Implementation of Wireless Sensor System and Interface for Agricultural Use

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Abstract. Problems involving agricultural know-how can be addressed with the use of IT. For example, IT can reduce the risk that know-how may be lost due to the increasing age of agricultural workers. Also valuable fruits which require sensitive environmental control can be monitored with IT. Data collection, collation and storage will enable us to convert tacit knowledge into formalized algorithms. We made a remote information sensing system using a sensor board made in cooperation with Renesas Solutions Corporation. Furthermore, we had installed our sensing system in a melon hothouse, in cooperation with the Prefectural Research Institute. We set up an interface enabling access to data and photographs using a browser. Using this interface, we expect that farmers will be able to transfer tacit knowledge into formalized information.

Keywords: Wireless sensor network, Remote sensing, Agricultural sensor system, User interface.

1 Introduction

The agricultural demographic is changing; the median age of farmers increases while their numbers diminish. Precious agricultural know-how is in danger of being lost [1]. Moreover, cash crops, like hot-house melons (used in the present project) command prices upwards of $200 per fruit. It is important to maintain constant conditions in order to produce a uniformly high quality product. IT has potential for solving both of these problems. The painstaking procedure of drawing out the tacit knowledge of expert farmers can be facilitated with a data gathering protocol utilizing sensors, sensor board, and computer interface, enabling the system to collate and store a variety of searchable data [2]. This will enable us, on the one hand, to gather the expert knowledge of aging farmers for preservation and dissemination. The information can be utilized by anyone. Also we can facilitate the consistent control of the delicate environment with sensors monitoring such factors as temperature, atmospheric moisture, ground moisture, and light and so ensure a reliably high grade of produce.

J.D. Velásquez et al. (Eds.): KES 2009, Part II, LNAI 5712, pp. 572–579, 2009.

We developed a remote information sensing system using a sensor board made in cooperation with Renesas Solutions Corporation [3]. Sensor networks are critical tools for measuring and understanding the complex interactive dynamics of natural systems [4], and help promote new ways of agricultural management [5]. The cost of sensor technology is expected to fall in the near future while utility of IT will continue to develop for various agricultural applications [6][7]. We are developing the protocol for initiating the process of accumulating the massive store of information required to make agricultural knowledge available to everyone.

2 Remote Sensing System

2.1 Our Sensor Boards

This research concerns the construction of a sensor network utilizing a ZigBee node produced by Renesas Solutions Corporation. The Renesas node is used with a second board to make our sensor system. The first is the battery operated Renesas sensor board in Fig. 1 with three kinds of sensors: motion, temperature, and light. It can be operated either with 4 AAA batteries or an AC adaptor. This board is able to collect sensor values. This board, used as the sensor node, is the topic of this paper.

The other board is a ZigBee evaluation board shown in Fig. 2. It has no sensors and batteries, and therefore a power supply cable is required. This board is equipped with RS-232C interface which can be connected with a PC. The board can be used in three ways, one board each: the first as a ZigBee router, the second as a coordinator and the third as a sink node.

2.2 Basic Topology

The basic topology of the system consisting of these boards is shown in Fig. 3. The network topology shows the structure of the procedure. Each sensor is connected to the ZigBee router. The router channels the data from the sensors to the sink node. The sensors must be placed within the transmission range of the router. If the router is placed within the range of a sequential router, it is possible to transmit multi-hop data. Thus a continuous flow of data is sent to the sink node.

