1035894 "CPS: Medium: Managing Loosely Coupled Networked Control Systems with External Disturbances"

One of the urgent tasks for wastewater reclamation plants (WRPs) is to develop a cost effective infrastructure upon the existing facilities to meet the new regulations on the concentration of total ammonia nitrogen required by USEPA by 2014. To overcome the challenges and meet the urgent needs in a timely and cost effective manner, our research is to extend the legacy systems with available technologies, such as sensors and wireless networks, and provide real-time, on-line monitoring and process control to minimize energy demands and carbon footprint associated with nutrient control. We are the first to study cyber-physical systems as a loosely coupled networked control systems. One of our to-be-deployed systems can help a WRP to save millions of dollars on electricity bill.

We have developed a aquaponics testing system that can be used for testing our large scale system. The goal of this testing system is to create net-zero energy buildings by coupling independent industrial processes with complementing energy and material inputs and outputs and focused on the combination of adaptive industrial reuse and vertical farming. A group of students have prototyped a small control system that can remotely control the lighting and temperature of aquaponics systems. We also use the system that our students built to introduce the concepts, the challenges, and possible solutions about distributed, real-time, and embedded systems, about cyber-physical systems to students in our CPS class.

For the evaluation of protocols designed for this project, we also developed a wireless sensor network testbed composed of more than 200 sensor nodes and several DO sensors. This infrastructure will remain a research facility for other projects. Response times of cyber-physical systems for water resources management have a wide range. For example, we expect one of our applications will involve developing an intelligent sensor network to replace the dissolved oxygen (DO) monitors that MWRDGC has been using to assess DO concentrations in the Chicago Area Waterways (CAW). Data for those systems are currently collected weekly and response times, which play an important role in water quality in the CAW, are often several days. In contrast, we also expect to work with MWRDGC to develop intelligent sensor networks to monitor process performance in their aeration basins, where response times are several hours. Challenges for implementation of these systems include operator acceptance and training; sensor cost, maintenance, and reliability; process model development; and process control development.

We also successfully addressed several theoretical challenging questions such as efficient periodic data query, and top-k ranked elements query in multihop sensor networks,

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