Design of Intelligent Irrigation Monitoring System Based on GPRS and Zigbee

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Abstract In order to solve the present dual contradiction of the low utilization of water resources in China's agricultural sector and the low land management efficiency, using Zigbee wireless sensor network and GPRS technology, this paper designs an intelligent monitoring system based on the GPRS and Zigbee wireless network technology. The Zigbee wireless sensor network is established based on the IEEE 802.15.4/Zigbee protocol, consisting of terminal node for capturing and transmitting soil and environmental information to the coordinator node (gateway node) or acting the control command from the GPRS network. The irrigation remote monitoring network layer consists of coordinator node connected by the TCP/IP protocol, which can implement the precision irrigation of crops and the information management of arable land to the monitor center or user. And the monitor center using Java to write the system is safe and effective.

Key words Intelligent irrigation, Wireless sensor networks, GPRS technology, Zigbee

1 Introduction

At present, some problems in China's agricultural sector, such as low utilization rate of water resources and low efficiency of arable land management, have restricted the development of agriculture. The irrigation depends on the experience and feeling of farmers, resulting in a serious waste of water resources and affecting the yield and quality of crops. In recent years, the Internet of Things has been frequently applied in the field of agriculture, and it integrates short-range Zigbee, bluetooth, cellular mobile communication, satellite communication and other wireless communication technologies and Internet technologies, to achieve multi-scale transmission of information[1]. The transmission of data during irrigation should be reliable and timely, and the irrigation amount should be precise, therefore, a set of intelligent irrigation monitoring systems (with GPRS + Zigbee wireless networking technology as the core) are designed. Due to short distance, low cost and low power consumption, Zigbee is mainly used to monitor the point-intensive occasion. GPRS network is not restricted by communication distance, and the communication is reliable. It makes the underlying Zigbee network and Internet network achieve reliable data transmission, and gives full play to the advantages of the two wireless technologies, so that the security, reliability and usefulness of the system are guaranteed.

2 System framework design

The overall structure of intelligent irrigation monitoring system based on GPRS + Zigbee wireless networking technology is shown in Fig. 1, and it mainly consists of wireless sensor network, central monitoring server and terminal monitoring system. The wireless sensor network processes the data information collected by terminal node and then transmits the processed data to coordinator node through the Zigbee protocol. The data are fused and transmitted to monitoring center so as to complete data collection, processing and transmission. The central monitoring server analyzes the data received combined with meteorological information and derives the decision-making information in accordance with a certain algorithm based on expert decision-making system information to control the solenoid valve switches. Administrators can use the PC as a client for user management, information viewing and irrigation control. By the logging permission setting, users can log in the terminal control system through PC or mobile phone, to view the farmland soil moisture, irrigation amount and water rate. The intelligent irrigation monitoring system has the following main features:

(i) Precision irrigation. The data uploaded to the server are stored in the database, and by the expert system, the fuzzy algorithm is used to process data and generate the optimum irrigation time and irrigation amount based on different needs of crops at various stages of growth, to ensure that the crop is always in the best growth environment, thereby ensuring the quality and yield of crops.

(ii) Remote management. System administrators and users can access the data in monitoring center in the form of Web through the network for management.

(iii) Mobile control. The users having mobile phone can open GPRS service to view information concerning farmland and irrigation amount, and users can use mobile phone to control valve and implement irrigation when there is a need to irrigate but the system does not grant irrigation.

(iv) Smart fertilization. By testing the PH, EC values of liquid fertilizer in irrigation pipes and referring to the PH, EC values set by the expert system suitable for each crop growth stage, the

Received: March 10, 2015 Accepted: May 11, 2015
Supported by National Natural Science Foundation of China (61261045); Major Project of Education Department in Ningxia(NaY2014133).
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opening of fertilization pipeline is controlled to adjust the PH, EC values of liquid fertilizer[2].

