Position Papers of the 2013 Federated Conference on
Computer Science and Information Systems pp. 75–78

Wireless Sensor Based Monitoring and Content Management System for Agricultural Application

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Abstract—**This paper presents a Zigbee-based wireless sensor network system with an integrated hardware implementation and content management function for web-based monitoring in a greenhouse environment. The Zigbee is based on the TI CC2530 System on Chip and composed of key sensors such as a temperature, relative humidity and light intensity sensors. The content management system is based on open source software Joomla. The system provides the semi-real time monitoring of the environmental parameters with an epoch time of five minutes. In addition, it also provides a monitoring graph and the mean value of the parameter being measure with its High and Low value for a particular day monitoring. The proposed system has been implemented and tested in Dai-Yun Organic Farm in Taiwan that cultivate vegetable crops, the system performance showed the potential applications for precision agriculture and other fields.**

I. Introduction

AGRICULTURE is considered one of the most important sources of income and food production worldwide. Agricultural activities are affected by environmental factors such as ambient and surface temperature, relative humidity and light intensity; in turn, these factors have significant impact in the production and quality of agricultural crops. Therefore, it is important to monitor environmental parameters and make effective use of the resources through the design and implementation of a greenhouse monitoring systems.

Greenhouse production systems have become the alternative production practice to satisfy the consumer demand of healthier, safer and higher quality produce in a year-round manner, while implementing environmentally friendly methods that make efficient use of resources such as land, water, labor, capital and energy. However, they are highly dependent on energy, skilled labor, effective management and increased knowledge of growing specific crops [1], [2]. The main purpose of such systems is to produce a high quality produce at high production rates, consistently, in an economic, efficient and environmentally sound manner. To achieve this level of productivity, accurate monitoring and control of several aspects of the crop including plant health, growth rate, development and plant growth-mode, must be implemented during the production cycle.

In terms of network technology, many studies consider the circuit implementation of the Zigbee technology, the technology of choice for wireless sensor network due to its low-power consumption requirement, flexible network scale and cost effective design specifications. Reference [3] used CC2430 System on chip (SoC) based on Zigbee technology and integrates environmental sensors that monitor soil temperature, soil humidity, air temperature and relative humidity, ambient light, and carbon dioxide for greenhouse application. Reference [4] used wireless microcontroller JN5121 that implements a Zigbee compliant sensor node, and integrated SHT1x, TSL2550, M25P10 that measure temperature, relative humidity, and luminance respectively. Gathered data from a greenhouse unit were stored in a flash memory in sleep-mode and sent back to the coordinator after waking up. The use of Wi-Fi technology was also explored. However, the protocol usually utilized a PC-based system intended as a substitute for wired LAN with a rather high power consumption requirement for a wireless sensor node implementation [5], [6].

II. System Implementation

A. System Architecture

The greenhouse environmental monitoring system based on a wireless sensor network consists of the sensor nodes, the coordinator node, the remote computer, and the webserver. The sensor node consists of the environmental sensor such as the temperature, relative humidity and light intensity sensor that measures particular parameters inside the greenhouse. The coordinator node serves as the communication bridge between the remote computer and the wireless sensor nodes. It is also responsible in the creation of the Zigbee network that adds other nodes in the system.

The data from the sensor nodes are stored in the remote computer database which is based on the MySQL platform and the system is being hosted in a remote webserver which consists of an Apache Webserver, MySQL database and PHP: Hypertext Preprocessor. The system block diagram is shown in fig. 1.

This work was supported by National Science Council, Taiwan for funding this project (NSC 102-2221-E-033-066)

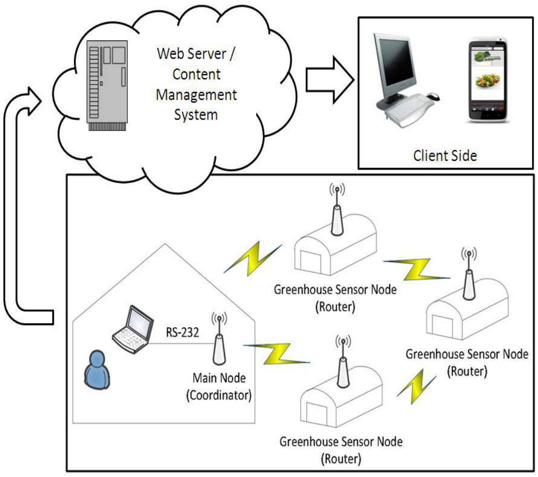

Fig. 1 System Block Diagram

In the webserver, a content management system (CMS) has been installed to manage the publishing, editing, and modifying content as well as maintenance from a central interface [7]. Joomla CMS platform has been installed in the webserver.

