

Root Cause Analysis of the September 23, 2003, Nordel Blackout

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In a project between Svenska Kraftnät and GoalArt, we have built a demonstration system, which can perform a root cause analysis of the September 23, 2003, alarm cascade in the Nordel grid. The system correctly identifies the two independent initiating events, a nuclear reactor scram and a sub-station short circuit, during the first minute after the start of the cascade.

The September 23, 2003, Alarm Cascade and Blackout

On Tuesday September 23, 2003, the Nordel grid experienced a major blackout of most of southern Sweden and Eastern Denmark. It was accompanied by a large alarm cascade, which in essence prevented the operators in the control center from locating the second root cause, (a short circuit in the Horred sub-station). This fault was not clearly identified until four hours into the event. The alarm cascade comprises some 400 alarms from more than 100 stations and over 150 lines. The first initiating event is easy to spot, while the second is hidden in a mess of out-of-order trip events, and quite difficult to identify under stressful conditions.

A Root Cause Analysis Pilot Project

In 2006, Svenska Kraftnät and GoalArt performed a pilot project using a new alarm management and root cause analysis technology, developed by GoalArt. The methods are based on multilevel flow models (MFM), which have been developed at Lund University, the Danish Technical University, Stanford University, and at GoalArt. The methods use simple models of power flows to capture the causality of a grid. They have been industrially proven in other industrial branches, for example, conventional and nuclear power generation.

The model used in the project was automatically generated from a net list dumped from the Oracle database of the SCADA/EMS system at Svenska Kraftnät. It covered the southern half of the Swedish part of Nordel, which is the part that was affected by the blackout. The alarm and event list used was the actual electronic list, saved by Svenska Kraftnät on September 23, 2003.

Results of the Project

The created system generates its model automatically from the grid topology database of Svenska Kraftnät. It reads the September 23 alarm and event list and correctly indicates the two initiating events as root causes and all other events as consequences. The analysis is available from the first minute after the start of the cascading outage. If the system had been available on September 23, the operators would have been able to identify also the second initiating event immediately, while in real life, it took about four hours.

Because of the speed of this particular cascade, it is highly unlikely that this knowledge could have helped the operators to avert the blackout. Restoration could probably have been performed in a more reliable way, however. In the case of a more slowly developing cascade, like the start of the August 14, 2003, event in Ohio, the system could most probably have helped to avoid the slow cascade becoming irreversible, avoiding the large blackout.

Further Developments

We feel that the pilot project in 2006 was quite successful. Currently, Svenska Kraftnät and GoalArt are working on a continuation project, with the aim of installing a GoalArt system in the control center of Svenska Kraftnät in Stockholm. We hope that this will be ready during the first half of 2008, following an upgrade of the current SCADA/EMS system.