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Design of Environment Monitoring System in Hatcheries Based on WSN

Zhiping LIU, Hanyu LIU

School of Electrical Engineering and Automation, Henan Polytechnic University, Jiaozuo, 454000, China

Tel.: 15939136585

E-mail: liuzhiping@hpu.edu.cn

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Abstract: The level of the environment monitoring system in hatcheries is low, and monitoring methods is not up to data, we propose a new environment monitoring method based on wireless sensor networks in hatcheries. The sensor nodes which distribute every room in hatcheries form a wireless surveillance sensor networks by Zigbee technology so as to provide information timely. When designing of the sensor nodes, we choose CC2430 from WXL Company, which integrate the CPU, RF transceiver, net protocol and the RAM together, as the core chip and combine the microcontroller technology. The design of coordinator node uses CC2420 and MSP430. Besides, the data collected by the nodes will be sent to monitoring platform of Visual Basic editor via the Zigbee network. The system automates the operation from the monitor to control, which can save the cost of labor and environmental monitoring. *Copyright © 2013 IFSA.*

Keywords: Hatcheries, Wireless sensor networks, Visual Basic.

1. Introduction

The hatchery is a relatively closed microenvironment, which includes hatcheries, brooder, egg chamber and office. The temperature, humidity, concentrations of carbon dioxide, ammonia and Hydrogen Sulfide will bring great influence to hatching rate and the growth of the chicks in the hatcheries [1]. The development of the information and intelligence of climate information gathering for each room in hatcheries is the key technology of implementing factory hatch technology. Many hatcheries adopted regular observation or wired information collecting equipments to achieve the micro environmental monitoring in our county, but the costs of cable data acquisition equipment investment and maintenance are high [2].

With the development of the wireless network technology, the wireless sensor network technology has been successfully applied to agriculture, wild biological, and grottoes micro environment monitoring and so on. According to the characteristics of the hatcheries environmental monitoring, an environmental monitoring system of the hatcheries is designed based on wireless sensor network, which can change the traditional periodic observation and cable network monitoring methods, save labor and reduce the complexity of wiring. The system combines wireless sensor network, microcontroller technology and PC's powerful monitoring and management function. The sensor nodes will transmit the gathering data to monitoring platform by Zigbee network. The observer can timely understand the state of the environment of the each room in hatcheries through the system. In order to keep the environment parameters vary in certain range, the control equipment start in time according to the setting threshold, and automatic adjustment of environment parameters is realized [3-6].

2. The System Overall Design

2.1. Zigbee Technology

ZigBee technology is a kind of wireless network communication technology characterized by low cost, low power, a low data rate, highly reliable, highly secure which towards automation and remote control applications. The protocol is set by IEEE802.15.4 and Zigbee alliance. The nodes adopt the unlicensed and unpaid 2.4 GHz ISM band which rely on battery power. So the network has the advantages of long service time, convenient operation and
high reliability.

The ZigBee network layer supports star, tree, and mesh topologies. In a star topology, the network is controlled by one single device called ZigBee coordinator. The ZigBee coordinator is responsible for initiating and maintaining the devices on the network. All other devices, known as end devices, directly communicate with the ZigBee coordinator. In mesh and tree topologies, the ZigBee coordinator is responsible for starting the network and for choosing certain key network parameters, but the network may be extended through the use of ZigBee routers. In tree networks, routers move data and control messages through the network using a hierarchical routing strategy. Mesh networks allow full peer-to-peer communication. We can choose different topology according to the need [7].

2.2. System Collective Structural Design

According to the features of the hatcheries, we adopt a new wireless monitoring system whose structure diagram is like Fig. 1. The system mainly includes computer (base station), coordinator (gathering node), router (cluster), sensor nodes (terminal node) and control nodes. Zigbee coordinator acts as the master controller, answering for the network establishment, management and maintancement, receiving the room sensor data and equipment state information, and sending the control command. The Zigbee router is placed at the gate of the each room which acts as a single controller, in charge of its room data process and sending to Zigbee coordinator. Zigbee terminal nodes are mainly responsible for collecting and sending the data to its router in the network. The control node control the corresponding equipment according to the receive command information from the coordinator. In the process of data transmission and command sending, the coordinator node plays a role as the bond between the computer and wireless network.

