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Reconfigurable Sensor Networks

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1 Introduction

Reconfigurable sensor networks is an emerging area of research. At the University of Berkeley in California, a project named Smart Dust has lead to the development of wireless sensor nodes called motes. These motes consist of a radio frequency transceiver, microprocessor, sensors and a power source which is usually a small battery. These motes were designed to be literally thrown into an environment and arrange themselves into a network to communicate information to a basestation where the information can be processed. Current research has concentrated on compacting these motes into a very small size, which at the moment is around a cubic inch. This type of sensor network has the potential to be used in many commercial and research applications which at this stage has not been explored at any great length. By developing and testing a wireless sensor network, this research could lead to larger more sophisticated applications.

2 Research Context

The characteristics of a networked sensor system determine its design. These characteristics include size, power consumption, concurrent operation, software portability and robustness. The motes in a wireless sensor system are of a small size so as to be fairly inconspicuous in the environment they are placed in. This physical requirement raises the problem of power consumption. Typically a mote will use a small battery as a power source and needs to preserve as much power as possible to function as long as it can. As the motes don't have a large amount of memory on them, information must be moved from mote to mote quickly and efficiently so as to use as less power as possible and to relay information gathered before more information is found.

The motes in a network will usually be of a large number and expected to function correctly while being unattended. Therefore enhancing the reliability of individual devices is essential. This can be achieved by accepting individual device failures and factoring them in to an application. The networked motes will usually be application specific, rather than general purpose, and only have the hardware needed for the application. As a wide range of applications are possible, software needed for an application should be portable across different applications. This means common jobs like sending and receiving information should not have to be reprogrammed for different applications.

This idea led to the development of the Tiny operating system (TinyOS)[3]. It acts as a generic development environment which allows specialized applications to be constructed from a number of common functions. TinyOS

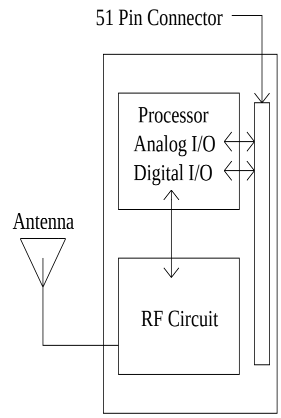

Figure 1: Block Diagram of Mote

is an event based operating system which allows high amounts of concurrent operation[2] in small amounts of memory while utilizing processor resources to preserve power.

To communicate, the motes use ad-hoc routing schemes which are designed with the earlier mentioned characteristics in mind. GAaRP (Geographic Addressing and Routing Protocol) is one such scheme that was developed[1]. This scheme used GPS (Global Positioning System) receivers as additional hardware to the motes. The routing protocol involves initial acquisition of a GPS position, followed by a RF (radio frequency) signal message used to trigger communication with modules in RF range. Once a module negotiates and establishes a valid route, the module announces this new route to other modules within RF range. This procedure is repeated in a radial fashion until the entire network is configured relative to a Home position.

TinyOS is run from flash memory in a Atmel microprocessor found on a mote. From this, various sensor boards can be connected to a mote through a 51 pin connector. This allows sensors specific to an application to be easily connected. The mote also consists of a 868/916 Mhz multi channel transceiver with a range of around 150 metres[5]. A basic block diagram of this can be seen in figure 1. Figure 1 Although currently most of the research has concentrated on physical size, a project called palms[4] was undertaken where a number of motes where dropped from an unmanned aerial vehicle onto a road and land vehicles passing the mote were tracked. The motes organized themselves into a network and transmitted data to a basestation where the vehicles were monitored. This type of idea is the motivation to develop a application where a room will be monitored, and depending on an event found by the sensors, the sensor system will reconfigure and perform another function. This type of idea may have potential for future applications in research and monitoring of environments.

3 Research Plan and Methods

3.1 Methods

The project will be developed from TinyOS. Programs written for the sensor system will use use the C and Java programming languages. Documentation for the software doesn't give an overall picture of how it works so a good knowledge of the software will have to be attained through testing. This will lead to development of an application where 3 motes will be used to find out information about an environment, in this project, a room in a building. The information will be seen from a basestation. If a certain event is found by the motes, for example a person entering a locked room or the temperature in the room is too hot then the motes will be reconfigured to detect information after this event.

3.2 Proposed Thesis Chapter Headings

1. Introduction
   (a) Purpose of Research
   (b) Objectives of Research
2. Wireless Sensor Nodes
   (a) Node Hardware
   (b) Node Software
   (c) Node Communication
   (d) Node Power Consumption
   (e) Overall Node Package
3. Reconfigurable Sensor Network
   (a) System Design
   (b) System Implementation
   (c) Results
4. Conclusion and Future Work
5. Bibliography
6. Appendix

3.3 Timetable

Date	*Activity*
5/5/03	Put Website Up
12/5/03	Research Methods Assignment and Literature Review
19/5/03	Research Methods Assignment and Literature Review
26/5/03	Research Methods Assignment
2/6/03	Interim Presentation and Literature Review
9/6/03	Literature Review Draft
16/6/03	Develop Network System and Code
21/7/03	Literature Review
28/7/03	Literature Review
4/8/03	Network System and Code
11/8/03	Network System and Code
18/8/03	Thesis Draft
25/8/03	Thesis Draft
1/9/03	Thesis Draft
8/9/03	Thesis Draft
15/9/03	Network System and Code
22/9/03	Thesis
29/9/03	Thesis
6/10/03	Thesis
13/10/03	Thesis
20/10/03	Final Presentation
27/10/03	Final Presentation
3/11/03	Logbook and Thesis
10/11/03	Website

3.4 Special Facilities Required

A copy of the TinyOS software used on the sensor nodes is required. Special privileges in the linux operating system are needed to use TinyOS software, so a PC outside the honours lab is required.

3.5 Potential Difficulties

The difficulties that may be encountered are that the motes may not be purchased. This will be solved by other methods to demonstrate a sensor network. This will be in the form of a mixture of PC's and FPGA's. A number of PC's will be connected together over an internet connection and will use TinyOS. FPGA's will then be used as the reconfigurable component to reconfigure the functionality of the system by downloading new data into the FPGA. This option would use VHDL implemented in the FPGA. This system would then be used to prove the reconfigurable sensor system.

3.6 Deliverables

The deliverables of this project will start with development of a reconfigurable sensor architecture. Once the architecture has been developed, a sensor network will be developed which will include a routing algorithm. Packet format and processing will also be developed. The system will then be simulated and debugged and the system proven.

4 Relevance of the Project

Current existing work on wireless sensor nodes has focused on the size that the nodes can be produced. Many commercial and research applications have therefore not been developed. This project will use the existing software that has been developed to design and develop an application for a wireless sensor network where it can sense an environment. This will be proven on functioning wireless nodes or on mote style nodes developed to proves the system design and coding. As the sensor nodes use "off-the-shelf" components, they are relatively cheap. Development of an application which can monitor an environment then reconfigure itself to gather different types of data could lead to the sensor nodes being used for many applications as well as a cheaper alternative to existing sensor systems.

5 Bibliography

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