Web-based Real Environment Monitoring Using Wireless Sensor Networks

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Abstract - *Ubiquitous computing is one of the key technology areas in the "Project on Development of Ubiquitous computing and network technology" promoted by the Ministry of Science and Technology as a frontier business of the 21st century in Korea, which is based on the new concept merging physical space and computer-based cyber space. With recent advances in Micro Electro Mechanical System (MEMS) technology, low cost and low-power consumption wireless micro sensor nodes have been available. Using these smart sensor nodes, there are many activities to monitor real world, for example, habitat monitoring, earthquake monitoring and so on. In this paper, we introduce web-based real environment monitoring system incorporating wireless sensor nodes. It collects sensing data produced by some wireless sensor nodes and stores them into a database system to analyze. Our environment monitoring system is composed of a networked camera and environmental sensor nodes, which are called Mica2 and developed by University of California at Berkeley. We have modified and ported network protocols over TinyOS and developed a monitoring application program using the MTS310 and MTS420 sensors that are able to observe temperature, relative humidity, light and accelerator. The sensed data can be accessed user-friendly because our environment monitoring system supports web-based user interface. Moreover, in this system, we can setup threshold values so the system supports a function to inform some anomalous events to administrators. Especially, the system shows two useful pre-processed data as a kind of practical uses: a discomfort index and a septicity index. To make both index values, the system restores related data from the database system and calculates them according to each equation relatively. We can do enormous works using wireless sensor technologies, but just environment monitoring. In this paper, we show just one of the plentiful applications using sensor technologies.*

Keywords: Wireless sensor networks, environment monitoring, TinyOS, motes

1 Introduction

Ubiquitous computing is one of the key technology areas in the "Project on Development of Ubiquitous computing and network technology" promoted by the Ministry of Science and Technology as a frontier business of the 21st century in Korea, which is based on the new concept merging physical space and computer-based cyber space. With recent advances in Micro Electro Mechanical System (MEMS) technology, low cost and low-power consumption wireless micro sensor nodes have been available. Using these smart sensor nodes, there are many activities to monitor real world, for example, habitat monitoring, earthquake monitoring and so on [1]. In this paper, we introduce web-based real environment monitoring system incorporating wireless sensor nodes. It collects sensing data produced by some wireless sensor nodes and stores them into a database system to analyze. Our environment monitoring system is composed of a networked camera and environmental sensor nodes, which are called Mica2 and developed by University of California at Berkeley. We have modified and ported network protocols over TinyOS and developed a monitoring application program using the MTS310 and MTS420 sensors that are able to observe temperature, relative humidity, light and accelerator. The sensed data can be accessed user-friendly because our environment monitoring system supports web-based user interface. Moreover, in this system, we can setup threshold values so the system supports a function to inform some anomalous events to administrators. Especially, the system shows two useful pre-processed data as a kind of practical uses: a discomfort index and a septicity index. To make both index values, the system restores related data from the database system and calculates them according to each equation relatively. We can do enormous works using wireless sensor technologies, but just environment monitoring.

This paper is organized as follows. In Section 2, we explain the Mote systems. In Section 3, we introduce our web-based environmental monitoring system for ubiquitous sensor networks. Finally, we conclude this paper with some future works in Section 4.

2 The Mote

2.1 Hardware

The Motes are simple, robust, and are designed to be built from readily available components. The basic structure of the original Mote baseboard (the "Rene") consists of an Atmel AT90LS2343-4SC microcontroller and the RFMonolithics TR1000 amplitude modulation 916.5 MHZ Hybrid ASH Transceiver. The devices were fitted with a Microchip Tech Inc. AT90LS2343-4SC IC serial EEPROM to act as non-volatile flash memory. The Rene boards were powered by two AA-sized alkaline batteries and did not have any on-board power control circuitry. The most common antenna was a 90 mm long copper wire. Some of the later Crossbow-packaged devices used a stubby 80 mm whip. At the time there was little direct optimization of hardware variables such as antenna design, micro-controller choice, or memory type. For instance, the Atmel micro-controller was chosen over the StrongArm and TI MSP430 because there was a gcc compiler available through Gnu [2].