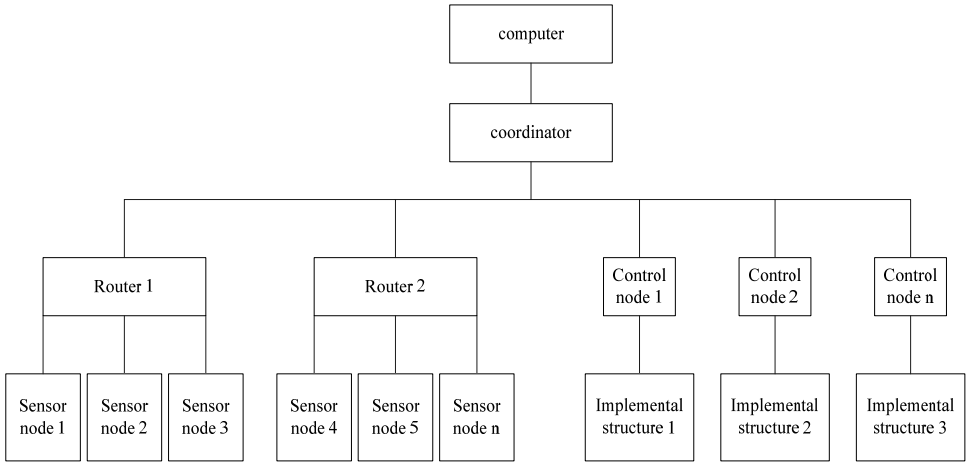

Fig. 1. Schematic diagram of the control system.

3. System Hardware

The paper introduces the design of sensor node, coordinator node, power module and control circuit. Considering the characteristic of hatchery, each room is not large, the end nodes will transfer the gathering data to router node through single-hop method. The router will send the collecting data to coordinator. Eventually, all the data gathered by end nodes should be sent to the monitoring center.

3.1. Sensor Node

The wireless sensor network node is usually made up of sensor module, processor module, wireless communication module and power module. However, processor module and wireless communication module are integrated on CC2430 chip, which greatly simplifies the radio-frequency circuit design. We choose CC2430 as the ZigBee protocol core chip, and connect various sensors through sensor adjust circuit. The integrate temperature and humidity sensor SHT11, carbon

dioxide sensor T6004, ammonia gas sensor MIC-NH3 and hydrogen sulfide gas sensor M-100. The sensor node functional block diagram is shown as in Fig. 2.

3.2. Coordinator

The coordinator plays a very important role and processes more data than other end sensors in the network, as a result, we choose MSP430F1611 as the coordinator processor. MSP430 MCU, a 16-bit microprocessor of TI company, is widely applied in portable instruments and meters for its low power consumption, simple but sufficient orders and strong functions. Wireless receiving module uses CC2420 as the core chip of the coordinator. In order to ensure the long-term and the stability of the coordinator, which has two kinds of power supply modes: city's power and battery. The coordinator node structure is shown in Fig. 3.

