Understanding the Resilience of Cyber-Physical Systems Using Complex Networks Theory

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Project Description:
Critical infrastructures (e.g., power grids, transportation systems etc.) are witnessing growing integration of information and communication technologies (ICT) for their safe and efficient operation. Such systems involve a cyber network (i.e., the IT infrastructure) closely interacting with the physical infrastructures, and are collectively addressed as cyber-physical systems (CPSes). The integration of ICT, though improving system efficiency, incurs cybersecurity risks that may lead to catastrophic consequences such as cascading failures and blackouts. The December 2015 attack against the Ukraine's power grid was a real-world example, which caused power outages for a large number of customers for hours [1]. It is thus important to design CPSs that are resilient to such cyber attacks.

The topology of a CPSes, together with its operative state determine, for the most part, the robustness against cyber attacks. The proposed internship project will use complex networks theory to assess the structural vulnerability of CPSes and design resilient architectures. The key idea is to map the cyber network and physical network into complex network graphs (see Figure 1) and identify metrics to assess the vulnerability of the system to cyber attacks. Particular focus will be on understanding the interaction between the cyber network and physical network and their joint design in enhancing the CPS resilience. Application areas will mainly include power grid as CPS.

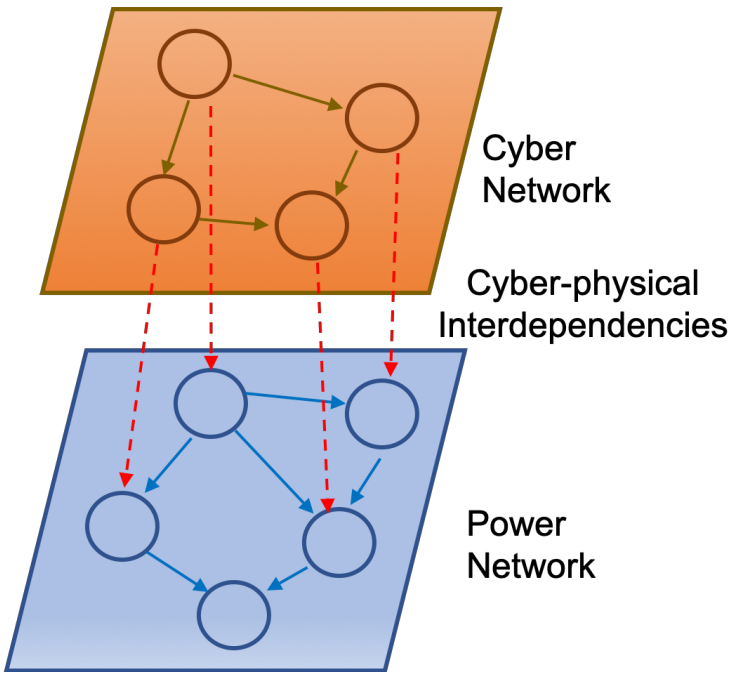

Figure1: Cyber-Physical System as a Complex Network

Desired Skills: Interest in mathematical modelling of networks. Fluency in using MATLAB/Phthon. Experience in Monte Carlo simulations will be useful.

Suggested Reading:

[1] "Confirmation of a coordinated attack on the Ukrainian power grid," https://ics.sans.org/media/E-ISAC_SANS_Ukraine_DUC_5.pdf

[2] Yakup Koç, Martijn Warnier, Robert E. Kooij, Frances M. T. Brazier: “Structural Vulnerability Assessment of Electric Power Grids”. CoRR abs/1312.6606 (2013)

[3] Xiangrong Wang, Yakup Koc, Robert E. Kooij, Piet Van Mieghem: “A network approach for power grid robustness against cascading failures.” RNDM@WMNC2015: 208-214