Networked Information Gathering and Fusion of PMU Measurements

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Reviewers: Floyd Galvan (Entergy), Naim Logic (SRP), and Shimo Wang (SCE).

Topics
I. Networked communications of PMU data
II. Networked computation and fusion of PMU data
III. Robust architecture for smart grids

Principal Investigated Issues
A. Design of communication network technologies for guaranteed delivery and timely processing of PMU data
B. Approaches to efficient information fusion of bulk PMU data to support various monitoring and control applications
C. Architecture design of interdependent systems (power grid and communications system), robust against cascading failures

Significance to Future Power Grids
• Future power grids are envisaged to integrate a considerable amount of renewable energy resources and responsive demands
• Deregulation of power industry has moved the operations of power grids from vertically integrated centralized ones to coordinated decentralized ones
• Urgent need to build up a next-generation information infrastructure, which can capture the multi-timescale dynamics of power grids, and support various distributed applications to secure the power grids
• Reliable communication system for synchrophasor data is one fundamental building block of the information infrastructure of power grids
• Power grid and communication network are becoming more and more coupled together, i.e., one system depends on the other to function well
• Critical to understand the interdependence and cascading phenomena between power grid and communication network of PMU data

Networked Communications of PMU Data
• Information architecture for smart grid should support coordinated operations between ISOs/RTOs and utilities
• Communication systems at intra-/inter-utility levels
  - Redundant configuration at intra-utility level
  - Data delivery at inter-utility level
    a) Diverse QoS requirements of synchrophasor data delivery: latency, rate, priority, ...
    b) Deficiency of off-the-shelf communication technology (particularly widely used TCP protocol): deadline-unaware, inflexible bandwidth reservation for grid data communications
    c) Towards a deadline-driven flexible delivery: queue management; dynamic rate allocation; flow quenching

Networked Computation and Fusion of PMU Data towards Secure Smart Grids
• Data mining for dynamic security assessment (DSA)

Robust Architecture for Interdependent Power Grid and Communication Network
• Cyber-physical system architecture has great impact on robustness against cascading phenomena in smart grids
• A “uniform” allocation strategy is developed, where each node in the two networks has exactly k inter-edges

• A knowledge base through offline exhaustive studies
• A classifier is trained via boosting simple decision trees, and updated near real-time by using new cases
• For online DSA, security decisions are immediately obtained by using real-time PMU measurements
• Synchrophasor data fusion for fault diagnosis
  a) A Gaussian Markov random field (GMRF) model for synchrophasor data
  b) Fault diagnosis through hypothesis testing on the changes of partial correlation coefficients
  c) Multi-scale decomposition of GMRF
  d) Decentralized network inference

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• Uniform allocation improves resilience compared to conventional random allocation strategy
• Studies can help understand and design the topology for interconnecting power grid and communication network

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