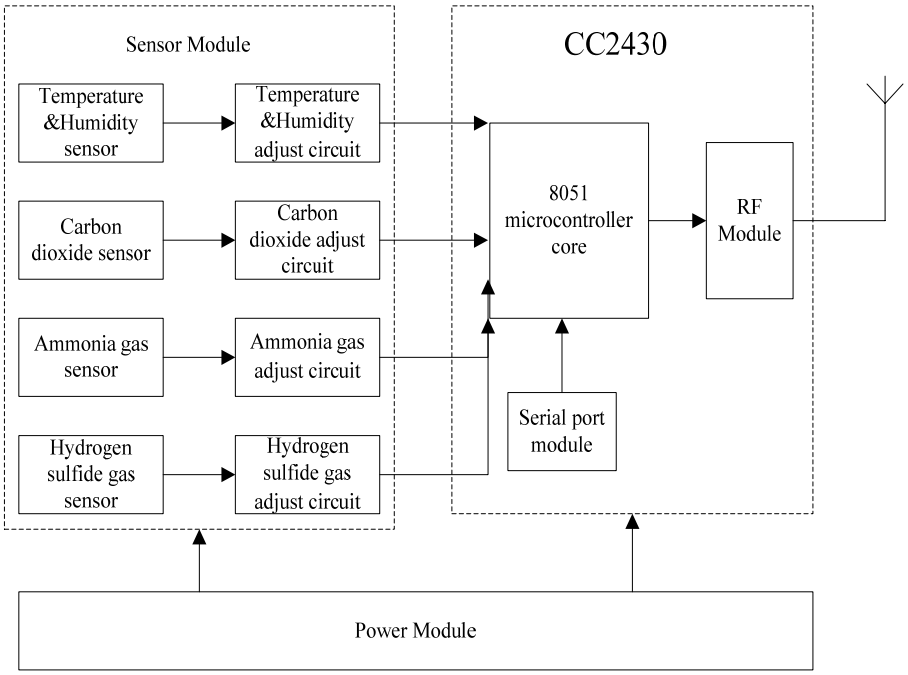

Fig. 2. Schematic diagram of sensor node.

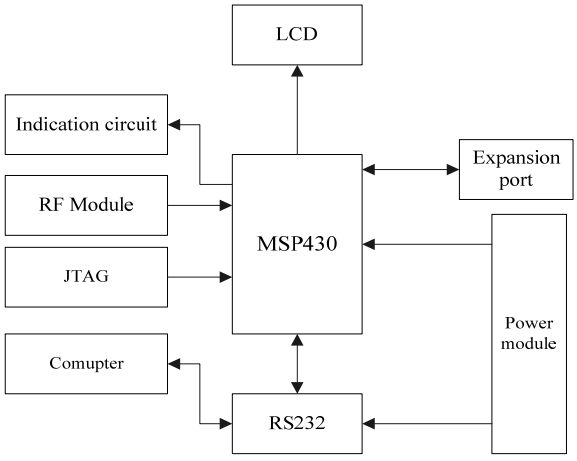

Fig. 3. Structure diagram of coordinator node.

3.3. Power Modules

The coordinator adopts the double power source as power supply. In common condition, the system uses city's power supply. However, at time of power failure, the system will automatically switch to mode of battery power supply. The main power supply voltage is 5 V. The backup power consists of 4 Ni-Mh batteries, which the rating voltage is 4.8 V. The power supply circuit design is shown in Fig. 4. The circuit consists of voltage detector (HR7030), small power switch transistor (2N2222), field-effect transistors (SI9942) and backup power and so on. When the power supply voltage is greater than the battery voltage, switch transistor (VT1) can turn on, and the final output voltage is 3.3 V. If the city's voltage less than 4.8 V, the switch transistor (VT3) will turn off. Then field-effect transistors turn on, the battery provides power supply for equipment.

4. Design of the Control Circuit

Control nodes are deployed in the outside of each room and they can directly communicate with the coordinator node, which decides whether to communicate with the control nodes according to the setting threshold to realize the control equipment on or off, so as to realize the automatic detection and control of hatching factory, and change the indoor

environment, restore to the ideal state of environment. The single node control circuit is shown in Fig. 5. When the control node receives control commands from the coordinator, it will output high level of its P1.3-pin. The triode S8050 and optocoupler P521 are turned on, which lead to the AC relay switch closes and the corresponding equipment is turned on. The electric insulation of the core circuit and control circuit is achieved by using P521, which avoids interference caused by strong electricity or destroying chips.

