

Networked Information Gathering and Fusion of PMU Measurements

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PSERC

Topics

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

Principal Investigated Issues

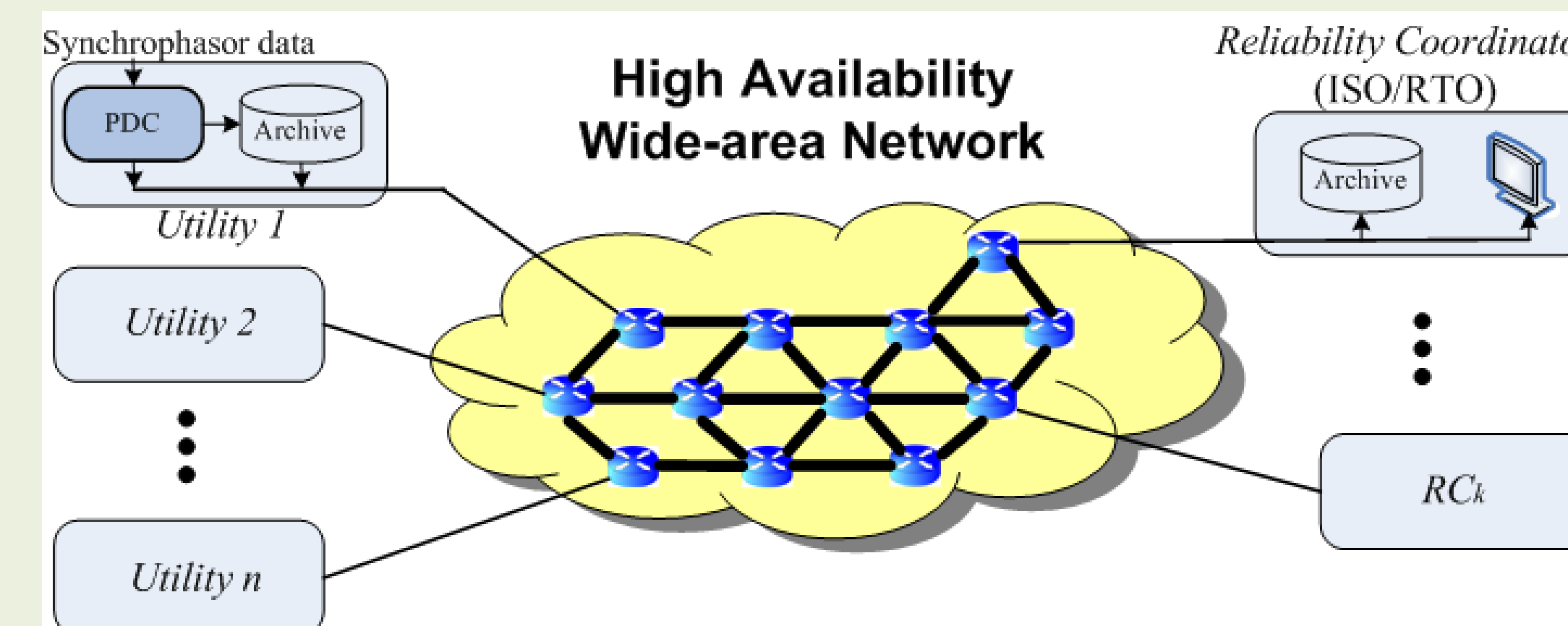
- A. Design of communication network technologies for guaranteed delivery and timely processing of PMU data
- B. Approaches to efficient information fusion of bulk PMU data to support various monitoring and control applications
- C. Architecture design of interdependent systems (power grid and communications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

