Demo Abstract: Rapid Deployable System for Human Contact Network Research

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Abstract

Current sensor network nodes are not designed for a rapid succession of large-scale deployments. While hundreds of nodes have been deployed in static networks (e.g. ExScale, GreenOrb) large-scale, mobile, repetitive deployments are difficult to manage. We developed a new platform, the WREN, to be a low-cost, easy to maintain and rapid to deploy, wireless sensing node for human contact network measurements.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design - Wireless Communication

General Terms

Experimental, Deployment, Measurement

Keywords

Rapid Deployment, Low-Power Wireless Network

1 Introduction

We collected contact and mixing network information of school-aged children in a project sponsored by the Center of Disease Control (CDC). During a deployment, every child receives a wireless node, and over the course of the day the node senses the proximity of neighboring nodes. The contact and mixing information is then used by epidemiologists to model the behavior of air-born diseases.

Initially, we used the popular TelosB node, but quickly realized that the limiting factors for scaling are packaging (see acrylic box design in Figure 1), physical size, and the lack of a charging circuit for the battery. While impressive one-time deployments of 1000+ nodes in similar setups have been performed [1], a quick redeployment, preferably on a daily basis would be prohibitive. We later replaced the TelosB with the Irene mote [2] and custom charging circuit. In addition, we built a 200-port USB based charging station that allows a computer to download and communicate with 200 nodes simultaneously. While this improved manageability, the high cost and problems with the case lead us to redesign our system, optimizing for weight, deployability, maintainability, and cost reduction.

Figure 1. TelosB with custom acryllic case in charging station.

The redesigned system consists of a new sensing node, the WREN, that updates the aging components of the Irene and TelosB. In addition, it adds a Lithium Polymer battery charger right onto the node, such that additional chargers are unnecessary. The WREN also solves a big problem of scaling. While wireless download and reprogramming often works, a charging station is still necessary to recharge between deployments. We built a custom bootstrap loader into the WREN node that allows to reprogram 127 nodes at once over a Two-Wire connection. This significantly reduces reprogramming, downloading, and interfacing as only two wires are necessary between the different plugs to accomplish this.

2 System Description

The WREN features a TI MSP430F5342 microcontroller with 10 kByte of RAM and 128 kByte of on-chip flash storage. We decided to choose the latest Atmel AT86RF233 radio transceiver, a IEEE 802.15.4 compliant radio with a special low-power receive mode (6 mA) and possibilities to

Figure 2. Irene nodes during assembly of custom charging circuit and case.

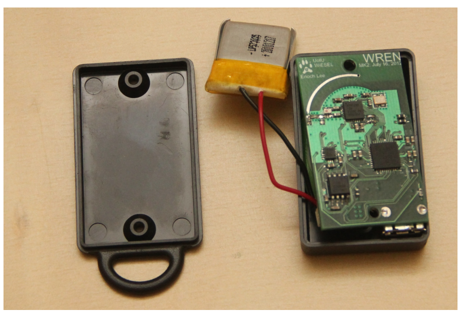

Figure 3. WREN with case and Li-Po battery

switch the data rate to 2 MBit/s. To support longer deployments, we added a 32 MBit flash from Atmel and a 240 mAh rechargeable Lithium Polymer battery. This should allow us sensor deployments of several days even at only moderate duty cycles. For movement and tab/click detection the WREN features a ST LIS331DL 3D accelerometer. While slightly less accurate, with less features, and higher power, it costs 50% less then the more popular ADXL345.

We learned the hard way that keeping time during the deployments can become a significant issue. Node resets, algorithm time corruption, and changing environments can introduce significant timing errors, and thus invalidate node contact logs. To sidestep potential problems with synchronization algorithms, we added a NXP2721A real time clock (RTC) with integrated temperature compensated oscillator. This will allow us to synchronize the nodes once, and then rely on that synchronization for the rest of the deployment, without worrying about error accumulation. In addition, the RTC is battery backed and will keep time well past the dropout voltage of the rest of the system.

2.1 Charging, Reprogramming, and Data Download

A significant problem of rapidly deploying a mobile network for only a short (days) amount of time with a redeployment in short succession is the data management, maintenance of node, and recharging. A popular way of programming wireless nodes is through a USB Communication Device Class interface. For that purpose, we initially built four 50-port USB hubs that could recharge our Irene nodes and reprogram from a Linux system. While the theoretic limit is 128 devices per USB bus, we found that our Linux system (Ubuntu 11.10) only saw about 140 nodes, no matter how we distributed the boxes over the 3 available USB buses. Thus, even if we built our custom computer with 10 available USB buses, we couldnt easily manage a network of 1000 nodes from just one computer.

We investigated new ways of programming the MSP430. Fortunately, the 5000 family provides a mechanism to reprogram the bootstrap loader, commonly using a UART interface, to use any other communication interface available. We decided to use a Two-Wire protocol as it allows us to have 127 devices per master, without the need for hubs. With a simple USB to Two-Wire master converter we can now quickly scale to significantly larger charging stations with the capability of reprogramming all of them over the wire. If necessary, the Two-Wire interface could be extended with a 16-bit address, thus scaling this to even higher numbers of nodes per master device.

An important aspect of the recharging station is its physical size. It can't be too large or heavy, or else we would need an army of people to deploy them. With the current case, we can support 100 nodes on a 10" x 24" surface. This includes the external power supply providing 80 mA per node for battery recharging purposes. The idea is to stack multiple of these 100 node stations on top of each other, such that transport can be made as easy as possible. Overall, the WREN should cost <\$50, including the battery and case[1].

3 Demonstration

In this demonstration, WRENs will be deployed during the conference demo time. Each attendee will receive a WREN after signing one out from our demo, while every demo/poster has a stationary WREN node. The system will track in real time how many people are standing in front of a poster/demo for how long. Depending on the floor layout, we can show the collected data in real time. If necessary, the WREN nodes can store the information in their Flash storage for later download and data processing.

4 References

[1] M. A. Kazandjieva, J. W. Lee, M. Salathe, M. W. Feldman, J. H. Jones, and P. Levis. Experiences in measuring a human contact network for epidemiology research. *HotEmNets*, June 2010.

[2] Moteware. Irene Datasheet - Rev. A. http://www.moteware.com/pub-docs/datasheet-irene.pdf.

[1] Final pricing not available yet, but will be by the time of photo ready version.