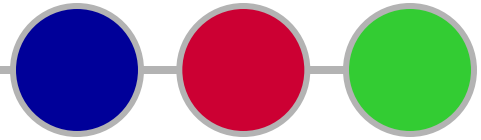
WASHINGTON STATE UNIVERSITY

World Class. Face to Face.



Modeling Communications for Wide-Area Power Grid Monitoring & Control

Tao Yang & Anjan Bose
School of EECS

The Big Picture

Assume that NASPInet/GridStat/etc in 10 years make the following true:

- **Can get any PMU/sensor data from anywhere, quickly, reliably, and (cyber-)securely**

Questions:

- **What do we do with those data?**
- **What latency (delay) requirements are there for NASPInet? Chicken-and-egg (power and IT)**

This study is a first step in this direction…

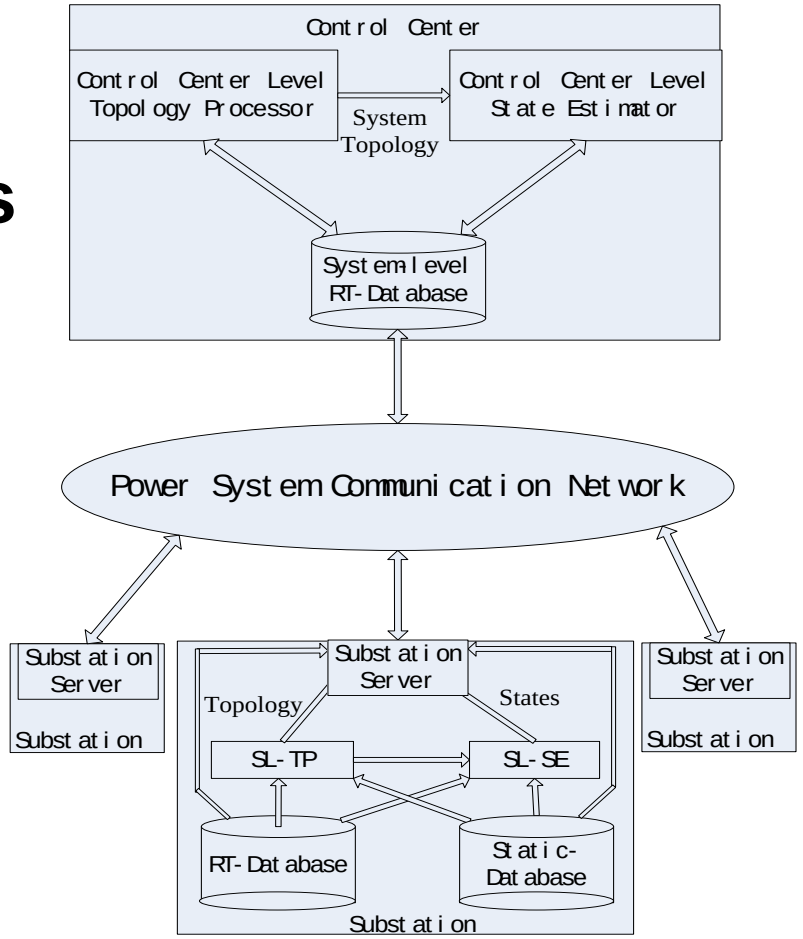
Future Time Sensitive Applications

Goal: move away from today's *modus operandi*: send all data to a central place at the highest rate anyone might need it at

- **State Estimator**
  - **Measurements from All Substations**
  - **Once per Second**
- **WAPS/WACS**
  - **Measurements from A Few Substations**
  - **30 or 60 Times per Second**

