2021 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

CAREER: A Compositional Approach to Modular Cyber-Physical Control System Design

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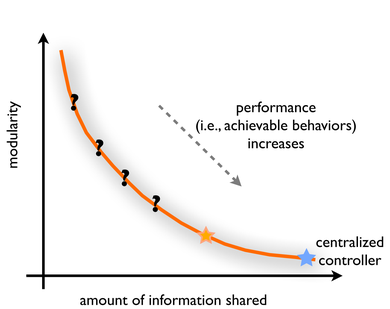
Challenge:

- Scalable tools for control design and verification (theory and algorithms) for complex CPS are lagging
- Decentralized control synthesis and verification problems are generally hard (i.e., undecidable)
- Key idea: Modularity to manage complexity during both design- and life-cycles for CPSs

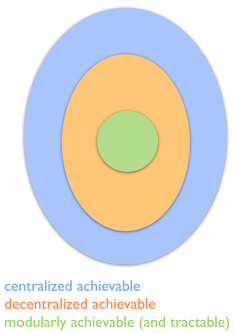
Solution:

- Composition: Assume/guarantee contracts for designing individual systems and composing them
- Decomposition: Methods for splitting a complex system and specification into local ones
- Handling uncertainty and partial information: New control synthesis methods for subsystems



★ decentralized control where local controllers use models of all other subsystems and all other local controllers

? compositional control where local controllers only use some assumptions summarizing the behavior of other subsystems



Scientific Impact: Theory & algorithms to:

- efficiently compute controlled invariant sets for systems with actuation delays (fully mitigating the state-explosion due to delay dynamics)
- synthesize correct-by-construction controllers with missing measurements (e.g., package drops in communication, sensor glitches, perception failures etc.)
- synthesize distributed path execution policies for multi-agent systems with collision and deadlock avoidance guarantees

Broader Impact:

- Applications in autonomous systems: automotive and robotics
- Industry interactions: Toyota Research Institute, Ford Motor Company, Mathworks
- Workforce development: 5 PhD students, 10 undergrads involved in the projects

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