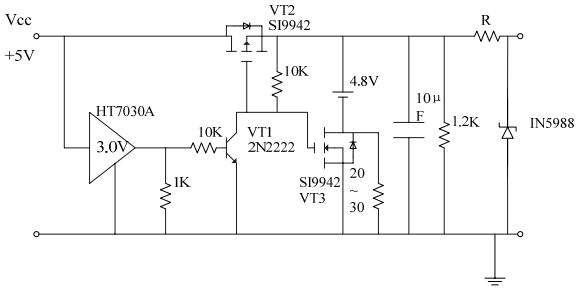

Fig. 4. Power circuit.

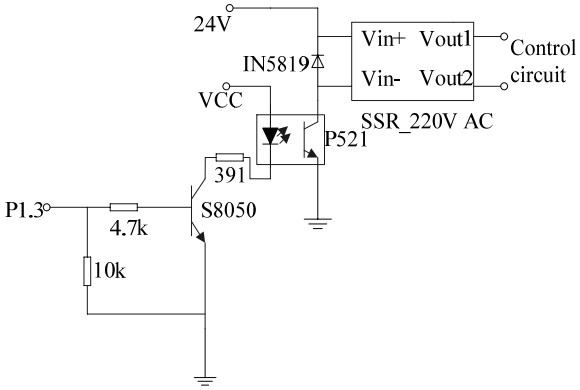

Fig. 5. Control circuit.

5. System Software

In a practical application, host computer software design is as important as the sensor node, the router node, the coordinator node. Because the hatchery hatching room, egg chamber and the brood chamber is separated from each other, different types of sensor nodes need to be placed in the different rooms when monitoring each room: end node placed indoor, router nodes placed in each chamber door, coordinator node placed in the top of the center of the hatchery [8]. The initialization is as follows:

5.1. The Initialization of the Coordinator Node

The coordinator node initialization is shown in Fig. 6. After powered on, the coordinator node enters initializing state, which is designated. Selecting a suitable channel and assigning a specific ID number for the coordinator node. Coordinator receives joining request from router nodes and control nodes, assigns a network address, sends confirmation information, and establishes binding connection. Then it waits for receiving data sent from router nodes, and analyzes the data packets, and then sends its data to computer after identifying as router information. Meanwhile, the data transmitted by router nodes will be received by coordinator and shown in the LCD.

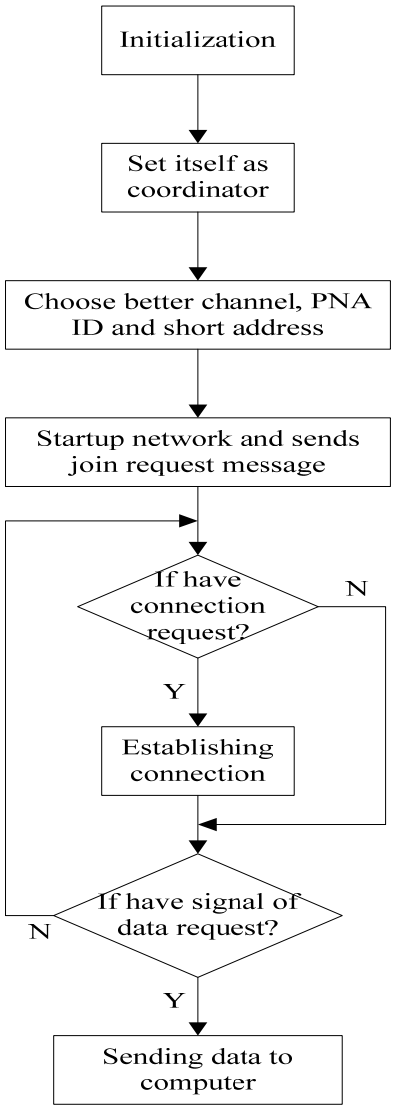

Fig. 6. Flow chart of coordinator node.

