COLLEGE OF ENGINEERING
COMPUTER SCIENCE & ENGINEERING
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Dissertation Defense

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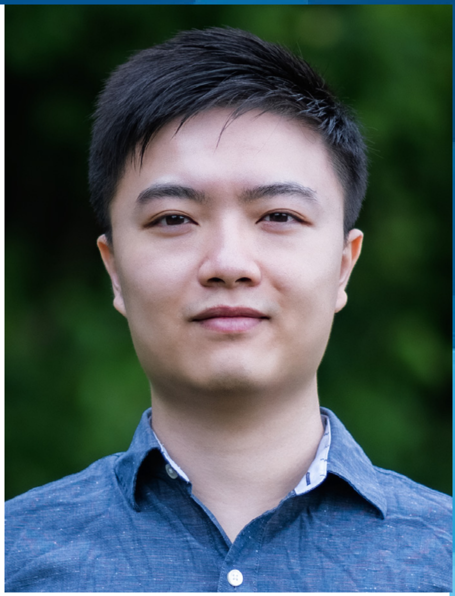
Enabling and Improving Centralized Control in Network and Cyber-Physical Systems: An Application-Driven Approach



Friday, July 31, 2020
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ABSTRACT: Cloud providers and carriers are actively adopting a centralized control paradigm, as in Software-Defined Networks (SDN), to achieve high flexibility and agility in network management. This paradigm allows applications (apps) to easily monitor/reconfigure network devices based on a global view. With emerging hardware (e.g., internet-of-things, autonomous/connected vehicles, smart manufacturing) and software technologies (e.g., digital twins), Cyber-Physical Systems (CPS) can also leverage this paradigm to improve their performance and reliability. However, to reflect rapidly emerging device capabilities and use cases, apps need to evolve constantly, which introduces new requirements for programmability, extensibility, and data availability. As a result, it is challenging and sometimes impossible to deploy existing SDN(-like) solutions as they are without resorting to ad hoc patches that are time-consuming to develop and hardly reusable.

In this dissertation, we argue that (1) it is possible to systematically address such problems without tailoring to specific apps, and (2) generalization of apps' behaviors is key to the solutions. To support these claims, we present three systematic solutions that enable and improve centralized control in different network systems and CPS. For apps that buffer network packets during device mobility to prevent loss or reordering, we expand SDN programmability to support in-network buffering with Programmable Buffer. For apps running in a heterogeneous network, we generalize SDN traffic management abstractions with Egret. To enable centralized control in CPS and support data-driven apps, we develop an extensible and generic framework named SDNator. We demonstrate that these solutions can not only support legacy and emerging apps but enable the innovation of new ones.

Chair: Prof. Z. Morley Mao