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IEEE PES Power System Conference and Exposition

Vulnerability Assessment for Cascading Failures in Electric Power Systems

Task Force on Understanding, Prediction, Mitigation and Restoration of Cascading Failures

IEEE PES Computer and Analytical Methods Subcommittee

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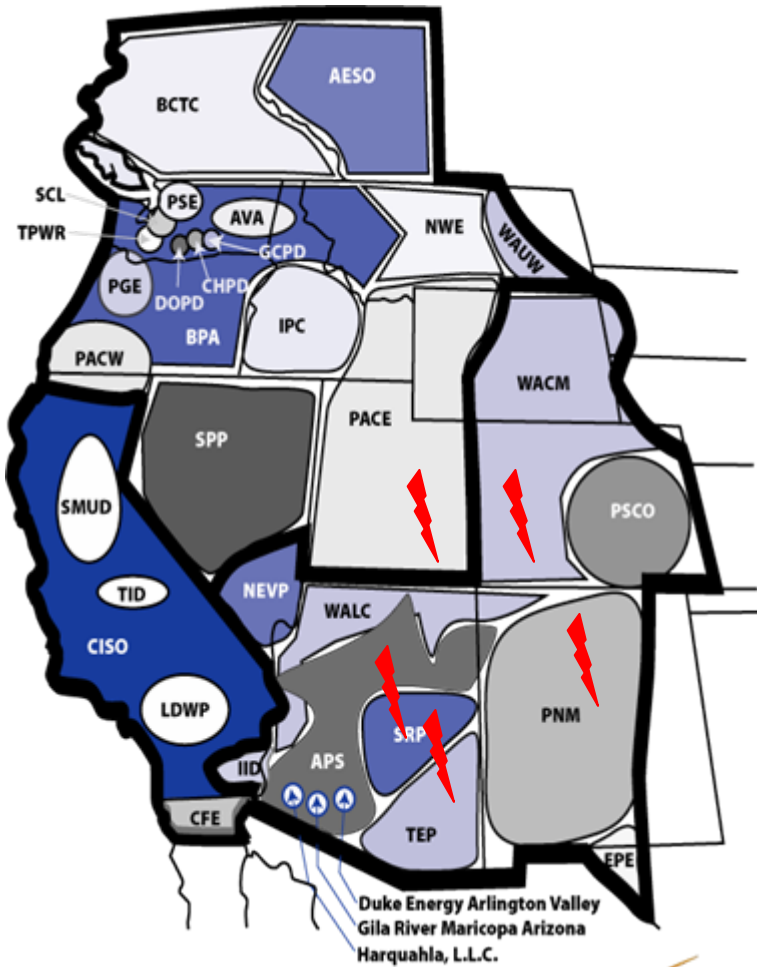
Outline

- Power Flow Based Analysis
  - “N-x” contingency analysis
  - Simulation models of cascading events
- Graph Analysis
  - Small world network
  - Scale free network
  - Betweenness centrality
- Role of Emerging Technologies
  - PMUs
  - Visualization
  - High-Performance Computing
  - Data Mining
- Future Research Needs

“N-x” Contingency Analysis

- From “N-1” to “N-x”
  - To improve situational awareness
- From Balancing Authorities to a Wide Area
  - Example: 35 BAs in west
  - Further require “N-x” CA
  - To better understand cascading failures
- N-x Contingency Analysis
  - Result in a large number of cases. “N-5” → 10^{20} cases for the west US
- Challenge: better contingency selection and post-processing



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Simulation Models of Cascading Events

- Examples of Simulation Models
  - TRELSS (Transmission Reliability Evaluation of Large-Scale Systems)
  - OPA (Oak Ridge-PSERC-Alaska) Model
  - Manchester Model
- General Characteristics of Simulation Models
  - Based on ac and/or dc power flow models
  - Can usually simulate multiple contingencies
  - Employ certain system failure criteria
  - Assess system vulnerability with random initial conditions
- Challenge: Only a subset of possible conditions are simulated. Gap exists between simulation and reality.

Graph Analysis

- Graph analysis captures some generic features of the cascading process but do not attempt to represent details of the cascading mechanisms
  - Small-World Network
  - Scale-Free Network
  - Betweenness Centrality
- Provides a complementary way to assess system vulnerability
- Challenge: The graph analysis cannot help understand particular cascading sequences as detailed cascading mechanisms are not modeled.

Role of Emerging Technologies

- Phasor Technology
  - Fast and time synchronized measurement provides opportunities for enhancing current method and developing new methods in vulnerability assessment.
- Advanced Visualization
  - Visualization can present and reveal system vulnerability
- High-Performance Computing
  - Reduce computation time and conduct more comprehensive analysis (esp. N-1 ➔ N-x)
- Data Mining
  - Methods for handling large volume of data

Future Research Needs

- Vulnerability assessment with dynamic modeling
- Develop “N-x” contingency selection methods
- Evaluate existing tools for cascading vulnerability assessment
- Develop benchmarking systems for vulnerability assessment
- Gather and sanitize data from actual cascading failures
- Role of intermittent resources in cascading blackouts
- Role of the distribution system in cascading blackouts