Moreover, Crossbow offers a variety of sensor boards for the Mote such as MTS series. The MTS300CA is a flexible sensor board with a variety of sensing modalities. These modalities include Light, Temperature, Acoustic, and Sounder. The MTS310CA is a flexible sensor board with a variety of sensing modalities as like as MTS300CA. It supports 2-Axis Accelerometer, 2-Axis Magnetometer, Light, Temperature, Acoustic, and Sounder. Developed in conjunction with UC Berkeley and Intel Research Labs, the MTS400CA and MTS420CA are two new additions to Crossbow's expanding family of low-cost sensor boards. These boards offer five basic environmental sensing parameters and an optional GPS module (MTS420CA). The MTS400CA and MTS420CA sensor boards utilize the latest generation of IC-based surface mount sensors. Theses energy-efficient digital devices in turn provide extended battery life and performance wherever low maintenance field-deployed sensor nodes are required. These versatile sensor boards are intended for a wide variety of applications ranging from a simple wireless weather station to a full mesh network of environmental monitoring nodes. Applicable industries include Agricultural Industrial, Forestry, HVAC, and more.

Table 1 shows some boards of MTS sensor series and their functions [3].

Table 1. Sensor and data acquisition boards

Sensor Board Name	Sensor and Functions									
	Accelerometer	Barometer	Buzzer	GPS	Light	Microphone	Magnetometer	Photo-sensitive Light	Rel. Humidity & Temperature	Thermistor
MTS300			O		O	O				O
MTS310	O		O		O	O	O			O
MTS400	O	O						O	O	
MTS420	O	O		O				O	O	

2.2 TinyOS

A key innovative capability of the Mote is its pervasive support of fluid software, i.e., 1) it has the ability of processing, storage and data management functionality; 2) it can arbitrarily and automatically distribute itself among information devices and along paths through scalable computing platforms integrated with network infrastructure; 3) it can compose itself from preexisting hardware and software components; 4) it can satisfy its needs for services while advertising the services it can provide to others; 5) it can negotiate interfaces with service providers while adapting its own interfaces to meet components it serves. Recent progress in this area is the development of TinyOS, an embedded operating system for Motes. TinyOS migrates the event-based model being developed for clusters into a very light-weight form for Motes.

The heart of TinyOS, communications, must be able to scale to thousands or millions of nodes within a single network and be flexible to dynamic topology changes. It must also be tolerant of failures due to lossy links or failed nodes and support concurrency-intensive operations required by networked sensors with minimal hardware requirements. TinyOS implements the Active Messages model with intra- and inter-device connectivity to meet these requirements – Motes automatically detect the "best" routing topology and propagate all data to collection points. The TinyOS group has currently demonstrated the ability to deploy a self-configuring network of devices, but this work needs to be extended to support larger collections of devices. This will be done by improving networking protocols and by reducing the total amount of data being communicated back to a central location through automatic data aggregation inside the networks.

Because the Motes will be widely distributed, system power consumption must be limited, and software can play a major role in controlling the efficient use of the various hardware resources. This is particularly important in the case of the power-hungry radio components. Thus, future revisions of the software will focus on reducing power consumption as a primary goal while improving current levels of functionality.

3 Monitoring System

3.1 System Overview

Ubiquitous sensor networking (USN) is one of the key technology areas in the ubiquitous computing. Especially, University of California at Berkley is one of the advanced and they have very enthusiastically studied both sensor hardware technology and senor applications. In the research on the ubiquitous sensor networking (USN), we investigate the technologies of system integration and extension of USN and research on the technologies of real-time application monitoring throughout remote ubiquitous sensor networks. Then we construct web-based real-time environment monitoring system using our sensor network technologies.

For constructing web-based environment monitoring system, we use some facilities for sensor networks such as Mote MTS310CA, MTS420CA, the Stargate and PTZ network camera. The Stargate is a high performance-processing platform designed for sensor, signal processing, control, and wireless sensor networking applications. It is based on Intel's Xscale® processor, and it is the same processor found in today's most powerful handheld computers including the Compaq IPAQ® and the Dell Axim®.

Figure 1 represents the network model for our monitoring system.

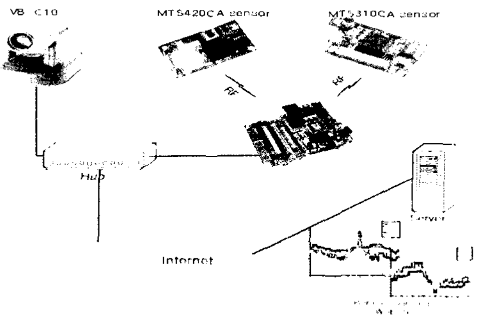

Figure 1. Network model for our monitoring system

3.2 The Functions of the system

Our monitoring system consists of two MTS310CA sensor boards, one MTS420CA sensor boards and one PTZ network camera. Throughout the system, we can acquire such information as Light, Temperature, Humidity, and Voltage until now. All of information is represented by graph. This information is equal to each menu of the system. Each menu has four sub menus; present, daily, weekly, and monthly. As we know from the name of each sub menu, each menu shows average value of ten minutes, a day, a week, and a month respectively. Moreover, users can look all over the monitoring area because they can control the network camera of the system.

