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Design of Environmental Parameters Monitoring System for Watermelon Seedlings Based on Wireless Sensor Networks

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Abstract: Nowadays, farmers mainly adopt watermelon grafting technology to avoid wilt with the survival rate of grafted seedlings affected by temperature, humidity and light of the environment. Assurance of optimal environmental conditions has a direct influence on watermelon seedlings growth performance. At present, farmers usually observe the environmental temperature only through a thermometer, and manage the watermelon seedlings by experience in rural areas. Therefore, in order to solve the problem of poor accuracy and waste of labor, in this paper, we use the devices based on the wireless sensor network to real time monitor the parameters in the plastic greenhouse of watermelon nursery, including temperature, humidity and light. Then the environmental parameters will be sent to the monitoring system and be analyzed. If the values of parameters beyond the given threshold, the monitoring system will give a warn to the administrator to improve the environment, which, to some extent, ensures the survival rate and produces healthy watermelon seedlings consequently increasing farmer's income.

Keywords: watermelon seedlings, wireless sensor networks, monitoring system.

1 Introduction

Watermelon planting acreage is increasing along with the agricultural structure adjustment. In many areas, watermelon production has become a major industry to improve the income for the local farmers. However, wilt [1] is a very serious disease after watermelon planted. In case of wilt, the die rate reaches the percentage of 20 up to 30, while the worse situation is harvesting nothing. Watermelon wilt has become a major bottleneck in production. At present, grafting technology is commonly used in most parts of the country, which significantly reduces the loss caused by wilt. Grafted, seedlings have high resistance to disease, especially wilt, and have many other characteristics of strong plant roots, high yield, stable growth, good quality, and significantly increase [2].

However, how to manage grafted watermelon seedlings in order to ensure the high survival rate becomes another outstanding problem. The survival rate is closely related to the temperature, humidity, light intensity and other factors [3]. In rural areas, farmers mainly measure temperature through a thermometer hanging in the plastic greenhouse, which has the drawbacks of poor accuracy and waste labor for entering the canopy to read temperature. Moreover they usually manage the watermelon seedlings through years of experience. The case of temperature, humidity, light intensity and other factors inside the plastic greenhouse going beyond the given thresholds will lead to the death of watermelon seedlings. Unfortunately, farmers need grafting again, which may miss a good opportunity for seedling, and cause great loss to farmers.

Wireless sensor network is a new generation of sensor networks, which has very wide application prospect. Its development has great influence on human's life and production. Currently, wireless sensor network has shown its high advantage in fields of agriculture, industry, military, and building monitoring. Wireless sensor network is a collection of sensor nodes linked by a wireless medium to perform distributed sensing and acting tasks [4]. In order to guarantee the high survival rate of watermelon seedlings, this paper uses wireless sensor network to real-time monitor environmental parameters in plastic greenhouse, including temperature, humidity and light intensity.

If the monitored parameters by sensors exceed a preset value, the monitoring system will give a timely warn, which tells farmer or administrator to improve the environment of plastic greenhouse by using ventilation devices, heating to change the temperature and humidity, shading or providing artificial light to change internal radiation and CO2 injection to influence photosynthesis, and watering for humidity enrichment (a deeper study about the features of the environment control problem can be found in [5]) [6]. Changes in temperature, humidity, light, and other factors in plastic greenhouse conditions can have a profound effect on the productivity and quality of plant growth. In addition, by continuously monitoring numerous environmental variables at once, a grower is better able to understand how growth conditions are fluctuating, and react to those changes. So we can get the most suitable environmental parameters and cultivate healthy watermelon seedlings consequently increase yield and farmers' income.

2 System Architecture

The environmental monitoring devices of watermelon seedlings plastic greenhouse based on wireless sensor network include sensor node, base station, server and monitoring terminal PC and provides friendly interface for users, adopting B/S model. The sensor nodes within the plastic greenhouse collect environmental temperature, humidity and light intensity, and sent them out through the antenna of the RF module. Base station receives the data sent by sensor nodes, which is finally transmitted to the server by serial port, USB port or Ethernet port. In the PC, users can real-time monitor environmental parameters within the area. The system architecture diagram is show in Figure 2.1.

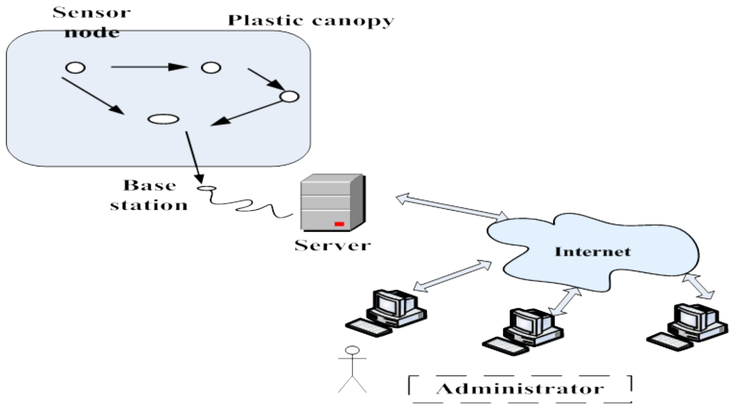

Figure 2.1: Wireless Sensor Network System Architecture

3 Hardware Structure of Monitoring Devices

3.1. *Sensor Node*

The environmental monitoring devices adopt MICAZ node produced by Crossbow Company [7]. The sensor boards are MTS400CA and MTS310 which are connected with A MICAZ node by 51-pin expansion connector.MTS400CA sensor board integrates light, temperature, humidity, barometric pressure and other sensors. MICAZ node uses the Chipcon CC2420, IEEE 802.15.4 compliant [8], ZigBee radio frequency transceiver integrated with an Atmega128L micro-controller.