Significance to Future Power Grids

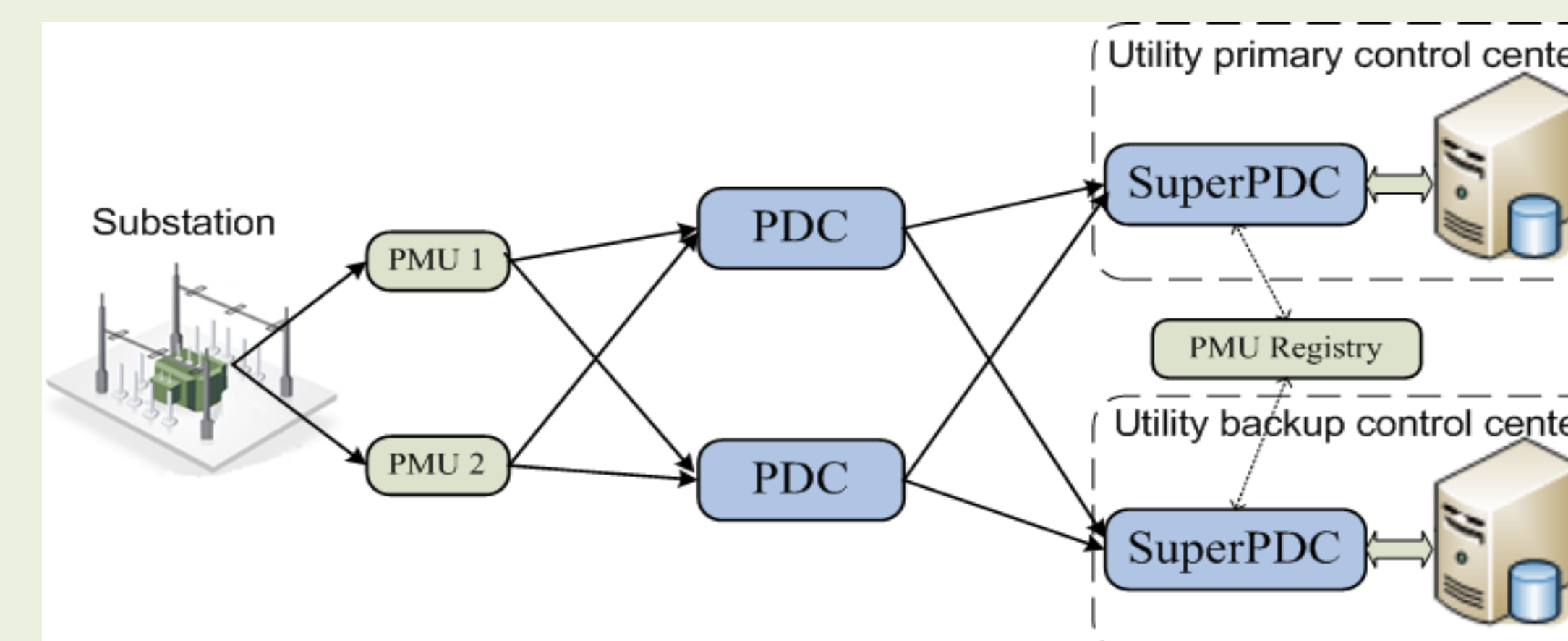
- Future power grids are envisaged to integrate a considerable amount of renewable energy resources and responsive demands
- Deregulation of power industry has moved the operations of power grids from vertically integrated centralized ones to coordinated decentralized ones
- Urgent need to build up a 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

