Managing Information Overload in Power Grid Control Centers

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A new technology for analyzing alarm cascades in power grids is currently being tested in an EPRI research project with GoalArt as the principal contractor. It involves Midwest ISO and First Energy as direct participants and other utilities and ISOs in project reviews. The aim of the project is to test whether the method can provide a solution to the information overload problem, which occurs in association with large alarm cascades.

Alarm Cascades

In power grids, a larger fault usually leads to several *consequential faults.* Most of these consequential faults create alarms. Normally, alarms arrive out of time order, depending on system physics, alarm limit settings, and clock skew, and it is usually hard for operators to analyze the developing fault situation, to understand what is really going on, and to take actions to alleviate the situation or perform a graceful reconfiguration of the grid in time.

The effect is known as an *alarm cascade.* It is the most difficult alarm problem and also the most dangerous, since it appears in exactly those situations where the alarm system is needed the most.

Potential Technical Solution

Methods based on multilevel flow models (MFM) have been developed at Lund University, the Danish Technical University, Stanford University, and at GoalArt. These methods use simple models of power flows to capture the causality of technical systems. An algorithm based on MFM offers a complete and efficient solution to root cause analysis. Both the algorithm and modeling concept has been industrially proven in, for example, conventional and nuclear power generation.

MFM models of power grids can be *generated automatically from topology databases.* This means that a plug-and-play solution to the problem of alarm cascades in power grids is possible.

Advantages of the Method

The MFM-based algorithm can handle all possible combinations of faults, including multiple independent root faults and circular causations in a theoretically correct and complete way. Thus, it makes no single fault assumption. In a sense, it is a final solution to fault causation analysis.

The algorithm is *linear* in target system size, for execution time and memory demands, and also very fast. The First Energy power grid model can be automatically generated from a CIM file in sub-second time, and a root cause analysis on this model is also performed in less than a second. A translation of the entire MISO grid takes about a minute, and a root cause analysis takes less than a minute. GoalArt is currently working on lowering these times further. Thus, we believe that it will indeed be possible to analyze large alarm cascades in real-time, while they develop.

Current Project Status

So far, our main testing environment has been the EPRI Operator Training Simulator (OTS) and the generic Power & Light system. Here we have studied a number of cascade and blackout scenarios. We have also studied the reliability of the method in face of changing flow patterns. In addition, we have made modeling investigations using larger system, such as the First Energy and MISO grids. The aim of the next phase of the project is to install a live demonstration system in a control center of one of the participating partners.