3.2. *Base Station*

Base station is composed of gateway MIB520 and MICAZ node, and they are connected by 51-pin expansion Connector. Gateway MIB520 connects to server through USB port, which is used for communicating and programming online. The USB port is converted to two virtual serial ports in server. Gateway MIB520 has an on-board processor, and can run MICA processor /RF board. Due to the USB bus used, no external power supply is needed.

4 Software Structure of The Monitoring Devices

The monitoring device software is divided into three sections, namely the software on sensor node, middle layer software, and monitoring management software for users on server. System software architecture is shown in Figure 4.1.

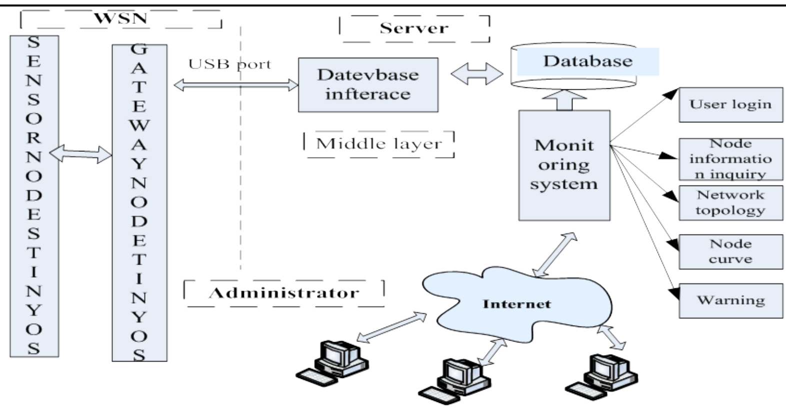

Figure 4.1: System Software Architecture

4.1. Software Running Sensor Node

The software used in sensor node is embedded operating system TinyOS [9] developed by the university of California at Berkeley. TinyOS is an open source and component operating system, using component description language nesC. TinyOS's hierarchical structure divides all the components into different layers according to certain criteria. The upper layer calls the commands from the bottom through constructing interface, and the bottom informs events through constructing interface [10]. The architecture of TinyOS from top to bottom is shown as Figure 4.2, which includes application layer, management layer and hardware abstraction layer [11].

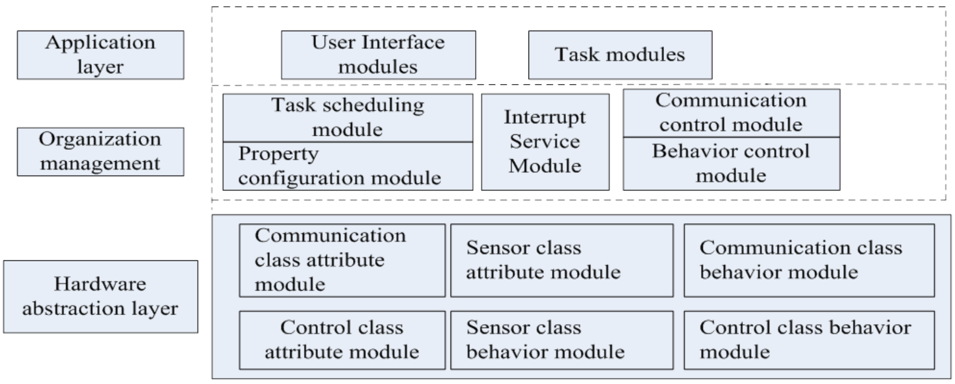

Figure 4.2: The Layer Structure of TinyOS

4.2. *The Middle Layer Software*

The middle layer software mainly establishes a unified interface to receive environmental parameters for the database interface, and analyzes how to transmit data through the interface high efficiency. This database interface makes the software and hardware separately to shield the hardware details for the users.

The gateway connects to the server through USB port converted to virtual serial ports, and transmits data to server. Then the server parses data packets based on the network protocols in wireless sensor network, which helps to store data to database conveniently.

4.3. *Monitoring Management Software for Users*

Monitoring system provides friendly interface for users, and adopts B/S model which is convenient for system maintenance and upgrading. Therefore, the client does not need to install other software, and only uses browser to visit real-time data. Server monitoring terminal system includes the following functions:

(1) User management module. This module mainly completes functions of user register, login, and related operations. According to different requirements of users, the system will sets corresponding authorities for data access.

(2) Analysis module for monitoring changes. This module takes time as the horizontal axis and allows users to read monitoring data from a database table and draw a time-varying curve to analyze the continuous changes.

