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

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Problem Context: Cascading failures in the electrical energy cyber-physical system (CPS) have caused a significant amount of customer-hours of lost electricity service that is comparable to major natural disasters. Modeling, prevention, and recovery is the focus.

KEY CHALLENGES

Modeling cascading failure:

- Striking a balance between accuracy vs complexity - Hybrid modeling
- Unifying independent CPS models of SCADA and WAMPAC

Prevention of cascading failure:

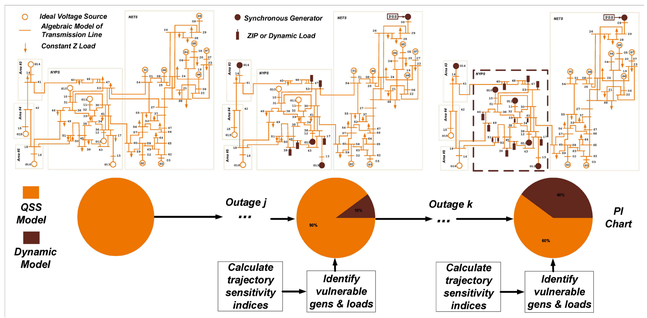
- Mitigating cascade by generation rescheduling considering stability limits and uncertainty in controllability and observability
- Integrating the proposed preventive controls with CPS model

Restoration following cascading failure/natural disaster:

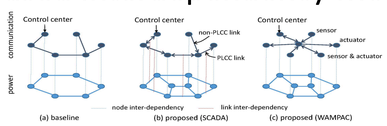
- Lack of information from sensors
- Uncertainty about failure location

PROPOSED WORK

- Spatio-Temporal Hybrid QSS-Dynamic Model

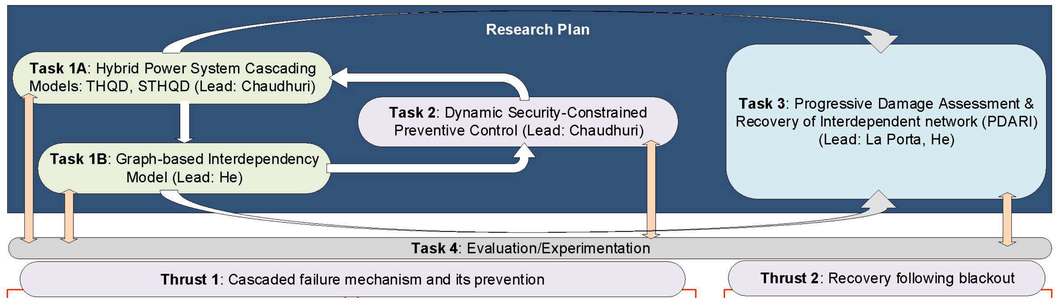


- Unified Graph-based Interdependency Model



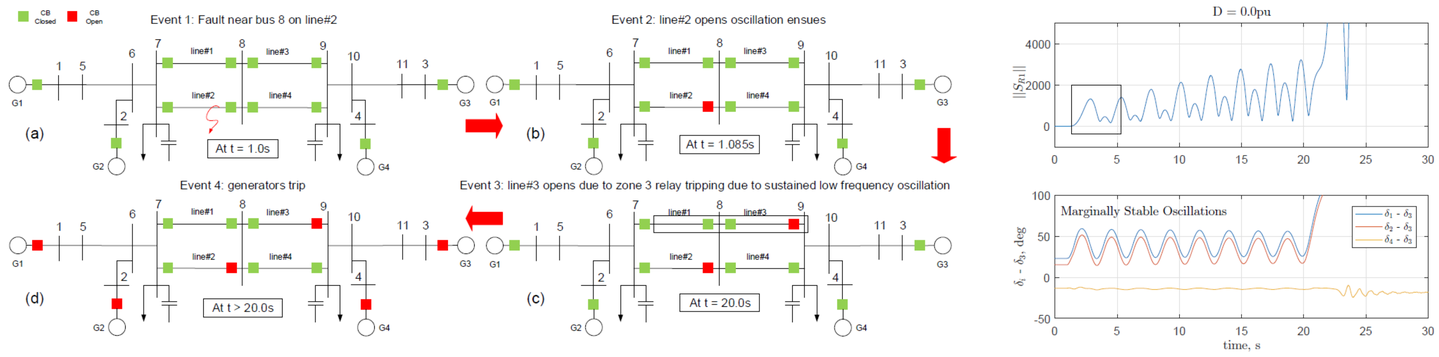
- Dynamic Security-constrained Preventive Control
- Progressive Failure Recovery under Uncertainty

RESEARCH PLAN



- 2 PhD students, 2 MS students
- Weekly meetings
- All tasks progress in parallel
- Models developed in Tasks 1A-1B will be incorporated in Tasks 2-3 later

INITIAL STUDIES



SCIENTIFIC AND BROADER IMPACTS

- Theories developed for fundamental understanding of cascading failures in energy CPS can be applied to other CPSs, which are coupled cyber-physical systems having a dynamic physical system
- Proposed preventive control strategy can protect critical infrastructures from large-scale outages
- Proposed recovery strategy is applicable in the aftermath of a blackout caused by cascades, a natural disaster, or other event, which will reduce downtime of the critical infrastructure
- Proposed research will be integrated into the one-week summer camps offered by the School of EECS at Penn State. Presentations about this research will be given to high school students over the course of the week on this topic in the 2019 camps, and then a camp focused on curriculum on the topic of this research will be offered in 2020

PennState EECS School of Electrical Engineering and Computer Science

CPS: Medium: Coupled cAscade Modeling, Prevention, and Recovery (CAMPR): When Graph Theory meets Trajectory Sensitivity

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