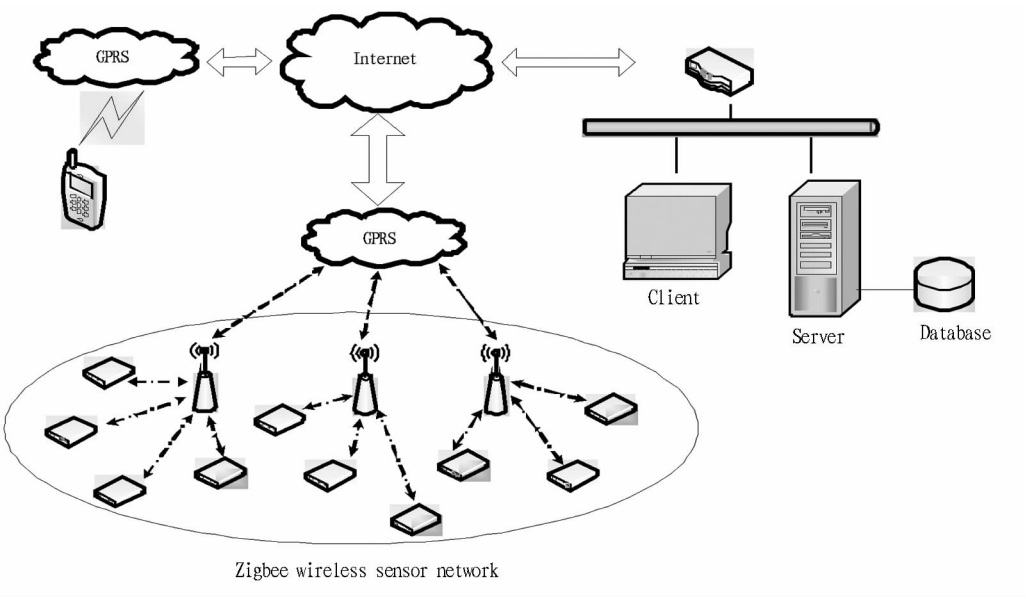

Fig. 1 Framework of intelligent irrigation monitoring system

3 Design of wireless sensor network

Given the vast area and large differences in the soil conditions in the irrigation region, we design the two-layer wireless sensor network based on clustering structure[3]. The wireless sensor network includes coordinator node and terminal node. It uses coordinator node based on Zigbee technology to achieve short-distance farmland data collection and transmission, and uses the GPRS module of terminal node to achieve remote transmission of data. It is suitable for IEEE 802.15.3 technology with wireless control and low-rate automation application, namely Zigbee technology[4]. Each Zigbee network can set 254 slaves and 1 master at most, and the distance between nodes can be extended from the standard 75m to a few hundred meters or even a few kilometers[5].

3.1 Design of Zigbee node hardware Zigbee terminal node is the basic unit of wireless sensor network, consisting of four parts (data acquisition module, information processing module, RF antenna and power supply module), as shown in Fig. 2. It uses tipping-bucket rain-sensor to measure the liquid precipitation, precipitation intensity and precipitation start and end time, and transmits the pulse signal to the acquisition system. The information processing module uses CC2430 chip which can meet the needs of Zigbee-based 2.4 GHz ISM band application for low cost and low power consumption. Zigbee RF front-end, memory and microcontroller are integrated in a single chip, combined with a high-performance 2.4 GHz DSSS radio transceiver core and a compact and efficient 8051 controller. The sleep mode of CC2430 and a short time to switch to active mode, are especially suitable for those applications requiring very long battery life. The power supply module uses large-capacity high-energy alkaline batteries to provide power[6].

