

EcoDAQ: A Densely Distributed, High Bandwidth Wireless Data Acquisition System

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Abstract

Current wireless sensor networks achieve dense deployment by low duty cycling. Unfortunately, this represents a great mismatch with many real-world applications that require non-trivial data rates. To solve these issues above, we propose EcoDAQ, a new densely distributed wireless data acquisition system with a relatively high data rate. We implement a MAC layer protocol that minimizes complexity and memory footprint on the sensor node while guaranteeing collision freedom, without using multiple frequency channels. As a result, this work is not only highly scalable to at least 50 active nodes per squared meter, but at the same time the low complexity minimizes the cost of these ultra-compact sensor devices. The full demo would show a system deployment with a minimum of 50 active sensors on a poster board of 1 m² area. The monitoring station keeps gathering up to 500 accelerometer data samples per second from all of these 50 sensor nodes and displays them simultaneously on a fifty-screen tiled display system. A portable version that emulates the tiled screens in a reduced size will be shown at the conference.

1. Introduction

Wireless sensor networks to date have focused on applications that require only occasional, very low-bandwidth communication. This assumption is necessary in order to support the relatively high overhead incurred by the network protocol, the limited battery life, and dense deployment. Unfortunately, many real-world applications do not match these assumptions; instead, the end-users want the wireless sensor system to collect uninterpreted, raw data, which the application experts would then process. The data streams would also require much higher bandwidth, on the order of 500 samples per second per node. The deployment

density may be as high as 50 to 100 nodes in one cubic meter area. For instance, in a hospital setting, an EEG or an ECG system can easily require 5 to 10 nodes each. It is not uncommon for other vital sign monitors to also be attached on a patient, and several patients may be sharing a room.

In this and many other similar applications, existing solutions to wireless sensing would fail to work effectively. In fact, Bluetooth (over 802.15.1) and ZigBee or another custom layer on top of the 802.15.4 MAC have been previously considered and tested for such purposes. It has been shown that Bluetooth is more robust to interference by frequency hopping while 802.15.4 with its CSMA MAC is efficient when communication is sporadic. Unfortunately, neither is very scalable without high cost. Bluetooth's master node in a piconet can have up to 7 active slave nodes and must go to a scatternet structure to handle more nodes. 802.15.4's CSMA MAC will suffer from high packet collision rate in high rate, dense area applications [6]. Although hybrid TDMA/CSMA schemes have been proposed, the time synchronization complexity can be high and have mostly been limited to simulations.

To address these problems, we propose EcoDAQ, which is a densely distributed wireless sensing system that supports 50–100 simultaneous streams of wireless data at 500 samples per second, all sharing one frequency channel. This system has the property of intra-network collision freedom and is of low complexity, requiring very small code and RAM sizes. The low resource demand of our protocol makes it not only widely applicable to existing platforms but also makes it possible to build ultra-compact, ultra-wearable, and ultra-low-power systems. The lower cost of our scheme also makes it economically scalable to much larger sensor networks.

2. System Overview

The whole system is based on pulling mechanism. There is a light weight script server inside each sensor. The sensor will transmit sensing data if it gets a request command from the host. This means the wireless bus arbitration is done by the host. Therefore, the code size for MAC layer inside sensors can be reduced largely.

There will be a base station between the host and these sensors to bridge packets between wired Fast Ethernet interface and wireless interface. Figure 1. shows the structure overview of the system.

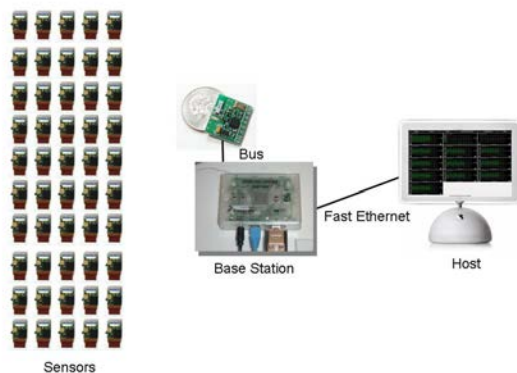


Figure 1. Eco DAQ System Structure

3. Hardware Platform

Our platform consists of the following:

- Sensor: Eco[5, 1], an ultra-compact, all-in-one sensor node. It contains 4KB RAM and 4KB EEPROM. It also comes with a three-axis accelerometer sensor with a temperature sensor, and an IR light sensor. Its radio is based on the Nordic nRF2401A transceiver.
- Ethernet Base Station: We built this by connecting the Freescale DEMO9SNE64 evaluation board [2] with a Nodic nRF24L01[3] transceiver module via SPI bus. The Nordic nRF24L01 transceiver is compatible with the nRF2401A on Eco at 1Mbps.
- Host: It can be either the front-end computer for HIPerWall or a conventional computer that emulates the interface to HIPerWall. The software is written in Python [4], a dynamic object-oriented scripting language.

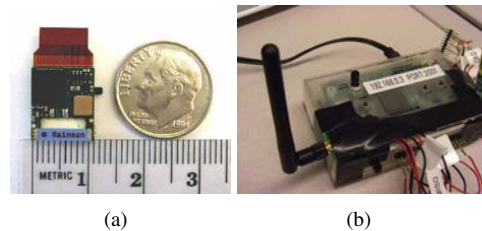


Figure 2. Eco Net System Platform Components. (a) Eco wireless sensor node (c) Freescale DEMO9SNE64 evaluation board with Noridc nRF24I01 Transceiver

4. Demo Deployment

Our proposed demo will show a system with 50 active Eco sensors transmitting at the same time without collision. The host will keep pulling data from the 50 nodes. Figure 3 shows the dense sensor deployment on a poster board in a 1 square-meter area, followed by the screen shot on the host.

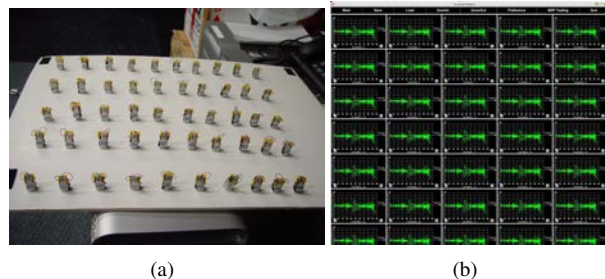


Figure 3. Eco deployment and GUI (a) 50 Ecos within an area of around one square meter (b) Python monitor stati 75n the host

References

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