Design of Greenhouse Environmental Monitoring System Based on Internet of Things

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Abstract. As a new type of network technology used for information exchange and communication, Internet of things has received more and more attention and has a great application prospect in the aspect of intelligent agriculture. The passage designs an environment monitoring system based on Internet of things technology according to the important environmental parameters in greenhouse. Taking data acquisition of temperature and humidity as an example, the system introduces the data acquisition unit, analyzes the working principle of Zigbee module chip and the software flow of coordinator to realize data sending and receiving. Users can view the local upper computer and remote mobile phone side, timely grasp of data changes and abnormalities. The monitoring system is helpful for the research of Internet of things technology in greenhouse, including the selection of sensors and the establishment of ad hoc network, which is helpful for the further application and popularization of Agricultural Internet of things technology.

Introduction

The Internet of things is more and more widely used in traditional agriculture beyond seas. First of all, agricultural sensors are developing towards miniaturization, intelligence and mobility[1]. The Fraunhof Institute in Germany developed a special sensor that detects the release of odors from fruits by using the special properties of metal oxides and judges the maturity of fruits; Secondly, data transmission technology has also been improved rapidly in foreign countries. Raul Morais has developed a Zigbee multi power supply wireless device to assist in the prediction of grapevine powdery mildew in vineyards [2]. Finally, the Internet of things intelligent processing technology has made important progress. The United States IBM company developed a big data platform, the system it developed supports continuous analysis of massive data flow, helps users quickly access, analyze and associate data from multiple real-time sources, achieves rapid response to data processing, and integrates applications to support structured and unstructured data sources [3].

In China, the Agricultural Internet of things has also begun to develop, and has some applications in environmental monitoring and control, precision agriculture [4,5]. Among them, the application of Internet of things technology in greenhouse has made some progress, but it also faces many problems and challenges. First of all, the application objects of greenhouse are complex, and there are many kinds of information, but there is no uniform standard in the selection of sensors, so it is impossible to unify the data collected by terminal nodes. Secondly, the establishment and application of ad hoc network is not mature enough, including the construction of ad hoc network between the internal perception nodes of greenhouse and the construction of communication network between greenhouse and farm monitoring center.

Taking the temperature and humidity sensor as an example, the selection and working principle of the sensor is analyzed so that the system can be applied to the unified application of the collected data. Constructing ad hoc network by using ZigBee wireless communication technology. It also includes the software design of data acquisition unit and coordinator, which enables users to monitor the
environmental information of greenhouse in real time, and realizes the intensive and networked remote management of greenhouse.

**System Overall Structure Design**

The agricultural internet of things can be divided into 3 levels, the perception layer, the transport layer and the application layer [6]. Design of perception layer includes air temperature and humidity sensors, CO$_2$ concentration sensor, light intensity sensor, the acquisition of environmental information parameters will be output in the form of string. The transport layer of the internet of things is mainly divided into the wired communication layer and the wireless communication layer. Considering the long-distance characteristic of greenhouse, the ZigBee wireless communication technology is adopted, and the collected data is transmitted to the application layer by using Zigbee Coordinator. The application layer includes the Web server, the local upper computer and the 3G signal to the remote mobile terminal. Users can timely monitor the environmental information of greenhouse in the form of web page access. The system structure is shown in Fig. 1.

![Figure 1. Structure chart of greenhouse monitoring system.](image)

**System Hardware Design**

**Data Acquisition Unit**

The sensor transforms some non-electric physical quantities such as temperature, humidity, CO$_2$ concentration and light intensity into digital signals or other forms of output. The most common sensors are DHT11, HTU21D and SHT75. SHT75 digital temperature and humidity sensors belong to the Sensirion sensor family in the pin type package series, so it also has the advantages of easy integration, excellent long-term stability and other technical advantages. It integrates a capacitive polymer humidity sensing element with a temperature sensor made of an energy gap material into the same chip and seamlessly connects with the A/D converter and serial interface circuit. The data interface of the transceiver serial interface is bidirectional DATA pin, any general input / output interface of the Zigbee chip can be connected with it to complete data communication, and it is connected with the pin P0_3 in the acquisition circuit of Fig. 2. Since the DATA pin is a three-state structure, the DATA is effective at the rising edge of SCK and remains stable at SCK high, otherwise it will change after the falling edge. In order to prevent conflict between the signal, the microprocessor should drive the DATA at a low level, so the need for an external 10K pull-up resistor to pull the high-level signal, and the pull-up resistor is usually included in the I/O microprocessor in circuit. The input pin of the serial clock is connected with the P0_2 pin of the Zigbee chip to complete the synchronous communication, and the temperature and humidity data can be read out smoothly.
ZigBee Hardware Design

