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Title: Control and Optimization in Cyberphysical Systems: From Sensor Networks to "Smart Parking" Apps

ABSTRACT: Sensor networks are multi-agent systems consisting of distributed nodes that cooperate to meet a common objective, often in an uncertain environment. Viewed as a cyberphysical control system, a sensor network encompasses three interconnected functionalities: coverage, data source detection, and data collection. We will describe an optimization framework for controlling the location and movement of nodes so as to combine these functionalities. We also address the issue of information exchange among nodes aiming to minimize inter-node communication. We show that event-driven, rather than synchronous, communication can guarantee convergence to optimal solutions while drastically reducing the need for inter-node communication, thus also reducing energy consumption and extending the network's lifetime.

Despite significant advances, these systems remain largely used for data collection from physical sources. There has been limited progress on the processing of data to drive actuation and form a complete closed-loop cyberphysical control system. We describe one such system recently developed for dynamic resource allocation in an urban environment. Termed a “smart parking” system, it dynamically assigns and reserves an optimal resource (parking space) for a user (driver) based on an objective function that combines proximity to destination and parking cost, while also ensuring that the overall parking capacity is efficiently utilized. When an optimal allocation is updated, it is guaranteed to avoid reservation conflicts and to preserve a monotonically nonincreasing cost for every user relative to current assignment. We will describe an implementation of this system at a Boston University parking facility based on driver requests entered through a smartphone app.