Fig. 1. Sensor board

Fig. 2. ZigBee evaluation board

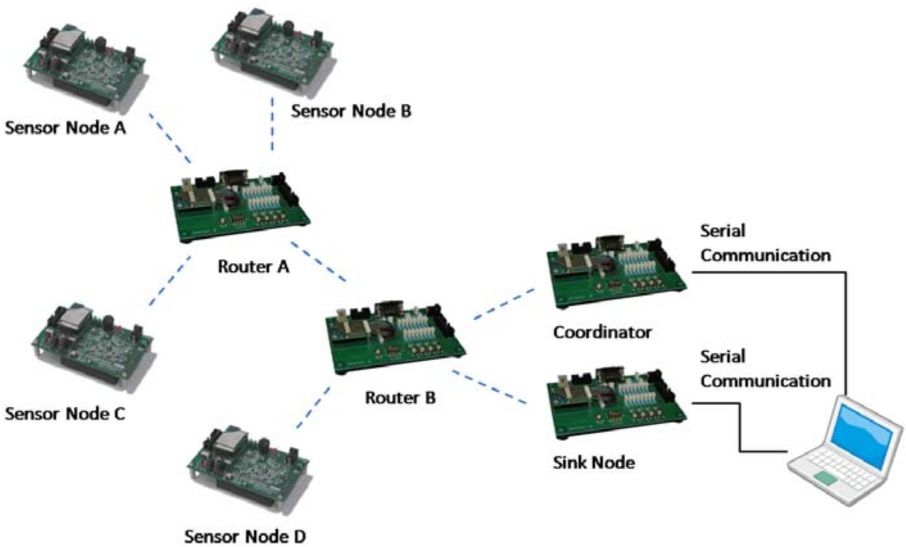

Fig. 3. Basic topology of sensing system

2.3 Sensing Data Gathering

The data received by the RS-232C serial port is then transferred to the PC. The information is then recorded in the data base (Fig. 4). The data received by serial communication is recorded in the Gateway HDD in a temporary file. Data is accumulated and transferred as a transaction at regular intervals to the PostgreSQL server in our laboratory. Because of the volume of the continual stream of data received from the sensors, once a day the program compiles the incoming data packets in searchable tables formatted with time, ID, and sensor readings categories.

2.4 Camera Data Gathering

Moreover, in response to the client user's request for more detailed visual information concerning data received from the sensors, photographic information is also recorded. A separate ZigBee network gathers photographs from network

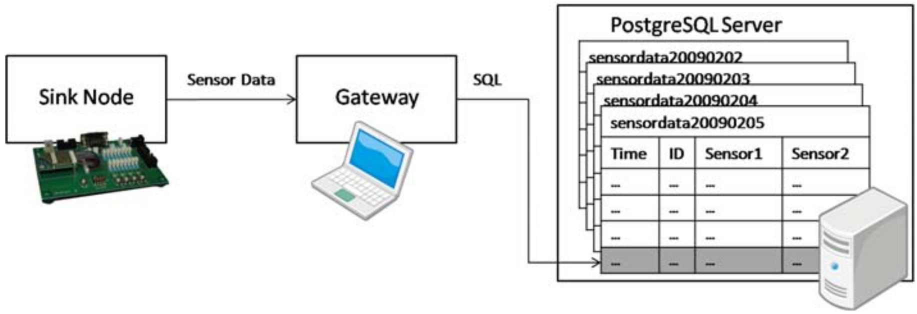

Fig. 4. Block diagram of sensor data gathering

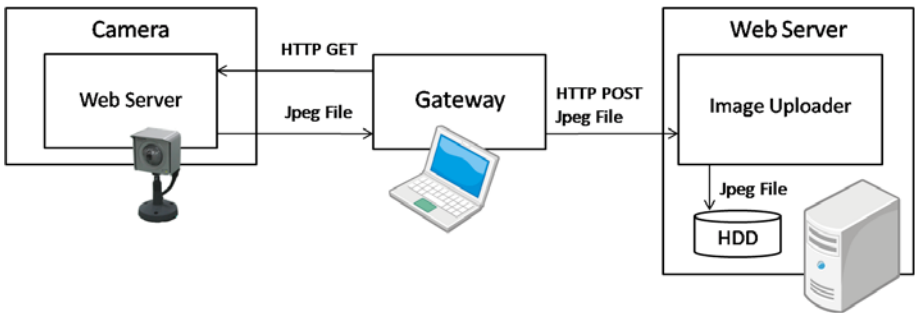

Fig. 5. Brock diagram of camera data

cameras at 15 minute intervals and transfers them by LAN using HTTP protocol to a designated server (Fig. 5).

The routing is arranged as follows: The network camera is equipped with a Web server. The Gateway accesses the network camera using HTTP protocol and receives the Jpeg files which it then relays by HTTP post to the server where a PHP program for image uploading transfers the Jpeg to the designated HDD for graphic images. The separately maintained data from the sensors and the photographic images can be collated later for viewing. It is beneficial to monitor the atmospheric conditions of the hothouse which affect the produce (i.e. melons) by having a sensor system to monitor variables such as temperature, moisture, and light and collate them for later analysis.

