2021 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

Coupled Cascading Failure in Energy CPS: Modeling, Prevention, and Restoration

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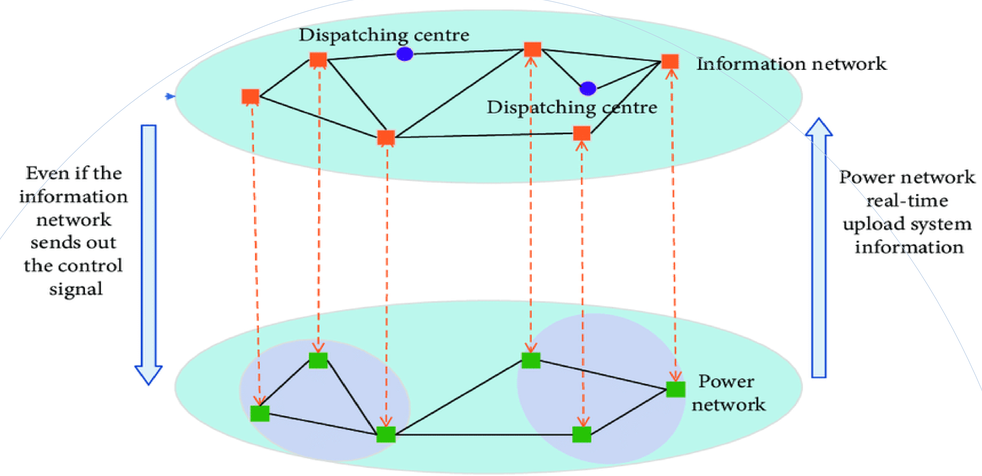
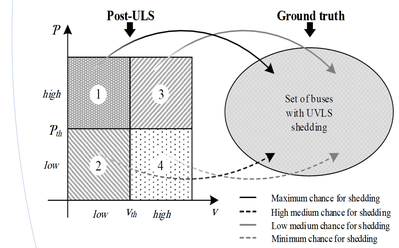
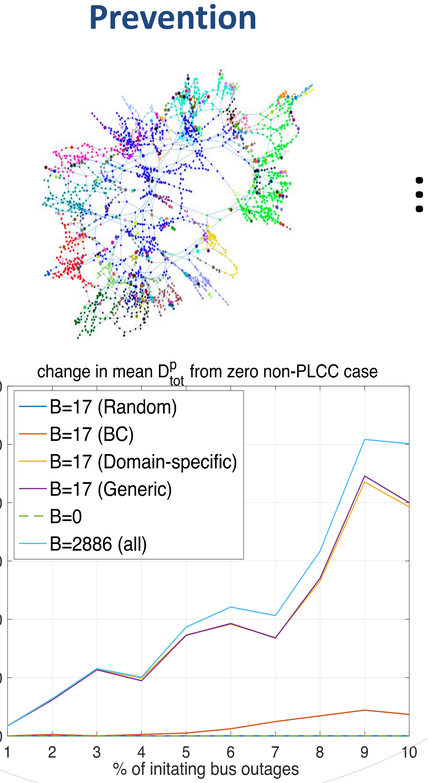
Broader Impact: Preventing cascading failures in the electrical energy CPS can save a significant amount of customer-hours of lost electricity service, billions of dollars of loss in economy, and stem negative societal impact.

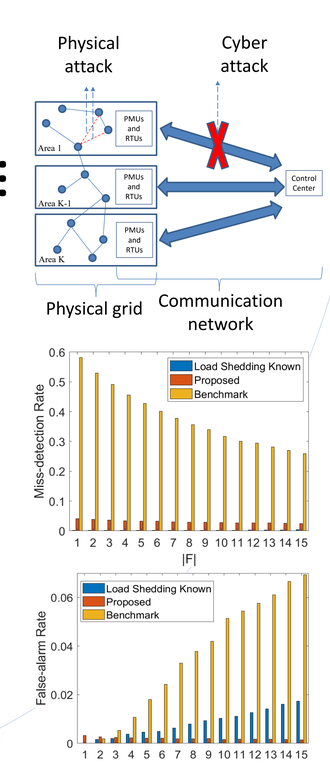
Challenge:

- **Modeling**:
  - Striking a balance between accuracy vs complexity - Hybrid modeling
  - Unifying independent CPS models of SCADA and WAMPAC
- **Prevention**:
  - Mitigating cascade by generation rescheduling considering stability limits and uncertainty in controllability and observability
  - Integrating the proposed preventive controls with CPS model
- **Restoration**:
  - Lack of information from sensors
  - Uncertainty about failure location and the possibility of islanding









Scientific Impact:

- **Modeling**: Improved AC-quasi steady state model to attain post-undervoltage load shedding (UVLS) equilibrium
- **Prevention**: Economic allocation of non-PLCC & PLCC links to maximize observability and controllability
- **Restoration**: Estimating unobservable state variables and topology under islanding

Solution:

- **Modeling**: Inclusion of pre-existing UVLS scheme in AC-QSS cascading failure model to mimic the ground truth – sensitivity index coupled with voltage magnitudes to recognize buses most prone to voltage collapse.
  - Proposed AC-QSS cascade failure model verified against a suitable dynamic model
- **Prevention**: Allocation of non-PLCC links with budget constraint to maximize load served after failure.
  - Proposed graph theoretic analyses fused with domain information
- **Restoration**: LP-based failure localization algorithm with verifiable recovery correctness condition