Wireless sensor-actuator networks (WSAN) consist of numerous sensing and actuation devices that share information over an ad hoc wireless communication network. Examples of such systems include the national power grid, ground/air traffic networks, and water/gas distribution networks.

This project studies the implementation of feedback control algorithms over WSANs. Controlling such physical processes usually requires some type of hard real-time support. This means that each packet of feedback data must be serviced within a specified deadline to assure the control application’s performance level. It has, in practice, been difficult to provide such guarantees in real-life wireless networks. This project addressed that issue by developing algorithms that allow control applications and network routers to work together in a way that ensures system performance under firm real-time service constraints.

The “physical” part of this system is the plant that is being controlled. Control is based on signals from sensors that are transmitted over a wireless communication network to an actuator that implements the control signal.

The “cyber” side of this system is the wireless communication network. Information is transmitted in discrete packets that may be corrupted or lost during transmission.

**Project Objectives**

- Ensure system performance under firm real-time service constraints.
- Be able to provide such guarantees in real-life wireless networks.

**Problem Statement:**

- Reduce the amount of feedback information needed to attain a desired control performance level.

**Minimizing Feedback Information**

- Only transmit the last sampled signal and the current signal.
- Quantize and dynamically quantize the measured information.
- Discretize the information flow in both space and time.
- Reduce the amount of transmitted information by event-triggered sampling.

**Dynamic Transmission Rate Adjustment**

One way of enforcing the application’s bit-rate requirement is to treat it as a deadline and then adjust the actual transmission rate in a manner that meets the deadline while minimizing transmission energy.

- Use an approach that modifies an earlier dynamic voltage frequency scaling (DVFS) algorithm known as Lp-EDF (Yao 1995) that is optimal for scheduling pre-emptive jobs on a single processor under EDF scheduling.

**Meeting End-to-End Deadline in WSAN**

- We used an approach that modifies an earlier dynamic voltage frequency scaling (DVFS) algorithm known as Lp-EDF (Yao 1995) that is optimal for scheduling pre-emptive jobs on a single processor under EDF scheduling.

- Our work applies Lp-EDF scheduling to determine rate schedules in wireless single-hop networks. The proposed rate adjustment algorithm is similar to one proposed by Zafer and Modiano (2M 2009). Our algorithm performs better than either ZM2009 or the earlier Lp-EDF algorithm.

- We studied the distributed local deadline assignment problem which appears in Wireless HART networks. In this problem, messages must be transmitted over a sequence of agents to a gateway by a specified end-to-end deadline.

- We maximizes the minimum time slack among all the messages.

**Leader-Follower Formation Control**

- The algorithm uses an EBB model of the channel state that is a function of the formation state. The leader’s information is dynamically quantized and transmitted to the follower. The follower uses both channel state information and the received data to adaptively switch to a less aggressive controller when the formation state is highly uncertain. Software simulations suggest that this approach can provide almost-sure guarantees on overall system safety.

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