3 Report of Melon House Experiment

We prepared the above described system of sensors, cameras, and servers for an experiment in remote sensing we placed the system in the melon hothouse, and connected it with the sensor node inside the building (Fig. 6). We placed the Sink Node and Gateway in a separate unmanned observation room 15 meters from the hothouse.

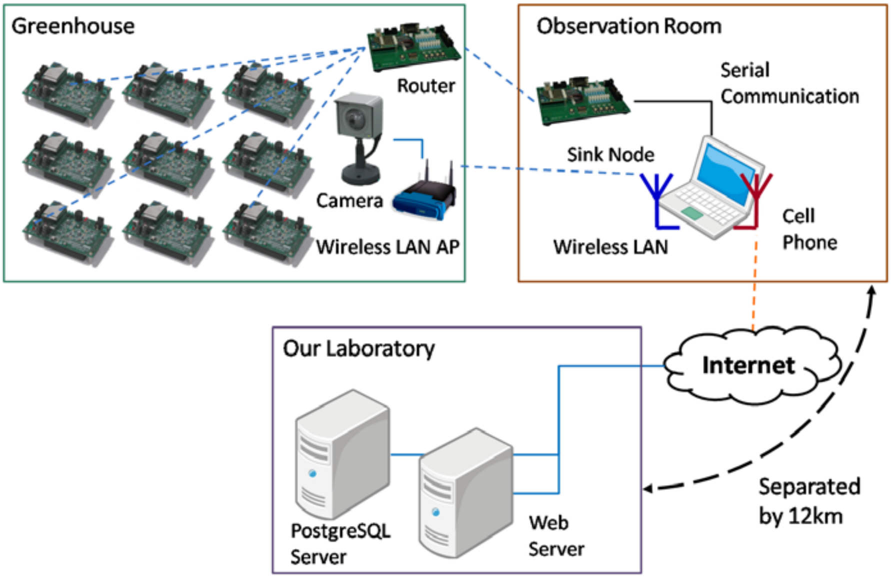

Fig. 6. Sensing system set in hothouse and observation room

In the melon house we placed the router in position so as to gather the information from all the nodes. Information is communicated by ZigBee between sensor node and sink node as described above. Because the camera is equipped with LAN cable we connected it to a wireless LAN access point inside the hothouse which transmitted data to the observation room. We made provisional use of cell phone to provide the internet access for the Gateway PC. We used this system to transfer the data from sensors and the photographic images from the network cameras to the laboratory.

3.1 Interface

We made an interface to put the information thus gathered by sensors and cameras into a readable format. It is possible to access this interface from a Web browser (Fig. 7). Sensor information during a day is displayed in this figure. The photograph is displayed in upper part of the page, and values of the light, motion, temperature, and voltage of equipped batteries have been graphed. At the time of accessing the interface to view selected records, the user inputs the ID for the selected sensor, a start and finish term and the number of records required, distributed evenly in the time period.

Because of the huge volume of information from the sensors, when all the information is downloaded, the infrastructure between the Web server and the PostgreSQL server is overloaded. As a solution for this problem, we implemented the function inside the PostgreSQL server to request the required amount of data (Fig. 8). The ID, term, and number of records of the desired data is transmitted