3.2 GPRS coordinator node design Zigbee network is intended for short-range communications, while GPRS is intended

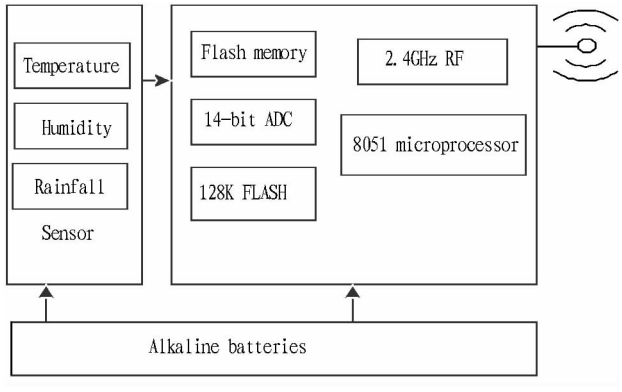

Fig. 2 The hardware structure of Zigbee node

for long-distance communications, with reliable data. The two complement each other. The coordinator node is responsible for the two-way data transmission of Zigbee network and GPRS network, and it is actually a conversion gateway based on Zigbee protocol and GPRS protocol. The system uses Huawei's GTM900 wireless module to achieve wireless sending, receiving, data processing and other functions. It supports the EGSM900/GSM1800 frequency band, and is embedded with TCP/IP protocol. It uses AT command set for serial communication via UART interface and external CPU[7]. Via RS232 interface, GTM900 module, data processing module and CC2430 storage chip complete GPRS network link, data receiving and sending. After the data transmitted to GPRS module go through processing and protocol encapsulation through the internal embedded processor, they are sent to GPRS network. GPRS network and the Internet are based on IP protocol and connected to each other[8], so if the irrigation monitoring center is connected to the network, it can receive the monitoring data through GPRS network, and store the data information in the monitoring server database. After GPRS power-on reset, we need to

first initialize the modules, such as operating mode, access gateways, protocol type and communication baud rate. After the initialization setup, the dial command is sent for GPRS network connection. The GPRS module is initialized as follows: (i) setting the communication baud rate, using "AT + IPR = 115200" command to set the baud rate at 115200 bps; (ii) setting the access gateway, using the "AT + CGDCONT = 1", "IP", "CMNET" command to set the Monternet access gateway; (iii) testing whether it is opened, using "AT + CGACT = 1" command to activate the GPRS function (If it returns OK, GPRS connection is successful; if it returns ERROR, GPRS connection fails); (iv) establishing the TCP connection with monitoring center, using "AT + CIPSTART = TCP", "172. 18. 55. 107", "2020" command to establish TCP connection ("2020" as the port number); (v) setting the mobile terminal category, using "AT + CGCLASS = B" command to set the mobile terminal category as category B (only one service can be run, GPRS or GSM).

4 Central monitoring server design

Central monitoring server is the information management and monitoring center of the whole system, and it is an important part of data processing. The server monitoring software uses Java language to achieve real-time display of the data. The SQL Server 2000 database is used to store the information collected about irrigation site and water rate management information. The database storage not only increases the storage efficiency, but also makes data query more efficient.

4.1 Central monitoring server functions The friendly interactive platform established can achieve the communication, data transmission and monitoring functions between monitoring center and underlying sensor, valve controller. This platform has the functions of administrator and user management, device management, water rate management, equipment triggering control, mobile user control and database management. It uses SMS service of GSM to send irrigation control information to users. At the same time, users can send mandatory irrigation control command and soil moisture data extraction command to the monitoring center, to complete remote monitoring of irrigation[10]. The framework of intelligent irrigation monitoring system is shown in Fig. 3.

