A Secure and Reconfigurable Power Grid

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http://panda.ece.utk.edu/wiki/PowerGrid

Vulnerabilities of Power Grid

The operators lack the capability to 1) obtain real-time status information of the vastly distributed equipment, 2) respond rapidly enough once events start to unravel; and 3) perform coordinated actions autonomously. Additionally, the traditional hardware lacks the capability to 1) provide reliable frequency and voltage control according to system demands and correspondingly, 2) rapidly reconfigure the system to a secure state.

New Approach

- Incorporation of advanced power electronic devices with appropriate sensing and control functions
- Control-theoretic modeling of the power grid to adapt to unpredictable changes, e.g., DoS attacks
- Coordinated attack-resilient power grid analysis, including both state estimate (SE) and N-x contingency analysis (CA)

Proposed Solution

Develop a hardware-in-the-loop reconfigurable system with embedded intelligence and resilient coordination schemes to tackle these vulnerabilities.

Research Impact

- Facilitate a more direct reconfiguration of the physical makeup of the grid
- Provide analytical real-time and resilience assurance when unpredictable changes occur
- Handle correlated attacks and large errors in the measurement data due to deliberate attacks

Adaptive delay control for real-time status dissemination

The impacts of security attacks on a power grid can be modeled as disturbances and system variations. Decentralized real-time scheduling algorithm is designed based on recent advances in feedback control theory to provide scalable solution to guarantee the end-to-end real-time deadlines of high-priority tasks even when the system is suffering resource contention caused by QoS attacks.

Attack-resilient state estimate

Existing approaches cannot handle large correlated measurement errors both efficiently and effectively. The proposed solutions seek good approximations that can be obtained efficiently.

Embedded intelligence for system reconfiguration - Intentional Islanding

The above simulation shows the grid was disconnected at 0.3 sec, and this event was detected at 0.30155 sec, after which the control mode was changed from current-controlled (for connected grid) to voltage-controlled mode for islanding operation.