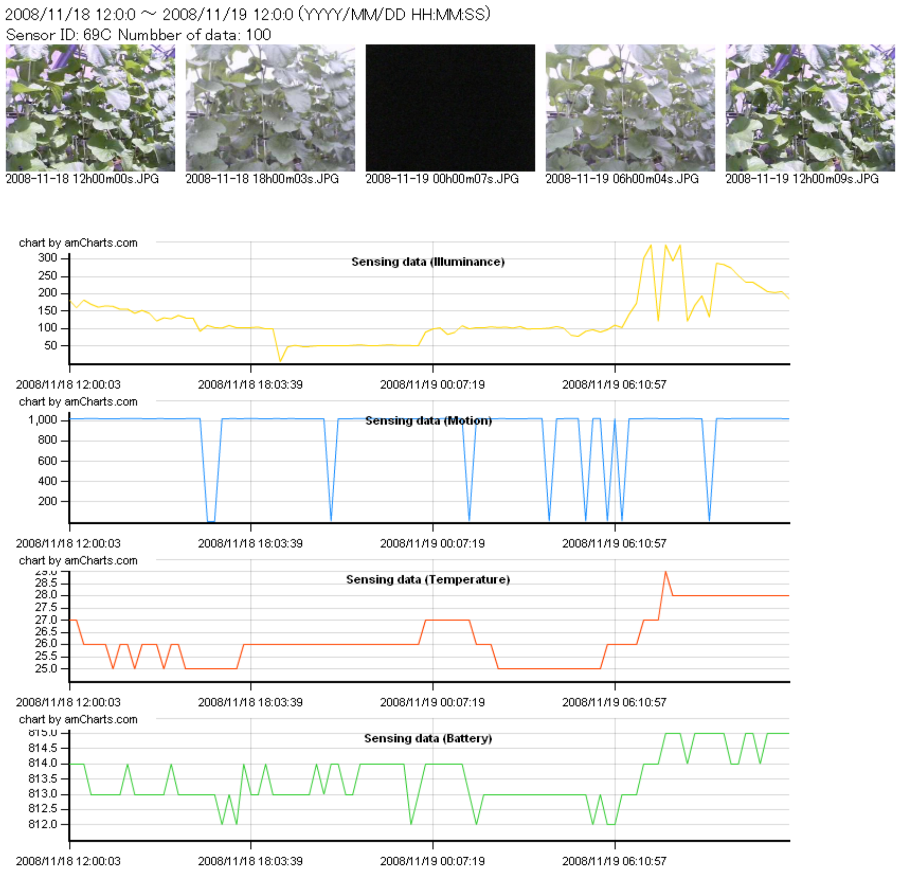

Fig. 7. Physical appearance of Web Interface

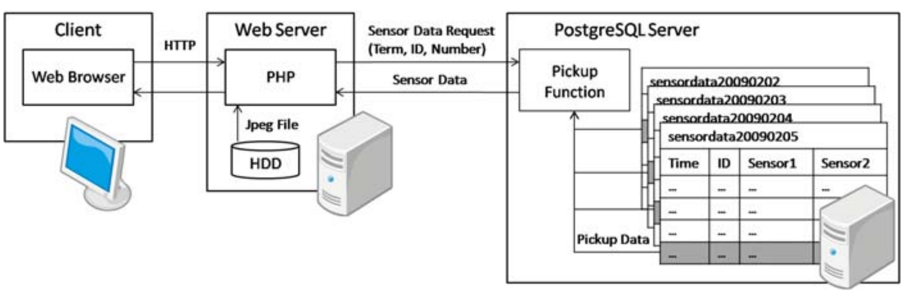

Fig. 8. Web interface block diagram

to the PostgreSQL server from the Web server PHP. The selection function, using a simple algorithm, gathers the requested information from the tables on the PostgreSQL database according to timestamp and sends them back to the PHP. The PHP makes an XML file from the PostgreSQL data and reads it with a graphic program. Then the PHP gets the saved Jpeg photographs on the HDD for the required period and sends them together to the client's browser.

4 Results

We conducted this experiment for 10 days 24 hours per day, and were able to successfully retrieve requested information. We tested the system by requesting reports from the laboratory. We monitored the equipment 8 times a day for proper functioning from the laboratory. System failure occurred only once. The cell phone connection failed and needed to be reconnected. We tested data sampling protocol (sensor ID, term, number of records) everyday. It was largely successful but the problems related to the cell phone must be resolved, whether by compressing data or replacing the cell phone with some other broadcast equipment. This research is still in progress and our goal here is to report the purpose and structure of the system.

5 Summary

In this paper, we have reported the experiment we conducted for a melon hot house with a remote sensing system that we constructed using a Renesas board, plus sensors, cameras, and servers. We expect that hereafter agricultural engineers will refine this system utilizing sensors for light, temperature, ground and air moisture, as well as potentially unlimited other factors. Access to sensor information will promote more reliable results. The reliable results will inspire the trust of the agricultural workers in the relationship between the information provided by sensors and the produce. When they understand the relevance of IT to their livelihood, agricultural producers will work to formalize their tacit knowledge. It is thought that by using formalized knowledge, agricultural best-practice can be widely disseminated. This will be a contribution to agricultural development.

Acknowledgments. This research was partially supported by the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Young Scientists (A), 21680007, 2009.

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