Demo Abstract: Responsive and Energy-Efficient Sensor Networking for Real Time Location Tracking

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Abstract

A large number of MAC protocols support energy efficiency in sensor networks by forming rigid sleep/wakeup schedules. This demonstration illustrates an energy-efficient protocol which adapts to changing sensor update rates, as required by certain application scenarios such as real time location tracking.

Categories and Subject Descriptors

C.3 [**Special Purpose and Application-Based Systems**]: Real-time and embedded systems; C.2.2 [**Network Protocols**]: Protocol architecture

General Terms

Algorithms, Experimentation

Keywords

sensor network, MAC protocol, energy efficiency, localization, ultrasound

1 Introduction

Protocols for energy efficiency based in and around the MAC layer have been the subject of much research in sensor networks. Some types of sensor network, such as basic environmental monitoring, tend to rely on the capture of sensor data at slow and constant update rates. These types of network might rely upon the nodes organising themselves in or converging on local or global sleep/wakeup schedules [1, 2, 3, 4].

Other types of network, such as those used for low-latency tracking, require more adaptive protocols, with scheduling and access control changing as appropriate for the network traffic [5, 6]. These allow nodes to utilise a very low duty cycle and conserve power when there are few changes in the network, and then quickly adapt to report sensor readings with high update rate and low latency in dynamic conditions.

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As a demonstrator, we show a sensor network whose nodes can sense the physical distance between one another. The nodes rely upon radio communication to coordinate and share their measurements. As long as the nodes in the network are motionless, they maintain a very low sensor update rate (i.e. duty cycle) to conserve power. When one or more nodes start to move, the update rate of ranging measurements to and from those nodes is dramatically increased to facilitate low-latency tracking. The nodes utilise an adaptive protocol having some similarities to the protocols presented by Rajendran et al. [5]; Li et al. [6]; and Mishra and Nasipuri [**?**].

2 Adaptive Protocol

Like S-MAC [1], the protocol used by the nodes is a rendezvous or *meeting-based* protocol where nodes adopt the same sleep/awake schedule by detecting their neighbour's schedule upon start-up. However unlike S-MAC, the duty cycle is function of the network traffic and sensor activity. *Meeting times* are typically several seconds apart, but the meeting interval can vary between tens of milliseconds to up to sixteen seconds with our current hardware implementation.

At a meeting time, nodes do not directly transmit data but instead advertise to the others their desired schedule for transmission of data. The advertisement includes the amount of data to send, the recipients, and the time at which data transmission will commence. Hence, a volatile and on-demand contention-free TDMA communication scheme is created.

As nodes advertise their desired schedule at the meeting time, a *transmission list* is built up which describes the upcoming network activity. Thus, the transmission list is an indicator of the network status and can be used by nodes to adjust their duty cycles to the situation. A very busy list will make nodes reduce their immediate and future sleep durations in order to reduce latency, while an empty list will make them reduce their duty cycle to save energy. The nodes can also use information from their sensors (such as a ball switch to detect movement) to advertise to others the possible need for low-latency monitoring, and nodes within sensing range can reduce their meeting intervals accordingly.

3 Demonstrator

The physical demonstrator consists of ten to twenty Particle[1] sensor nodes outfitted with custom ultrasonic sensor

[1] `http://www.particle-computer.de/`

boards. A USB dongle attached to a nearby laptop collects the ultrasonic range measurements reported over the nodes' radio network. This data is used by the laptop to compute and display a visualisation of the spatial arrangement of the nodes.

LEDs on each node indicate the rate of sensor readings, as well as the sleep/wakeup activity status for that particular node. Conference participants are invited to move the nodes, and observe two effects: (1) as one or more nodes are moved, the frequency of ranging events is increased to provide up-to-date estimates; and (2) the spatial arrangement of the nodes on the laptop screen begins to change in real time once the protocol has gone into the low latency traffic mode.

4 References

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