need for monitoring the system globally, rather than focusing on individual nodes in isolation.

"In order to understand how the effects of major disturbances can propagate across the North American power system, we need highly reliable and rigorous mathematical models that capture the dynamics of its various clusters, as well as the way those dynamics will evolve when the clusters are connected to each other in the overall system," Chakrabortty says. "Traditional measurement methods in power systems are too slow and, therefore, incapable of capturing these dynamics, which can change dramatically in fractions of a second. With the Synchrophasor technology today such models are possible."

Chakrabortty and his co-authors from Rensselaer Polytechnic Institute (RPI) and Southern California Edison have developed an approach for creating cluster models, which uses Synchrophasors from PMUs located at specific points within a cluster of nodes. The approach also allows one to identify how the clusters are connected to each other by comparing PMU measurements at different points in the system. "Once you have modeled the clusters and determined their connections," Chakrabortty says, "our algorithm enables you to model the interactive behavior of the clusters within the larger system in the face of large disturbances. We also show how to place PMUs optimally at the nodes so as to extract maximum amount of useful information for better modeling.

"Our models are informative, yet easy to compute," Chakrabortty adds. "They will help power-system operators track and predict the global health of any distributed power system in real time so that catastrophes such as the 2003 blackout can be prevented in the future. The study will lead to an entirely new vision of monitoring and controlling the North American grid, which is becoming more expansive, and, more chaotic day by day."

More information: The paper, "A Measurement-based Framework for Dynamic Equivalencing of Large Power Systems using Wide-Area Phasor Measurements," was co-authored by Dr. Joe Chow of RPI and Armando Salazar of Southern California Edison. The paper is published online in *IEEE Transactions on Smart Grid.*

Provided by North Carolina State University