Two-Level State Estimator Architecture

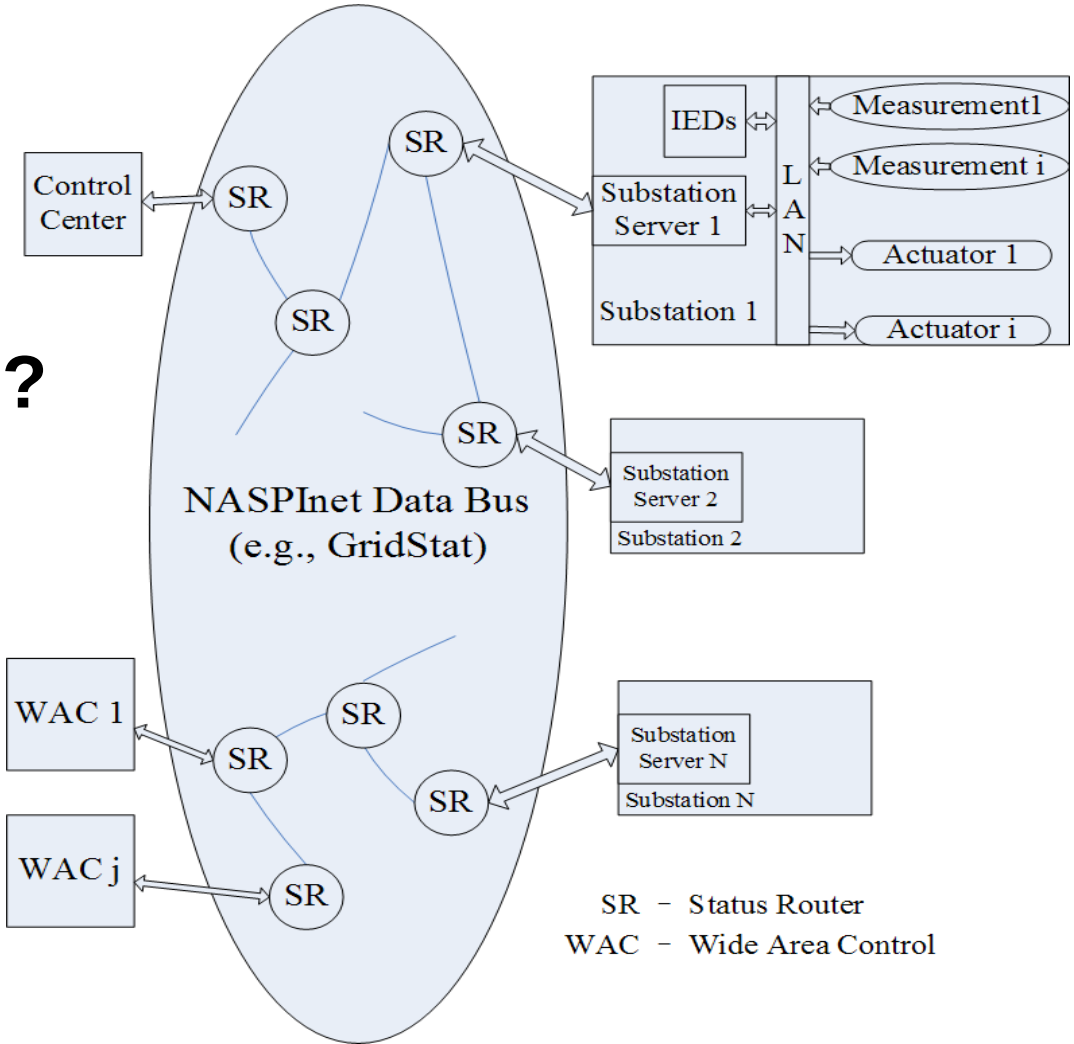
- Substation
  - Phasor Measurements
  - Substation Topology
  - Events
  - Distributed Database System
- Control Center
  - Commands
  - Distributed Database System



SL-TP: Substation Level Topology Processor
SL-SE: Substation Level State Estimator
RT: Real Time

Proposed Communication Architecture

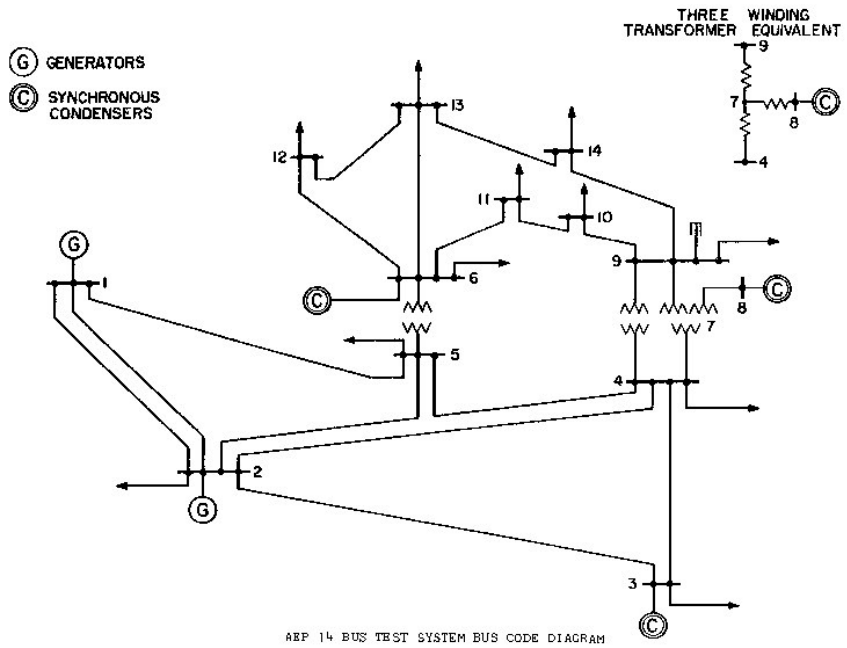
- How to Design Network?
- How to Evaluate Network Performance?
- How to Enhance Performance of Monitoring & Controlling System

