The D-Systems Project - Wireless Sensor Networks for Car-Park Management

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***Abstract*—Wireless sensor networks are collections of autonomous devices with computational, sensing and wireless communication capabilities. Research in this area has been growing in the past few years given the wide range of applications that can benefit from such a technology. This paper reports on a joint project between The Tyndall National Institute and the Computer Science Department at University College Cork, Ireland in developing a novel miniaturised modular platform for wireless sensor networks. The system architecture and hardware will be discussed as well as details of the deployment scenario chosen for the project – a car park management system..**

Index Terms—Wireless Sensor Networks, deployment, car park monitoring

I. Introduction

This paper describes a car park management system that utilizes a highly modular, miniaturised wireless sensor platform that addresses the issues of flexibility, power-efficiency and size. The platform was developed as part of the D-Systems project [1] investigating the development of distributed intelligent systems. From a hardware perspective, the key objective of the project is to produce miniaturised autonomous sensing units that can be easily deployed and maintained in an everyday environment. The target sensing module being a 25mm cube incorporating commercial-off-the-shelf (COTS) microsensors, ICs for signal processing, computation, and wireless communications, as well as a power source, all combined together within a highly innovative packaging configuration. In regard to software and protocols the project had several specific research outcomes:

1. A model for maintenance in wireless sensor networks and a new technique for routing packets so as to minimise post-deployment maintenance costs.
2. 2. An algorithm for determining the best nodes in which to perform data aggregation, when operating with a limited data delivery time budget.
3. Two new energy-efficient medium access control protocols – one that is suitable for periodic scheduled data, the other for offering deterministic data delivery.

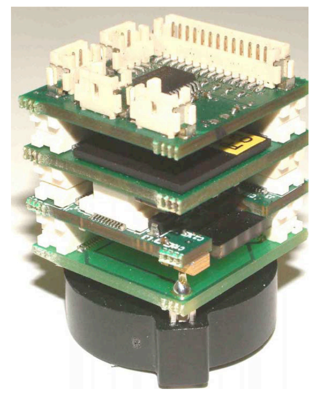

Figure 1. D-Systems wireless sensor Mote

II. Car Park Implementation

The target application demonstrator of the D-Systems project was a car park management system. Sensor networks are a natural candidate for car-park management systems, because they allow status to be monitored very accurately - for each parking space, if desired. Wireless sensor networks have the advantage that they can be deployed in existing car-parks without having to install new cabling for network and electricity to reach each sensing device. For this reason, wireless sensor networks also have use for road-side car-parking.

A. System Architecture

The overall architecture was guided by the principle of tiered functionality, with the lowest level comprising the sensing functionality, a middle tier dealing with data forwarding, and the upper tier handling data storage, processing and client interfaces. The architecture is depicted in Fig. 2 and mimics the actual physical topology used in our current deployment.

The DSYS25z [2] sensing nodes run Tiny OS Version 1.1.7 [3], together with custom medium access control (MAC) and routing protocols, and a driver for the magnetic sensor. The application-layer software is responsible for reading from the sensor at a regular programmed period and forwarding the reading to a neighbour for multi-hop delivery to a base station (currently a PC). A Java-based server interacts with a serial-forwarder program to acquire and process the data. First, it determines the originating node, then it processes the new reading as follows: If the reading indicates a change in the current value for that node, then the server records the time at which the new packet was received and if it receives several successive updates indicating the same change in status then it accepts and records the change. The idea is to avoid reacting to transient changes, due, for example, to vehicles driving over a vacant parking space.

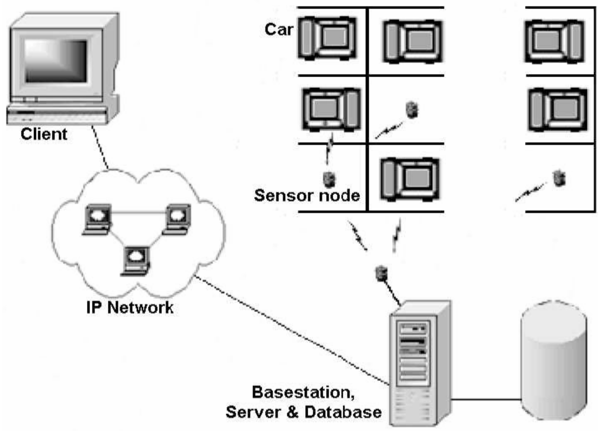

Figure 2. System Architecture

B. System Hardware

For the car parking application, the DSYS25 hardware platform consists of a communications layer, a sensing layer and a power layer. The communication layer is comprised of an ATMega128L [4] micro-controller with a CC2420 Zigbee [5,6] compliant transceiver and a simple wire antenna [7].

For the detection of cars, a specific sensing layer including a magnetic field detector was developed. The magnetic field detector used for this application is the Speake FGM-3 [8] which uses 12mA of power and is operated at 3.3v. It outputs rectangular pulses with frequency inversely proportional to the magnetic field strength. The presence of metal changes the magnetic flux of the surrounding area and this change is shown by a change in the frequency of a quartz oscillator. Due to the high frequency of pulses generated (range 50-120kHz) it was decided to treat the sensor as an external clock whose frequency could be measured by counting how many pulses arrived during a fixed interval measured by the processors internal clock. The sensor output was connected to a 16-bit counter pin on the processor (TimerCounter3).

The power layer was replaced by a set of two AA batteries (or alternatively a 9v battery as shown in Fig 3) as sensor node lifetime is considered more important than node size. The resulting system is encased in a 15cm x 15cm plastic box that can be glued to the ground.

Figure 3. Car Parking Node in Enclosure

III. Experimental Evaluation Summary

The system was extensively tested to evaluate the sensor, antenna, system connectivity and system routing. The results of the connectivity tests & application tests can be summed up as follows:

- Connectivity in the test environment is not solely dependent on transceiver distance
- Uneven surfaces can be highly detrimental to connectivity Connectivity is often asymmetrical to some degree
- The presence of a vehicle at the transceiver has significant effects on connectivity
- Transceivers are prone to bursty communication blackouts
- These communication blackouts are local and do not effect significant areas.

Due to space restrictions we are unable to include many details of the project including related work, but for further details see [9].

Acknowledgment

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