B. Wireless Sensor Node Components

The wireless sensor node shown in fig. 2 is composed of SHT10 digital humidity and temperature sensor, ISL29023 an integrated ambient and infrared light to digital converter, and the main core component TI CC2530, which is a true system-on-chip (SoC) solution for IEEE 802.15.4, Zigbee and RF4CE applications [8].

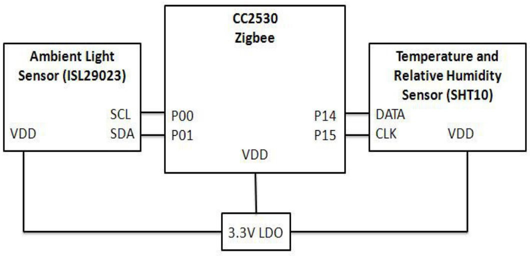

Fig. 2 Sensor Node Block Diagram

SHT10 is a temperature and relative humidity sensors manufactured by Sersirion[9], which measure temperature with a range from minus 55 to plus 125 degree Celsius, and measure relative humidity range from 0 to 100 percent. ISL29023 is an ambient light sensor manufactured by Intersil Company [10], which can measure illumination with range from 1 to 64000 lux. It can be controlled by CC2530 through I2C bus interface.

Coordinator node consists of CC2530 and PL2302. PL2303 is USB to UART transceiver. The coordinator node was used to create a Zigbee network, receive data from and send data to greenhouse sensor nodes, then forward to remote computer. The coordinator node also uses the sensor node PCB but instead of environmental sensor, the USB to UART transceiver has been integrated to serve as a link between the remote computer and the WSN.

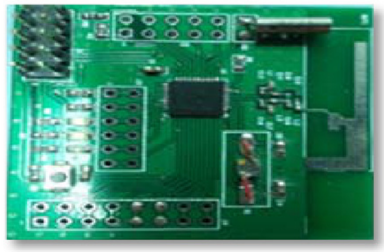

Fig. 3 Actual PCB of the Sensor Node

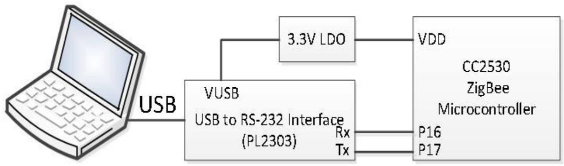

Fig. 4 Coordinator Node Block Diagram

C. Monitoring System Application

The desktop monitoring system application shown in fig. 5, running in the remote computer gets the data coming from the sensor node via the coordinator node and the serial RS-232 interface connected to the computer. It is also responsible in storing of data in the database server. The application program is made from Visual Basic Express 2010.

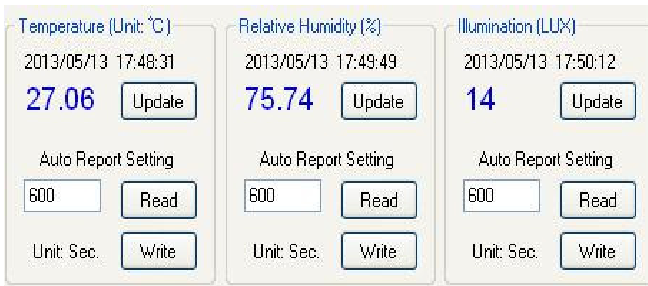

Fig. 5 Monitoring System Application Controls

The application controls in fig. 5 shows that the epoch time for the sensor node can be adjusted through the auto report setting controls. The read button check the current epoch time, or check whether the set reporting has been successfully updated in the sensor node. The write button updates the epoch time embedded in the sensor node.