(3) Network topology display module. Using this module, the user can view the whole network topology.

(4) Monitoring and warning module. In this module, the user presets the threshold of temperature, humidity, and light intensity. If the monitored data goes beyond this given range, the alarm module will pop up a tip to remind the users of taking appropriate measures to improve the environment of watermelon seedling.

5 System Testing

The hardware equipments of this experiment are made up of a wireless sensor node, a sensor board, a gateway node, a server, and monitoring terminal PC. The gateway node connects to the serve and transmits data through USB port.

5.1. *Collecting Raw Data*

This study adopts C# language calling WIN32 API and collects environmental parameters from a virtual serial port with MTS400CA sensor board. Received data from virtual port is shown in Figure 5.1.

Figure 5.1: Data Receiving from Virtual Serial Port of MTS400CA

5.2. *Data Parsing*

Through studying network protocols in wireless sensor network, the server parses data packets. The MTS400 sensor board has a variety of weather sensing modalities. These modalities include temperature, humidity, light intensity and so on. The raw packet structure [11] is as follows in Table 5.1. The difference between MTS310 and MTS400CA is the number of payload's bytes, and MTS310's payload is 16 bytes.

Table 5.1: MTS400 Raw Packet Structure

Bytes	Content
1	Frame synchonization
1	Packet type
5	TinyOS header
7	XMesh header
4	XSensor header
26	MTS400 payload
2	CRC
1	Frame synchronization

5.3. *Measured Data*

Based on the study of the sensors in sensor boards, this system realizes the parsing of the parameters of temperature, humidity and light intensity. We collect the environmental parameters with sensor board MTS310 and sensor node ID 1 in the Gouguai village, Guzhen town, Anhui province, on February 15, 2010. It was cloudy, temperature from -2^{0}C-1^{0}C on that day. Part of the data collected is shown in Table 5.2.

Table 5.2: Part of Data of MTS310

ID	Time	Voltage[V]	Temp[C]	Light[lux]
1	2010-2-15 14:40	2.9192	9.6035	979
1	2010-2-15 14:42	2.9057	10.125	995
1	2010-2-15 14:44	2.9057	10.986	999
1	2010-2-15 14:46	2.899	11.328	998
1	2010-2-15 14:48	2.899	11.839	995
1	2010-2-15 14:50	2.899	12.179	955

Environmental parameters are obtained by sensor board MTS400CA and sensor node ID 1, in College of Information and Electrical Engineering, China Agricultural University, on June 29, 2010. Part of the data collected is shown in Table 5.3.

Table 5.3: Part of Data of MTS400CA

ID	Time	Voltage[V]	Humid[C]	Humtemp[C]	Preamp[C]	Press[mba]	Light[lux]
1	2010-6-29 13:41	2.676	42.6	28.94	28.505	988.06	338.33
1	2010-6-29 13:42	2.676	42.5	29.02	28.606	987.93	353.05
1	2010-6-29 13:43	2.676	42.5	29.04	28.599	988.19	353.05
1	2010-6-29 13:44	2.676	42.9	28.99	28.564	988.04	353.02
1	2010-6-29 13:45	2.676	42.8	29.02	28.578	988.16	353.05

5.4. *Network Topology Display*

This module can real time display the topology of the wireless sensor network. Through analysis of MTS400CA packet, we can see two bytes of parent in XSensor's header which can determine its parent node in network topology. The network topology in this experiment is shown in Figure 5.2.

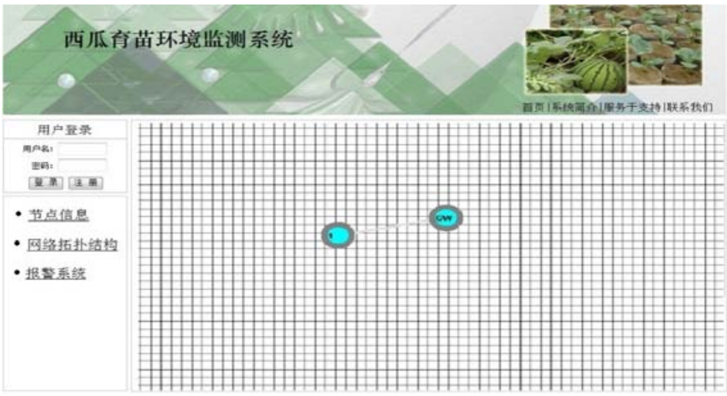

Figure 5.2: Network Topology Display

6 Conclusions and Related Work

Aiming at some of the rural areas using thermometer to monitor the temperature of watermelon breeding environment, as well as several kinds of monitoring methods with drawbacks of wiring complexity and high costs, this paper proposes the use of wireless sensor networks to real-time monitoring of environmental parameters for watermelon seedling. Through the deployment of wireless sensor network devices in the plastic greenhouse, this monitoring system implements the function of collecting temperature, humidity and light intensity. Furthermore, the administrator could use the browser to view the network topology at any time at any place.

Next challenges will involve different aspects of Maintenance, compressing the data to save more energy on radio communication, data mining, and nodes deployment for getting representative of the overall plastic greenhouse dynamics.

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