A Real World RF Characterisation Tool Set for Wireless Sensor Networks

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***Abstract*— Whilst conducting some preliminary research for an industrially-based Wireless Sensor Network (WSN) project within the rail industry, it became apparent that a method to obtain real world Radio Frequency (RF) performance characteristics without requiring expensive test hardware did not exist. It was also apparent that informative data on the real world characterisation of environments where WSN nodes are likely to be deployed was a neglected area of research.**

A design has been completed that addresses these issues. A cross platform set of tools will be able to collect a dataset from a number of test sites using standard WSN nodes. The project is now moving into the implementation and testing phase which will be completed by late August 2005.

I. Problem

It is often desirable to use WSN nodes in particularly RF-unfriendly and noisy areas such as in congested indoor environments or aboard vehicles. Some environments, such as on an electrically powered commuter train, are subject to maximum regulatory limits, however, the effects of radiated noise are sporadic and as such it is difficult to ascertain exactly how a system will perform when deployed.

To gain a real understanding of the differences between environments, our system can quickly collect a range of radio readings from a set of test nodes. This data can be subsequently analysed by a suite of tools. This application will close a gap within WSN research that will provide a valuable tool to anyone using and deploying real WSN systems in both academia and industry.

II. Related Work

Radio Frequency analysis is a well studied and documented field. Within WSN, some projects have looked into RF analysis, but no tools or methods to survey and evaluate real deployment scenarios have been found.

In 2004, Tereus Scott evaluated the original MICA mote and RF Monolithics transceiver [1]. This report uncovered some interesting findings about the performance of the MICA's built in antenna, but it provided little information about performance in noisy environments.

The Calamari [2] project at Berkeley has spawned some interesting data sets, however, these have all been collected with a view to using the data for ranging calibration, and as such does not reveal anything about the noise or interference levels experienced at each site. Other studies such as [3] contain an element of RF profiling, but these are used for localisation.

III. Proposed Solution

Our design focuses on a small test system that can be installed on off-the-shelf wireless nodes, enabling a range of areas to be characterised in a short space of time. There are three main software elements to the system:

- Base station node software
- Child node software
- Data analysis software

Each test results in a single layer star topology being created (Figure 1). It is felt that there was no need at present to extend the system to cover multi-hop networks, since it is the degradation experienced on each point-to-point link that we are interested in, and if a node falls out of range it is reported as such.

A. Test scenario

To run a test, the minimum requirement is to have one base station and one child node[1]. When the base station

[1]Our implementation supports up to 8 child nodes.

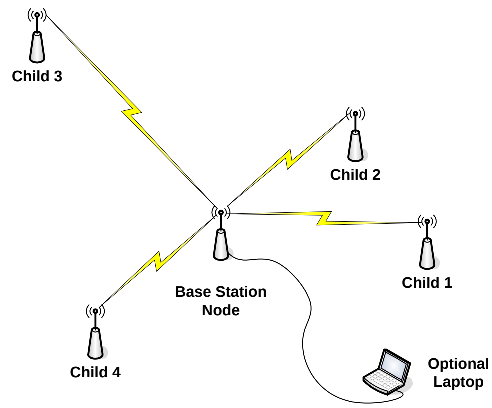

Fig. 1. Simple test network topology.

is powered up, the test is started and a request message is broadcast on the radio interface. All child nodes that receive the message will reply after a unique delay, calculated using their node ID. This procedure results in a slotted arrangement (Figure 2), and eliminates the potential for collision and congestion on the radio.

The tests are performed at a range of transmission power levels, enabling remote nodes to experience the full potential for communication at each site. Signal strength indications are returned to the base station in each response packet, enabling the following parameters to be recorded for each remote node at each Tx power level :

- RSSI[2] of parent node as experienced by the remote child
- RSSI of remote child as experienced by the parent
- Integrity of data received
- Reported child battery level at time of transmission

In addition, it is also possible to configure the system to use different communication channels, enabling the detection of prolonged localised interference in the spectrum.

B. Data logging and retrieval

To enable tests to be run in a wide variety of environments, a serial logging facility has been designed. This will permit tests to be run with the resulting captured data stored locally in the MICA2 serial flash. A serial client application can probe the device at a later date to retrieve the data.

This feature has been included to allow data to be easily collected from a variety of locations where having a wired connection to a laptop is not always feasible, for example, some locations within public railway and subway systems.

[2]Received Signal Strength Indication.

C. Analysis tools

When data is retrieved from the device over the serial link, it will be entered into an SQL database for ease of storage and processing. A suite of PHP tools will be written to allow the data to be analysed, providing both textual and graphical views of the data. This will allow comparison of collected data from different sites.

IV. Merits and Contributions

The main merits of the project are:

- The tool is a cross platform resource, and will enable the suitability of different physical radio technologies to be demonstrated in real-world situations using physical radio hardware
- Tests can be run anywhere using a simple set of battery powered WSN nodes
- Recorded data can be downloaded from the base station node at any time, in the field with a laptop or in the lab at a later date
- The ability to test all channels and power levels for a particular radio may yield interesting findings for some applications and provide an overall view of the system's performance

V. Early Results

The system will be tested in a variety of locations, such as a clean open space area for reference, congested indoor environments and on public transportation systems. By late August 2005, we expect to have a wide range of data sets, and will be able to show:

- The differences in environments experienced
- Differences in throughput
- Impact that varying the Tx power level has on communication between nodes in a range of environments and at a range of transmission distances

VI. Future Work

This project is part of an ongoing project between The Kelvin Institute and an industrial partner within the rail industry. The system will be used to perform intensive testing aboard a range of commuter rail services to characterise the nature of the environment, and its suitability for various forms of WSN physical layers.

Both the TinyOS module software and the analysis tools will be updated as required during the course of the project. The range of tests will be increased as necessary, along with extra functionality to perform tests

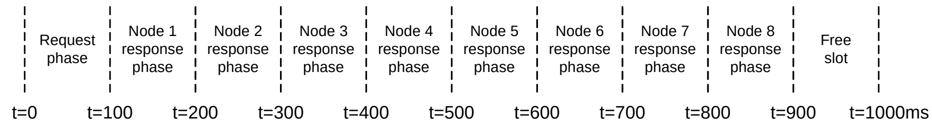

Fig. 2. Slotted structure for node responses

between remote nodes. Future upgrades may also include optional integration with a GPS to enable location and time stamping of test results on the device.

VII. Poster Contents

By the conference date, the implementation and testing phases of the project will be complete, and sample data will have been collected from a number of sites. This data will be analysed to draw some conclusions to be drawn from the use of the system.

The poster will contain three main sections. Firstly, the need for the system will be addressed in brief. This will lead into a high level graphical overview of the application, and a description of its operation. Finally, a set of results will be shown for some electrically different areas - shown both textually and graphically.

Acknowledgments

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References

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