MARQUETTE UNIVERSITY

Departmental Colloquium
Electrical and Computer Engineering

Understanding Cascading Failures in Modern Power Grids: A Markov-chain Approach

Tuesday, January 21, 2025
2:00 pm – 3:00 pm
Olin 125

Reception to follow in Olin 204
3:00 pm – 3:30 pm

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ABSTRACT: Modern power grids are examples of cyber-physical systems that encompass complex and interdependent subsystems involving humans in the loop. Despite their reliability, power grids are known to be prone to cascading failures in their transmission network—a phenomenon that can lead to large blackouts. Cascading failures are triggered by initial disturbances resulting from severe weather, wildfires, cyberattacks, or other damaging natural or manmade events. Predictive models for cascading failures are needed to identify the vulnerabilities in the power grid and to understand the extent of the resulting blackouts after the occurrence of an initial disturbance. Here, we review a reduced state-space analytic model, based on Markov chains, for predicting the phases of cascading failures and the steady-state probability distribution of the blackout size and loss in power delivery. The model captures the effects of operators' behavior, as quantified by the probability of human error as a function of the phases of cascading failures coupled with the human factors associated with diagnosis and corrective actions by grid operators. In addition, we report a recent extension of the model to capture the role played by the locations and attributes of the initial transmission-lines disturbances to identify the critical vulnerabilities in the power grid. This extension necessitates expanding the state-space of the Markov chain in a scalable manner to include the dynamical topological attributes of the failed transmission lines.

BIOGRAPHY: Dr. Hayat received his Bachelor of Science (summa cum laude) in Electrical Engineering from the University of the Pacific (in Stockton, CA) in 1985. He received the M.S. and the Ph.D. degrees in Electrical and Computer Engineering from the University of Wisconsin-Madison in 1988 and 1992, respectively. He is currently a Professor and Department Chair of Electrical and Computer Engineering at Marquette University. His research activities cover a broad range of topics including resilience and reliability of interdependent cyberphysical systems, dynamical modeling of cascading phenomena with applications to resilient power systems, avalanche photodiodes, statistical communication theory, signal and image processing, algorithms for spectral and radar sensing and imaging, optical communication, and networked computing. Dr. Hayat is a Fellow of IEEE, OSA, SPIE and OPTICA.