Beyond Stability: Performance, Efficiency and Disturbance Management for Smart Infrastructure Systems

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Project Overview

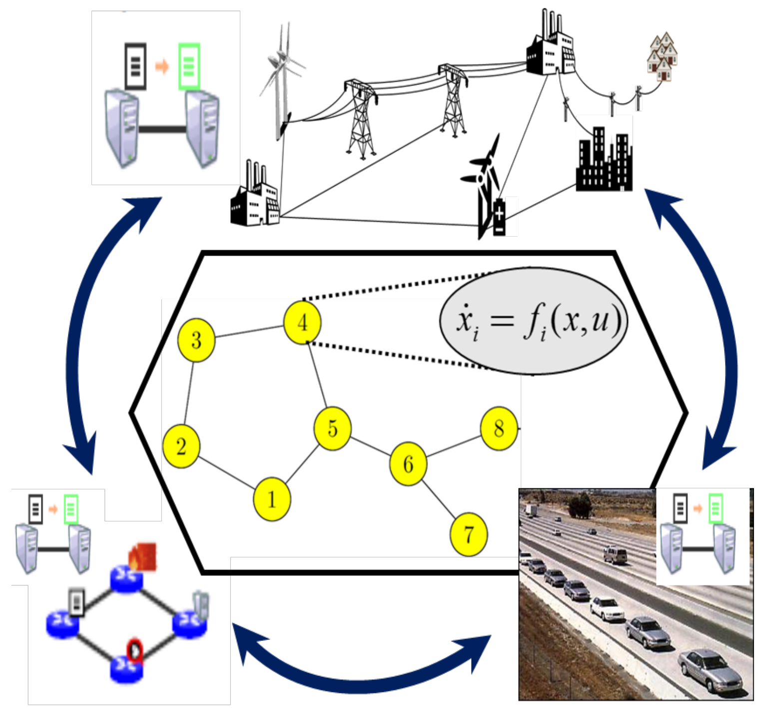
Developing theory, algorithms and tools (engineering & economic) to evaluate and improve performance (efficiency & robustness), and manage disturbances in next generation infrastructure networks (e.g. power, communication and transportation networks)

Research Themes:

- Characterizing performance
- Developing controllers that optimize performance & robustly manage disturbances
- Exploiting interconnection topology & mitigating the impact of delays
- Exploiting the interplay between engineered and economic controls

Broader Impact:

- Focus on efficiency and performance is directly tied to sustainability goals
- K-12 outreach: JHU STEM summer school; Women Serious about Science
- *Rigor & Relevance* blog
- SWE and SHPE mentorship



A coupled oscillator as a mathematical abstraction for evaluating and designing physical and economic controls to improve performance in cyber-physical infrastructure networks, e.g. power, transportation & communication networks

Generalization of performance measures

Many previous results used H2 based measures to evaluate performance in double integrator systems (e.g. vehicle and power networks) assumed uniform agents and undirected graphs

Extension 1: Directed graphs (systems emitting normal graph Laplacians) [1]

- A directed communication graph can improve the performance of a system
- *Fully connected systems*: the performance of a system with undirected communication is an upper bound on that of a system resulting from non-symmetric perturbations to the original graph (i.e. well studied analysis tools for symmetric systems provide good bounds in many cases)

Extension 2: Non-uniform agents and connections to power system measures such as Nadir, Rate of Change of Frequency, (RoCoF), and inter-area oscillations [2]

- Demonstrated that the role of inertia in determining performance is tightly coupled to the modeling paradigm, which may help to understand disconnect between results obtained through various analysis techniques in the literature

[1] H. G. Oral, Enrique Mallada and D. F. Gayme, "Performance of first and second order linear networked systems over digraphs", *Proc. of IEEE Conf. on Decision & Control,* 2017

[2] F. Paganini and E. Mallada, "Global performance metrics for synchronization of heterogenously rated power systems: The role of machine models and inertia," *Proc. of Allerton Conf. on Comm., Control, & Computing, 2017*