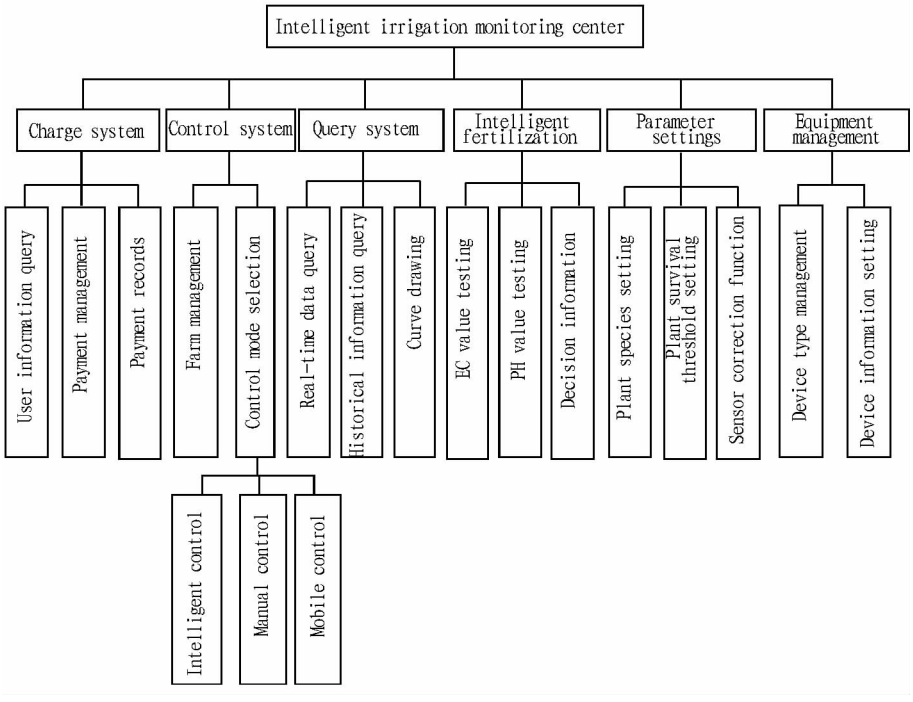

Fig. 3 The framework of intelligent irrigation monitoring system

4.2 Expert system The irrigation expert decision system uses the fuzzy control technology to design a dual input-single output water-saving irrigation controller. The input of controller is the difference between the setting value and actual measured value (E) and its rate of change (EC); the output is the irrigation time (U), and seven linguistic variables are defined (NB, NM, NS, 0, PS, PM, PB). The simple triangle membership function is used and the selected fuzzy inference conditional statement is "if A and B and B then C". According to different needs of crops at different growth stages, the fuzzy control table at various stages is obtained. By looking up the table, we can get the quantization levels of output. Through the defuzzification of output (namely being multiplied by a scale factor), we can get the irrigation time. The diagram of fuzzy control system structure is shown in Fig. 4.

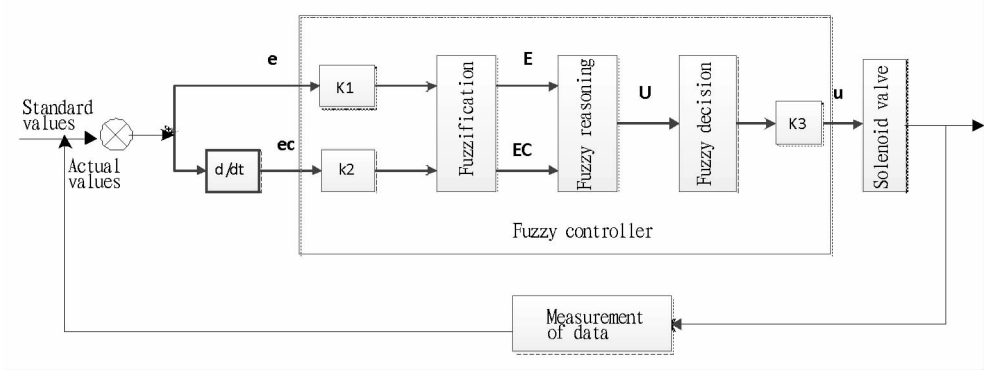

Fig. 4 The diagram of fuzzy control system structure

5 Conclusions

This paper describes an intelligent irrigation monitoring system based on Zigbee and GPRS technology, makes a specific study on the use of wireless sensor network to achieve farmland information collection and intelligent water-saving irrigation control, and designs the specific implementation programs of wireless sensor network and intelligent irrigation system. Zigbee technology not only has the features of low cost and low power consumption, but also avoids various problems caused by wiring in the irrigation site. It uses the Internet to make users access the central monitoring server through computer, or use the user name to log in through phone, to view farmland information and water rate anytime. This intelligent irrigation system can achieve water-saving irrigation, improve agricultural production and management model, and improve the quality and yield of agricultural products.

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