ON-LINE ROOT CAUSE ANALYSIS FOR LARGE CONTROL CENTERS

Jan Eric Larsson, GoalArt

Abstract
This presentation describes a new technology for analyzing large alarm cascades in a power grid in real-time, and thereby making it possible to prevent major blackouts.

Problem
In complex technical systems, a fault usually leads to several *consequential faults.* Most or all of these consequential faults may lead to fault indications, so called *events* or *alarms.* Normally, alarms arrive out of time order, depending on system physics, alarm limit settings, and clock skew, and it is often very hard for operators to analyze the developing fault situation, to understand what is really going on, and to take the appropriate actions to alleviate the situation or perform a graceful shut-down.

This effect is known as *alarm cascades*, alarm showers, or alarm floods. It is the most difficult alarm problem to handle and also the most dangerous one, since it appears in exactly those situations where the alarm system is needed the most. So far, no viable solution to this problem has been available.

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

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

Advantages
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. A complete worst-case analysis of 1 000 incoming events takes about 5 milliseconds on a standard PC, which means that 1 000 000 events need some 5 seconds. Thus, it is indeed possible to analyze large alarm cascades in real-time, while they develop.

Finally, since MFM models can be generated from grid topology databases, there is a *zero knowledge engineering effort* involved for a power grid.

Future Possibilities
In short, GoalArt offers the possibility of solving the problem of large alarm cascades. We believe that this will be one step towards enabling control centers to analyze and understand the fault situations that precede smaller and larger blackouts. This will enable operators to immediately understand the situation and perform corrective actions, before the situation escalates and a blackout strikes.

GoalArt, Tunavägen 39C, 223 63 Lund, Sweden; Phone +46 46 192640; E-mail: info@goalart.com; Web: www.goalart.com