5.2. The Initialization of the Router Node

The initialization of router node is similar to that of the coordinator node. After powered on, the router nodes automatically looks for network to join. It will bind itself to the coordinator node, and sends a joining request to it. The coordinator node will be assigned a network address for it after the consent of the coordinator node. In the network, router nodes not only have the effect of routing and maintain

communication network, and router node is placed in each chamber door generally, and commercial power and battery can be used as its power supply. The flow chart is shown in Fig. 7.

6. The Initialization of the Sensor Nodes

The terminal node initialization is relatively simple. In the network, the sensor node collects data and sends data. Battery is used as the power supply because its work environment condition is hard. The sensor node sends 16-bit network address to router node after joining network successfully. When the sensor node receives data collection instructions, it will enters the application layer, calls the handling functions, triggering the corresponding task event functions, such as temperature, humidity, carbon dioxide concentration. And then start the A/D sampling to collect related data. The process diagram is shown in Fig.8.

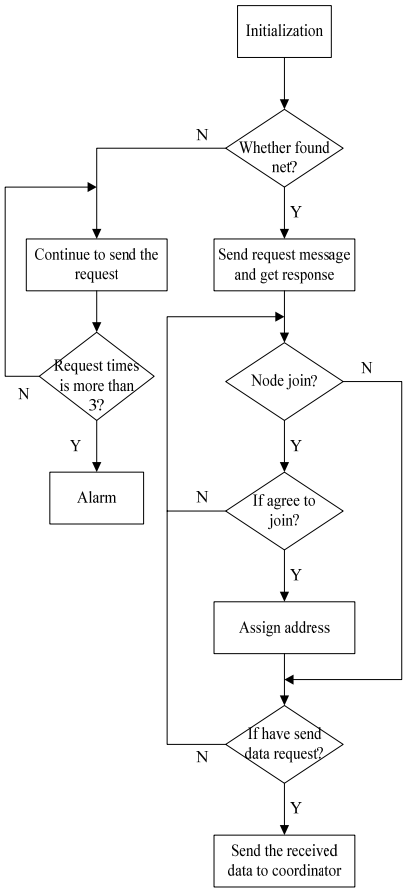

Fig. 7. Flow chart of router node.

7. Hatchery Monitoring Software Design

According to hatchery environmental conditions, the system has 4 dialog box selections: setting controlling conditions, setting timer, setting relevant parameters, showing current data and querying history data. Is mainly used to display the sensor nodes to collect information such as temperature, humidity, carbon dioxide concentration. The system has the following functions:

(1) Can display the information collected by sensor node;
(2) Can query related information within a certain time;
(3) Can set relevant parameters;
(4) Should be safe, set the password;

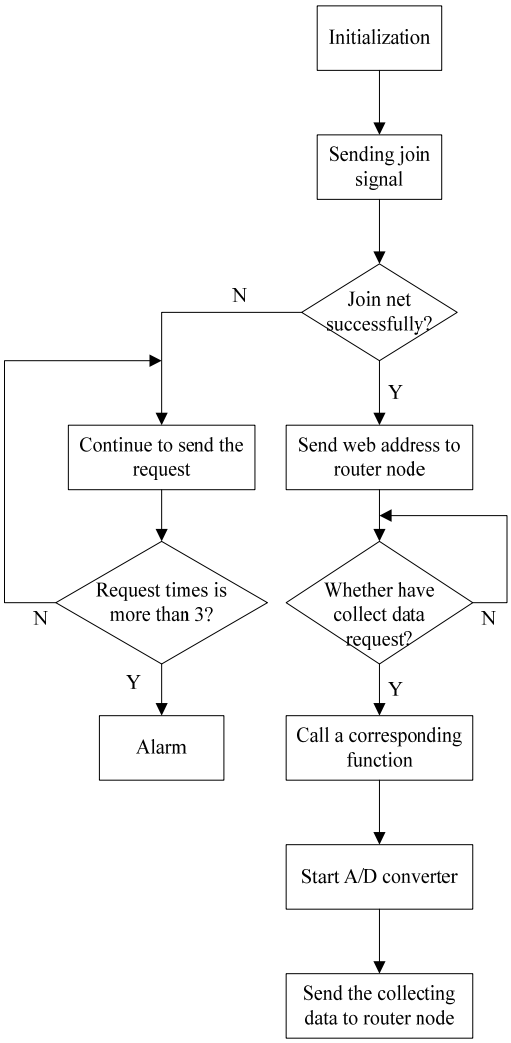

Fig. 8. Flow chart of sensor node.