It is our final goal of USN research to connect the result of our research to real application area such as weather prediction system. As the first step, in this year, we construct web-based environment monitoring system. It collects sensing data and stores them into the database system to use for some application. Figure 2 shows a database table for MTS310CA sensor boards and Figure 3 shows a sample data of MTS310CA.

Field	Type	Null	Key	Default	Extra
group_id	tinyint(3) unsigned			0	
board_id	tinyint(3) unsigned			0	
packet_id	tinyint(3) unsigned			0	
node_id	tinyint(3) unsigned			0	
parent	tinyint(3) unsigned			0	
voltage	smallint(5) unsigned			0	
temp	float			0	
light	smallint(5) unsigned			0	
mic	smallint(5) unsigned			0	
accel_x	float			0	
accel_y	float			0	
mag_x	float			0	
mag_y	float			0	
time	datetime			0000-00-00 00:00:00	
etc	char(20)				

Figure 2. Data table of MTS310CA sensor board

group_id	board_id	packet_id	node_id	parent	voltage	temp	light	mic	accel_x	accel_y	mag_x	mag_y	time	etc
125	132	1	1	0	2519	30	2434	455	40	380	23.17	23.17	2005-03-14 17:47:[illegible]	
125	132	1	1	0	2514	30	2430	454	40	340	23.17	23.17	2005-03-14 17:47:[illegible]	
125	132	1	1	0	2513	30	2432	457	20	380	23.17	23.17	2005-03-14 17:47:[illegible]	
125	132	1	1	0	2514	30	2430	452	40	380	23.17	23.17	2005-03-14 17:47:[illegible]	
125	132	1	1	0	2519	30	2434	452	20	380	23.17	23.17	2005-03-14 17:47:53	
125	132	1	1	0	2514	30	2430	424	20	380	23.17	23.17	2005-03-14 17:47:5[illegible]	
125	132	1	1	0	2519	30	2434	453	20	380	23.17	23.17	2005-03-14 17:47:55	
125	132	1	1	0	2519	30	2434	497	40	380	23.17	23.17	2005-03-14 17:47:57	
125	132	1	1	0	2519	30	2434	512	40	340	23.17	23.17	2005-03-14 17:47:[illegible]	

Figure 3. Sample data of MTS310CA sensor board

Our monitoring system supports two simple applications; the discomfort index (*DI*) and a septicity index (*Del*).

Equations for *DI* and *Del* are followed [4].

$$DI=9/5*Ta-0.55(1-RH)\ (9/5Ta-26)+32.$$

$$Del = \{(H-65)/14\} * (1.054)^{t}.$$

where *Ta* is temperature, *RH* is humidity, *H* represents average humidity a day, and *t* is average temperature a day.

In addition, the monitoring system has alarm function that notifies administrator of anomaly events. For example, user can set up threshold value of temperature as 35 °C. When temperature is greater than threshold value, the system sends e-mail to the user.

We set up our system at the real environment, the pond of KAIST. Figure 4 shows overall deployment.

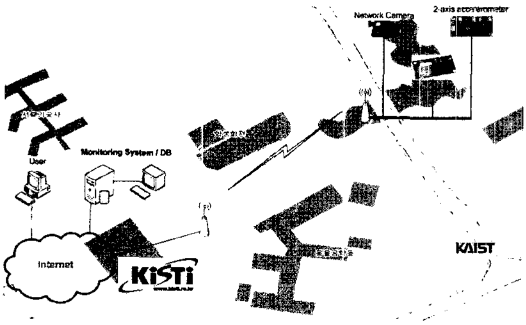

Figure 4. Deployment of our monitoring system in real environment

4 Conclusions

Our environmental monitoring system is composed of two MTS310CA sensor boards, one MTS420CA sensor boards and one PTZ network camera. The monitoring system is user friendly because it is web-based system. Our system saves all sensing data but until now, it supports Light, Temperature, Humidity, and Voltage. In addition, users can set up threshold value, then they get alarm message in case of anomaly events.

The USN technology can be applied to many application areas. For example, technology for sensor networking in ubiquitous environment can use our USN methods and application engineers can develop the infrastructure for various next-generation ubiquitous environment and application using our results. It is our final goal that USN technology can activate Sensor Grid, which collects distributed information through sensor nodes and processes it using wired and wireless grid resources.

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