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Cybersecurity for Energy Delivery Systems

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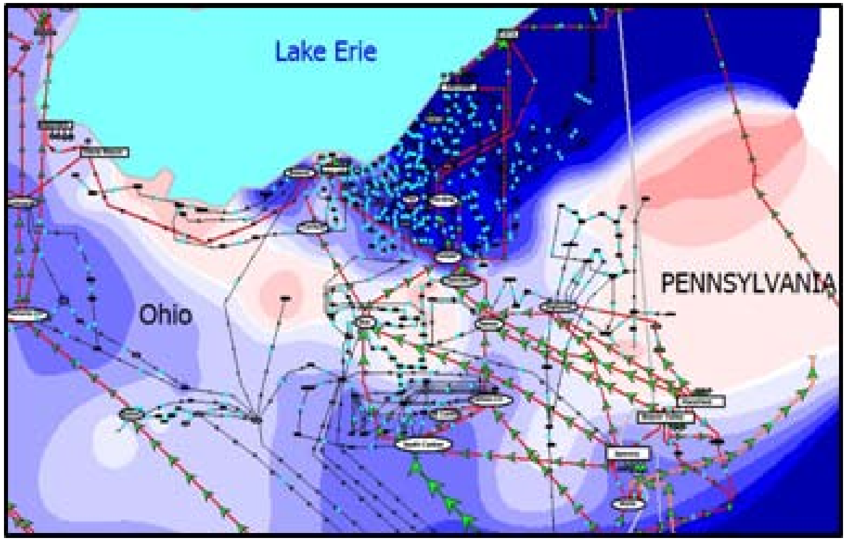
Thomas J. Overbye

University of Illinois at Urbana-Champaign

TCIPG – Smart-Grid Enabled Distributed Voltage Support Framework

Summary Slide: Project Title

- **Outcomes:** Demonstrate the viability of distributed reactive resources to provide more resilient system voltage control. This will require near real-time distributed control and local control communications



- **Roadmap Challenge:** Control system networks that automatically provide contingency and remedial actions
- **Major Successes:** Project is just beginning; initial simulations are promising

- **Schedule:** 2010 to 2013
- **Level of Effort:** TCIPG funding
- **Funds Remaining:** TCIPG funding
- **Performers:** **U**niversity of Illinois at Urbana-Champaign
- **Partners:** Non-formalized relationships with power system software vendor, PV inverter manufacturer and electric utilities

Background – Importance of Voltage Magnitude

- **In power system operations maintaining adequate voltage magnitudes is crucial**
  - Lower voltages result in higher currents, resulting in higher losses (proportional to the square of the current)
  - Lower voltages increase the risk of induction motor stalling, which can result in very high reactive power loading, leading to a system voltage collapse
  - Distributed generation resources can result in large variations in feeder loading (i.e., shading of PVs caused by passing clouds)

Background – Reactive Power Generation

- **Power system reactive power is usually provided by the synchronous generators and shunt capacitors**
  - Shunt capacitor reactive power outputs vary with the square of their terminal voltages
- **Traditional generator owners have incentives to operate their generators at unity power factors to maximize their real power outputs**
- **The anticipated growth in loads/generation with inverters and often unused kVA capability opens new possibilities, which we are looking to leverage (i.e. PV, PHEVs)**

Background – Voltage Control Challenges

- **In contrast to power system frequency, which is essentially a global system state, voltage magnitude is quite localized**
  - Because of the relatively higher line reactance relative to resistance, reactive power is local
- **In order to maintain adequate voltage magnitude to all customers on a feeder, its voltage profile can be quite load dependent**
  - Simply sensing the local voltage magnitude is usually inadequate; hence wider area control is necessary

Technical Approach and Feasibility

- **Approach**
  - Simulations of both the cyber and the power system infrastructure will be constructed to better understand the coupling between these infrastructures
  - Wider-area voltage control algorithms need to be developed to determine the control signals
  - A mixed hardware/software simulation environment is needed to test the concept
  - Leveraging work in load identification to know which loads may be available for control

Technical Approach and Feasibility

- **Metrics for Success**
  - The first metric will be the creation of the coupled power system and simulation environment robust enough to demonstrate the voltage control algorithm; paper published describing the environment
  - The second metric will be the creation of the voltage control algorithm; paper published
  - Third will be the construction of the mixed hardware/software simulation environment; industry demonstration

Technical Approach and Feasibility

- **Challenges to Success**
  - The development of a robust voltage control algorithm that avoids making incorrect control decisions
    - Overcome through adequate research/simulation
  - Sufficiently speed and secure communication
    - Research is needed to determine requirements
  - Sufficient incentives to owners to allow control
    - System incremental costs need to be controlled
- **Technical Achievements to Date**
  - A prototype voltage control algorithm developed

Collaboration/Technology Transfer

- **Plans to gain industry input**
  - We have strong relationships with industry, both at the device manufacturer level, software developers and with electric utilities, and our team has a strong record of research commercialization. As this project develops we will be engaged in ongoing discussions with industry for its commercialization.
- **Plans to transfer technology/knowledge to end user**
  - The technology could be used either by electric utilities, leveraging their existing communication infrastructures, or by third parties selling this reactive control service to industry.
  - Concern about voltage instability is a well known industry problem, so the key selling point will be cost and reliability.
  - This technology cannot be deployed widely until the number of inverter-based load/PV systems increases.
  - A startup company is a potential mechanism for technology transfer

Next Steps

- **Approach For the Next Year – All of topics mentioned previously will be considered next year**
  - Simulations of both the cyber and the power system infrastructure will be constructed to better understand the coupling between these infrastructures
  - Wider-area voltage control algorithms need to be developed to determine the control signals
  - A mixed hardware/software simulation environment is needed to test the concept
  - Leveraging work in load identification to know which loads may be available for control