Engineering Research Center for

Reconfigurable Manufacturing Systems

Time Synchronization Applications in the Smart Grid and Beyond

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Control over Ethernet

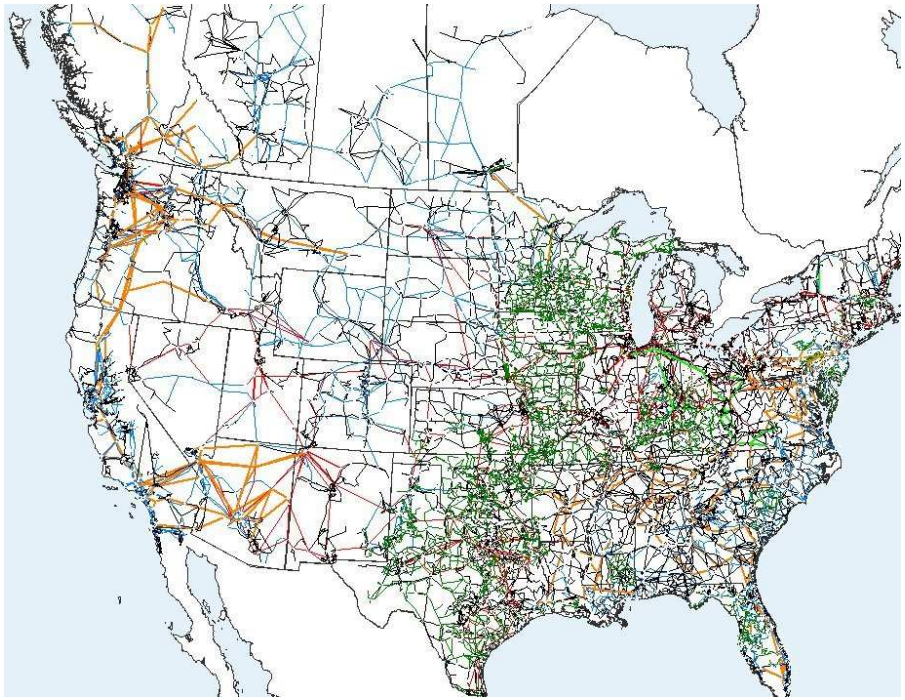
- The fact is that it is hard to do real time control of dynamic systems
- In the presentations ahead, including mine, improving control performance over Networks will be the primary motivation
- The demo behind you is a toy example that showcases this difficulty

Overview

- Purpose of the Smart Grid Exploration
  - The smart grid is a wide scale network control problem
  - Many smart grid sensors and actuators have time synchronization capability
  - Time sync / stamping is important for wide scale network control problems
  - Recently developed standards overlap
- Expected Results
  - Standardize time accuracy requirements
  - Develop key experience with microsecond time synchronization and time-stamping applications
  - Network topology
- Research Content
  - Time stamped based estimators for control
  - Shared Model libraries between control levels

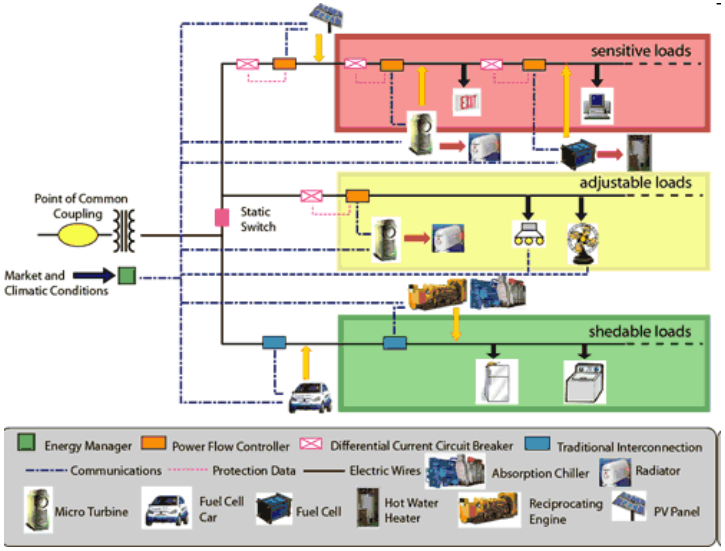
The Smart Grid

- Wide Area Control Problem Involving Many Nodes
- Multi-Level Feedback Control
- Ethernet Communication Networks
- How can we optimize control strategies?



Focus Areas

- Substation Automation
  - IEC 61850 Communication Networks and Systems in Substations defines substation network requirements
  - **Ethernet networks will play a central role in communication and control**
  - **Many control and safety actions require very stringent synchronized responses of multiple actuators**



- Microgrid
  - Small portion of grid that is capable of generating enough power to meet its own power demand
  - **Smart meters, smart appliances, and electric vehicles** will have a sizeable influence on the stability of the system

http://certs.lbl.gov/certs-der.html

Relation to the Automotive Industry

- Plug in Vehicles
  - Can operate as a sink or a source to the grid
  - Need to determine effective control strategies to leverage this trait
- Substations
  - Have high concentrations of nodes, and network topologies similar to a manufacturing setting
    - » On the order of 1-10 nodes per square meter
    - » Acceptable delay ranges from 1 μs to a few seconds
  - Face similar challenges in terms of network and control strategies
    - » Real time Ethernet?
    - » Wireless?
    - » Redundant ring protocol?
    - » Time synchronized control?
- **Our work will directly and indirectly impact the automotive industry**

Time Synchronization

- Time Synchronization
  - Current state of the art provides synchronization of clocks across a network down to 1 μs
  - Useful for system-wide monitoring, control, and safety
- IEEE 1588 Precision Time Protocol
  - Basis for next generation time synchronized control
  - **Provides time stamping accuracy of 1 μs**
- Time-stamping
  - **Out of order information can lead to improper control actions / diagnostics**
  - Next generation control strategies utilize accurate time-stamping of sensory and actuation data for high accuracy model based control
  - Provides platform for coordination across a distributed system

Conclusion

- We are currently working with NIST to develop a 1588 testbed
  - The testbed will valuable in researching time-stamp based distributed control

- We are beginning work on a proposal that will **leverage our 1588 experience and testbed** to demonstrate the interoperability of **microsecond-accuracy time synchronization with various smart grid network and topology protocols**

- Along the way, **our experiences develop best known solutions and standards** to utilize highly accurate time synchronization in a manufacturing setting