

Intelligent Self-Describing Controllable Electric Power Grid

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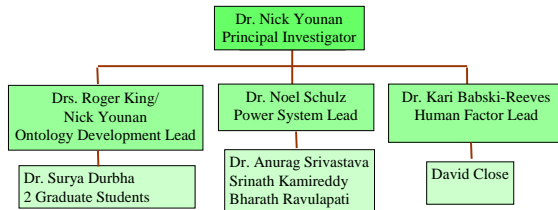
Abstract

Electric power grids are a key network in both day-to-day activities and in recovery efforts following natural disasters. This complex system may also be subject to blackouts caused by system instabilities or external threats. A key infrastructure issue relates to the models, studies and simulations of this complex network system, especially in the Gulf Coast region, which is vulnerable to hurricanes. It is necessary for electric utilities to handle these extreme conditions and recover as quickly as possible. Researchers at Mississippi State University with the help of regional utilities are working to develop a tool based on detailed power system analysis and a semantic-based ontology to provide web-based information and decision support. During a recent hurricane, one utility in Mississippi was able to restore power to customers in an efficient way using intentional islanding. System separation or intentional islanding of the electric grid should be done in an effective way to help restoration and not create system instabilities.

Electric network state data and up-to-date measurements will be published on the web and feature extraction will be done using ontology web language (OWL). Comprehensive power system analysis is progressing to develop a rule based-system to highlight methods for system separation and other restoration techniques. A visualization tool that incorporates operators in the decision loop can provide demand based situational awareness and decision support to provide assistance to utilities in extreme conditions.

Project Overview and Description

MSU Project Team



Industrial Partners

- Tennessee Valley Authority (TVA)
- South Mississippi Electric Power Association (SMEPA)
- Southern Company (SoCo)
- Alabama Power Company (APC)
- Mississippi Power Company (MPC)

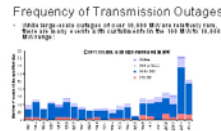


Objectives

- To develop semantic driven ontology based information services for wide area monitoring of the electric power grid.
- Specifically, the project is focused on response-based remedial action schemes (RAS) and restoration techniques that can be used to mitigate cascading blackouts and severe contingencies via system separations (islanding), distributed generation and conventional techniques.
- The semantics driven information services will provide critical information and a course of action in a timely fashion to system operators.
- This will be enhanced with new visualization schemes that are based on operator cognitive task analysis (CTA).

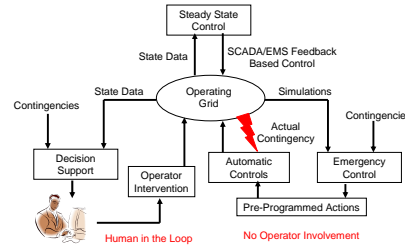
Grid Complexity and Problems

- Highly nonlinear system, aging infrastructure, power market, transmission expansion to meet growing demands, congestion management, handling distributed resources, dynamic reactive compensation, reliability coordination, need for oversight or regulatory audits, balancing between resource adequacy, reliability, economics, environmental constraints, and other public purpose objectives to optimize transmission and distribution resources to meet the needs of the end users.
- Approximately 24 outages per year in the United States with curtailments in 100 to 1,000 MW range
- About 5 outages in 1000 to 10,000 MW range
- One outage every 4 years at 10,000+ MW.
- This is a global issue
- Days needed to restore power after Hurricane Katrina



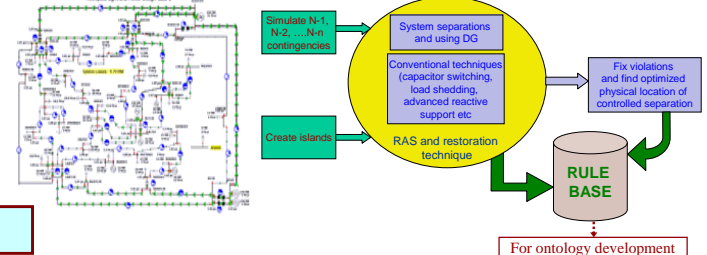
Electric Power Grid Control

Post-contingencies studies show that based on system states, and with proper decision support system, decisions can be taken in advance as well as in real time to avoid the blackouts and to restore the power more efficiently.



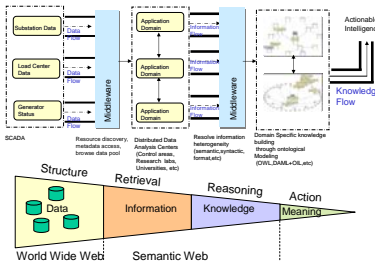
Power System Research Activities

Researchers are working on developing or modifying CIM for sensor data and developing rule bases for remedial action schemes and restoration during extreme contingencies by doing detailed power system analysis on 38-bus power system in PowerWorld 12.0. Work related to the investigation of state estimation algorithms in the case of lost state data is also in progress.



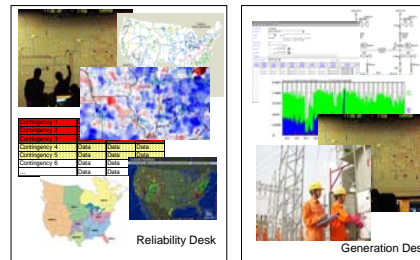
Research Activities Related to Semantic Web

To do knowledge extraction and to provide decision support to operators a software tool based on ontology will be developed using web sensors, OWL, and sensorML. Sensor web enablement provides an extensive monitoring and sensing system that contributes timely, comprehensive, continuous, and multi-mode observations for the power systems. A rule base developed by detailed power system analysis will be included in the ontology to provide decision support.



Human Factor Research Work

Researchers are working on developing an improved visualization strategy to assist with situational awareness and decision support for reliability and generation desks based on CTA and current visualization.



Summary

- The electric power grid is part of this country's critical infrastructure.
- Grid needs to be enhanced to incorporate the latest advances in sensing, communication, services, and visualization technologies.
- To protect this asset, we need to develop ontology based information services for power system monitoring and control. An architecture for using the semantic web and a sensor web enablement has been proposed here for wide area monitoring and power system monitoring, operation and control in general.



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