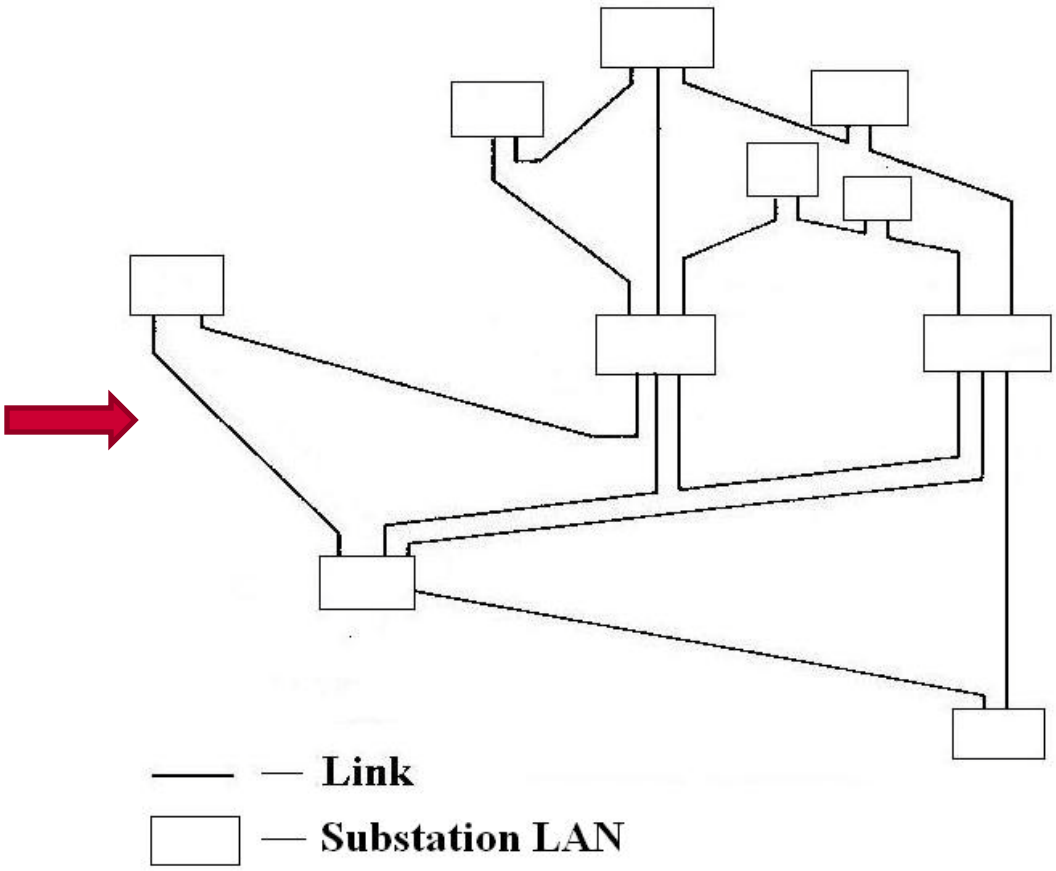


Simulations

- Tool: Network Simulator (NS-2)
- Experiments Parameters
  - Data Stream Parameters
    - Source & Destination
    - Traffic Type
    - Packet Length & Rate
  - Network Parameters
    - Topology
    - Link Parameters

Simulations





Results

- Packet Latency
  - Substation to Control Center
    - Largest Delay 2.0020ms (Small System)
  - Substation to WACS
    - Largest Delay 1.8730ms
- Other Results
  - Measurements & File Latency
  - Packet Delay Variation
    - Largest Delay
    - Variation

Conclusions

- Provide a Heuristic Way to Evaluate Network
  - Simulate Network Performance
    - Too Redundant & Too Sparse
  - Analyze Reasonable Signal Latency
- Lessons for Design of Time Sensitive Applications
  - Fast State Estimation
  - Wide Area Sensor Selection
  - Wide Area Actuator Selection

Future Work

- Implementation of the Two-Level State Estimator (only simulated so far)
- Integration with GridStat and eventually NASPInet

Q&A?

Thank you!!