The coordinator node is connected to the host computer through the RS-232 serial port. Based on Windows XP platform, in this paper, we use MSComm controls of Visual Basic 6.0 to implement serial communication design, which simplifies the development of serial communication, and use the properties of the controls to set up the serial port [9-10]. We write the control interface using the VB language, real-time monitoring of the collection of data, realizes the visual man-machine interface, convenient debugging of the system and network monitoring. In addition, we choose the Access as the

database, which is used to save the data gathered every time, and the data facilitate query, analysis. The interface of PC is shown in Fig. 9, Fig. 10 and Fig. 11. Login password is also set in login interface to ensure system security. The Serial Port debugging interface is designed for debugging serial communication easily because every computer com port setting is not the same. To make it convenient for the user inquiring the historical data, query interface is designed. Users can query and analyze the data information in the past every day according to the number of nodes, which facilitates a better decision.

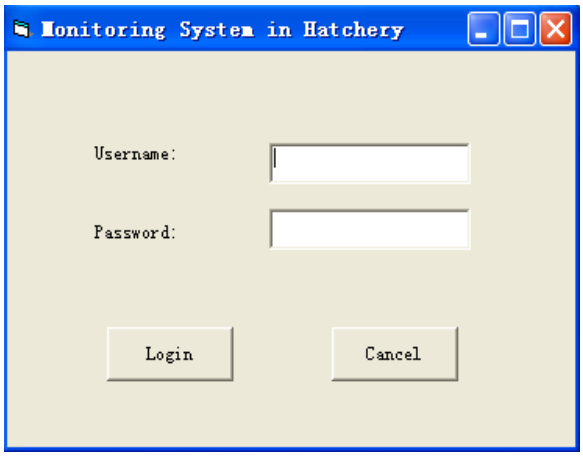

Fig. 9. The login user interface.

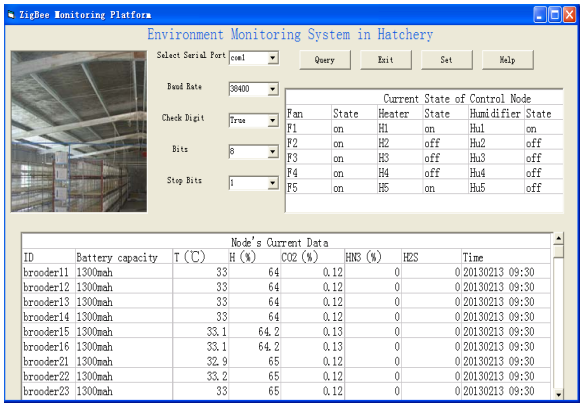

Fig. 10. The main interface.

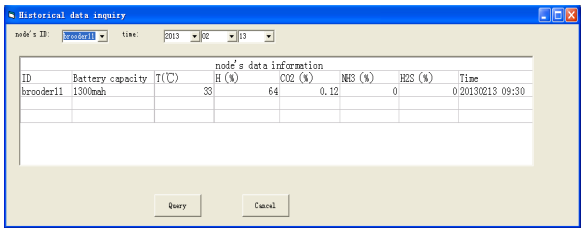

Fig. 11. The search interface.

8. Conclusion

The use of the advantages of wireless sensor network (WSN) in the system can not only monitor the hatch plant environmental effectively, also save a lot of manpower, material and financial resources, and time resource to a certain extent. To perfect the function of the PC, the alarm system will be added in control system in subsequent research work.

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