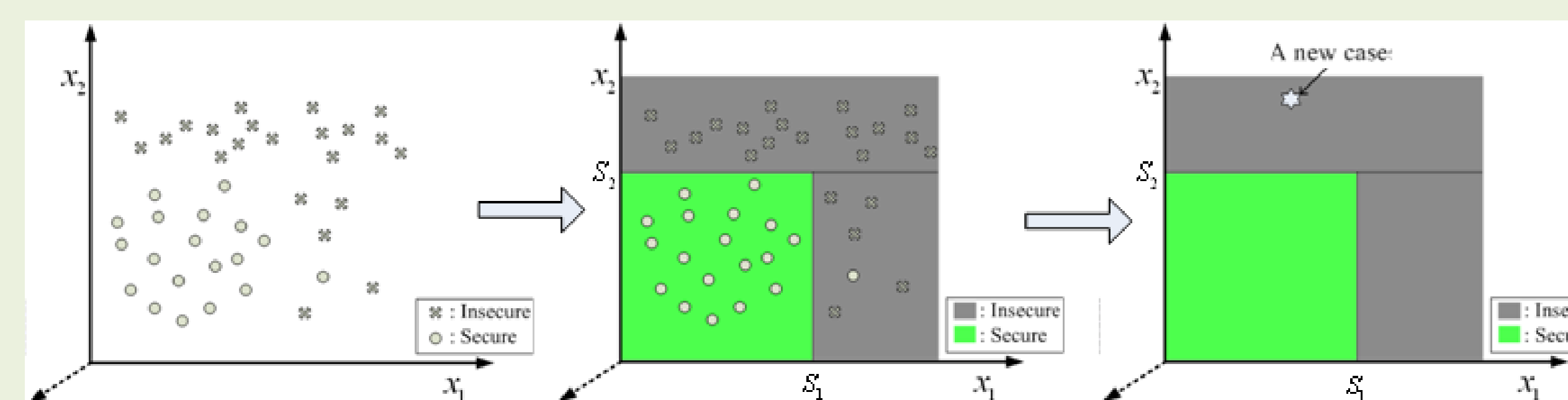


- Data delivery at inter-utility level
 - a) Diverse QoS requirements of synchrophasor data delivery: latency, rate, priority,...
 - b) Deficiency of off-the-shelf communication technology (particularly **widely used TCP protocol**): deadline-unaware, inflexible bandwidth reservation for grid data communications
 - c) Towards a deadline-driven flexible delivery: queue management; dynamic rate allocation; flow quenching

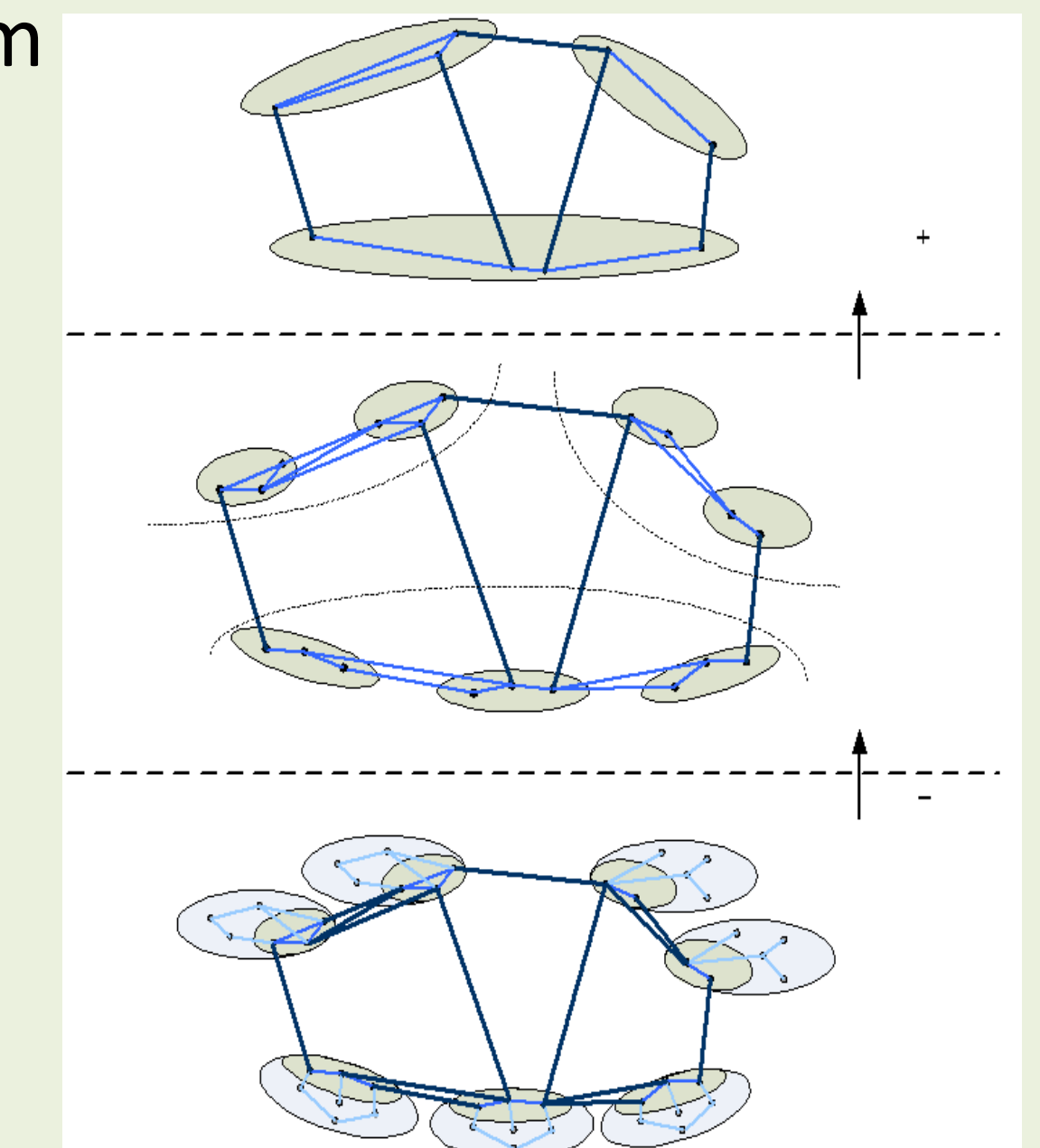
Networked Computation and Fusion of PMU Data