D. Content Management and Monitoring System

The content management system shown in fig. 1 is based on the Joomla CMS platform. It consist of frontend showed in fig. 6, which is readily available for client machines or users of the website, and the backend showed in fig. 7, wherein the maintenance, publishing, editing and modifying of the website content has been made.

The Joomla CMS platform advantages are the ease-of-use, extensibility and most of all it is an open source solution that is freely available to everyone [11].With this regard, integration of the CMS platform became a vital component of the Wireless Sensor Network Monitoring System.

Internet connection is a requirement in accessing the website in a client machine. Internet disconnection does not in any way affect the WSN monitoring, because internet connection is not a requirement for WSN and the remote computer transmission of environmental data.

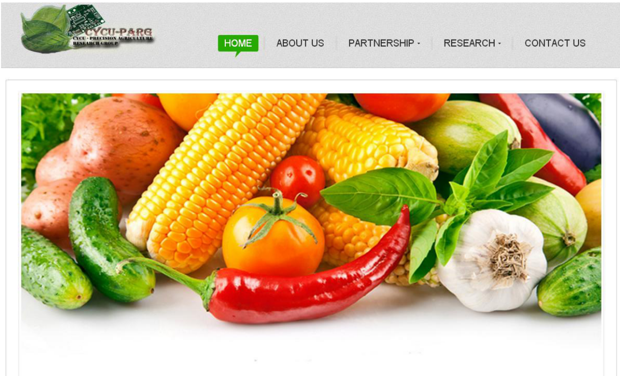

Fig. 6 Website Frontend

The website frontend page shown in fig. 6 provides a user browsing interface and the administrator backend shown in fig.7 offers the necessary tools and applications for the maintenance and editing of the website. The administrator can create users that are authorized to manipulate and maintain the website. The administrator can decide which article or section that a particular group of user can access in the website. The monitoring section of the system can be viewed solely by specific user or it can be made public.

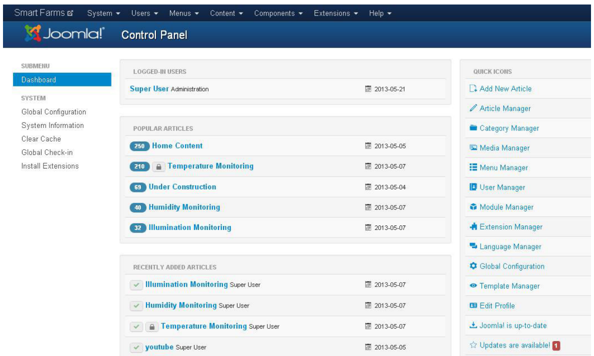

Fig. 7 Administrator Backend

The environmental data stored in the database was used to present in the content management system report in a form of a graph. Also, the mean, high and low measured value for the current day monitoring was computed and included in the report. Stored data in the database was retrieved using SQL command. Fig. 8-10 shows the environmental parameters being monitored.

The data from the WSN has been presented in the CMS platform, fig.8 shows the temperature monitoring with time interval for each data of five minutes.