Data towards Secure Smart Grids

- Data mining for dynamic security assessment (DSA)

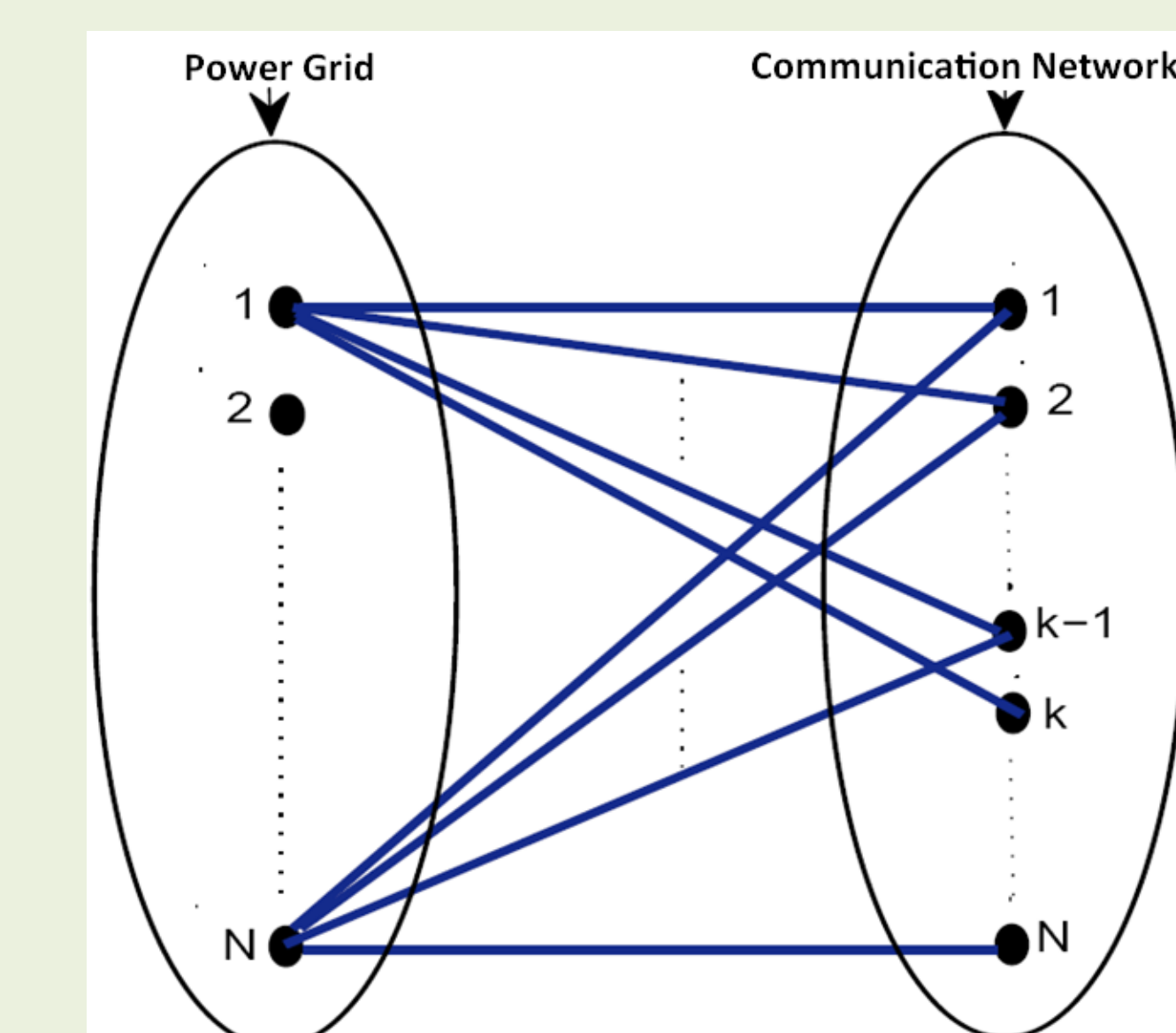


- a) A knowledge base through offline exhaustive studies
- b) A classifier is trained via boosting simple decision trees, and updated near real-time by using new cases
- c) For online DSA, security decisions are immediately obtained by using real-time PMU measurements
- d) Online DSA with missing PMU data is studied
- 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



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



- 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