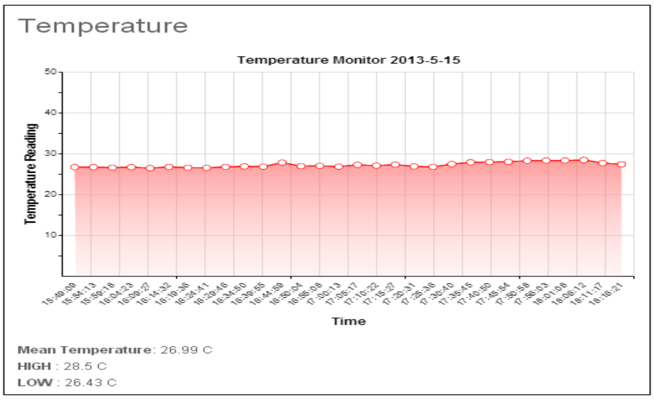

Fig. 8 Temperature Monitoring

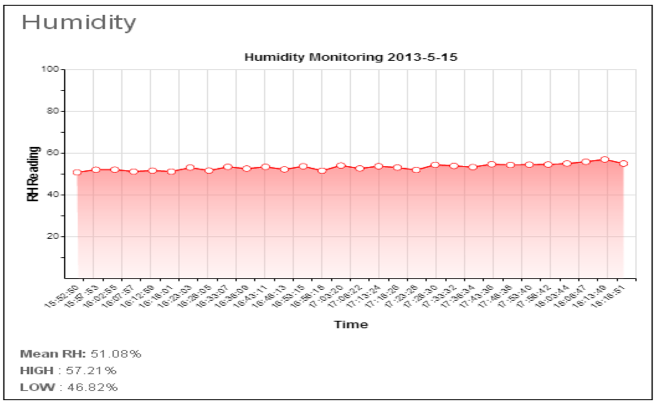

Fig. 9 Humidity Monitoring

The graphs demonstrated in fig. 8-10 show the last thirty reading for the particular environmental parameter. The Mean, High, and Low measured value was based on the current running data sent in the database and it is not just been based on the last thirty reading.

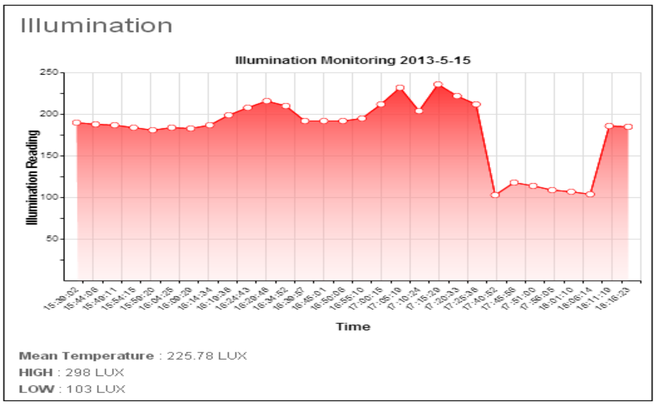

Fig. 10 Light Intensity Monitoring

E. Dai-Yun Organic Farm

Dai-Yun Organic farm is at the junction of Longtan and Guanxi, Taiwan (R.O.C.) which has an altitude about 250 meters. It had been verified and certified by Taiwan's organic production association in June 03, 2008. Currently, farm cultivating area is 8.8 hectares, (1.6 hectares for greenhouse, 7.2 hectares for open field). There are approximately 100 types of crops cultivated each year. Approximately 2000 bags is being harvest per day. Dai-Yun Organic Farm target market are organic shops, organic supermarket and fine dining restaurants. There are approximately 150 locations in the province selling their products.

Dai-Yun Farm provides high quality and high throughput of vegetable crops annually; with this regard Dai-Yun accumulates vital information in the field of organic farming and the WSN plays a vital role in the monitoring, storage and analysis of the data from the greenhouse farm. The main goal is the repeatability of the process wherein high quality and high yield in the farm will be maintain or can be optimized. Results and finding will be made available through the content management system, and farmers, students, and researchers can be benefited in information that we can provide.

Fig. 11 Dai-Yun Organic Farm

III. Future work

The wireless sensor network is composed of three sensors which are the temperature, relative humidity and light intensity sensors. We are in the process of integrating other sensors; carbon dioxide, soil moisture and pH sensors. Soil Moisture sensor will be integrated in the system for irrigation scheduling purposes, while the pH sensor will be used in determining the alkalinity and acidity of the irrigation water; various crops have different pH of water or soil requirement. Carbon dioxide sensor is one of the important factors that affect plant growth, monitoring of the carbon dioxide will be vital information in the Dai-Yun organic farm.

Advancement in the field of smartphone and cloud computing technologies paves a way for a new approach of providing information and services. With this regard, we are taking into consideration of integrating smartphone application that will maximize the capability of our Environmental Monitoring System, and offer cloud computing services.

The Content Management System can be extended not only in the greenhouse environmental monitoring but we can also extend its capability in developing “Smart Home” Monitoring and automation.

Acknowledgment

This work would like to extend its gratitude to Chip Implementation Center (CIC) for the technical support given.

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