Zigbee wireless communication networks have three topological forms, star network topology (star), tree network topology (tree) and network topology (mesh). The system design uses CC2530 as the chip Zigbee module, which is launched by TI company. CC2530 chip is a real system on chip (SoC) solution for 2.4GHz, IEEE, 802.15.4, Zigbee and RF4CE [7,8]. Its power consumption is very low, and can build a strong network node with very low total material cost, so its price is also relatively low. It integrates 8051 core MCU and 2.4G wireless RF modules. There are 21 IO pins in the chip, in which VDD, GND, RESET_N and two pins are used as download and debug interface, the 32Mhz external crystal is used as the wireless transceiver module. The wireless transmit receive pin includes RF_P and RF_N, from the pin out is the balun circuit, and dealing with the wiring problem of PCB is helpful to play the maximum transmitting and receiving distance of CC2530. The schematic diagram of the circuit is shown in Fig. 3.

Figure 2. Temperature and humidity acquisition circuit.

System Software Design

Design of the upper and lower computer is included in the software program of system. The design of lower computer includes terminal node software design and coordinator software design.
Program Design of Zigbee Terminal Node

The main task of Zigbee terminal node is to collect information. After the power is switched on, the nodes are configured first, order Type=ZG_DEVICETYPE_ENDDEVICE. Only when the address of the terminal node is consistent with the coordinator address can the terminal node join the network smoothly, and the network address can be obtained only after the terminal node is connected to the network. At this point, you can complete the device binding by calling the function that binds the request and the response pairing request to ensure the binding table has been successfully established in the coordinator, then the network address of the terminal node is obtained by using the clustered D in the binding table, and at this time the ZigBee terminal node registration has been completed. Finally, the terminal node calls the function ZB_send Data Reques to send the acquisition data to the coordinator, and the process of data transmission is periodic. The coordinator that receives the data finally transmits the data to the control center MCU.

Program Design of Zigbee Coordinator

Each ZigBee network only allows one ZigBee coordinator, one channel and ID identifier (PAN) is the necessary condition for the coordinator to start smoothly. After the coordinator starts the network, it can control the whole network, and when the network has problems, it can play the role of maintenance in time, table bindings used for indirect addressing can also be well maintained by the coordinator. The coordinator can also design the security center and perform other actions to maintain communication with other network devices. The coordinator first completes the application layer initialization, sets the application layer state and the receive state to idle, and then opens the global interrupt and initializes the I/O port [9]. After setting up the wireless star network, the coordinator will send the successful network address to the control center MCU, because the Zigbee coordinator is the same as the program part of the monitoring node, it is also identified as a member with 0 address. The polling program has swept the surface of the serial function. When the serial port has data transmission, the control command or the data receiving command is first determined. If it is a control command, it will be sent to the specified terminal node; If it is a data receiving instruction, the data will be combined and passed to the upper computer interface.

Upper Computer Communication Software

The upper computer can send commands directly. This passage uses the "Serial To MySQL" software developed by Microsoft Corp. The software sets the serial port, connects with the MySQL server, and finally receives the data of the serial port and writes it to the database.

Summary

Taking the temperature and humidity sensor as an example, the selection and working principle of the sensor type are proposed in order to help the system to unify the application of the collected data information.

(1) The wireless communication technology Zigbee is used to build self-organizing network for greenhouse, and the working principle is analyzed and introduced according to the design of peripheral circuit of Zigbee chip CC2530.

(2) Data acquisition and transmission cannot be separated from the software program in addition to hardware design. The program of data acquisition terminal node and coordinator is designed. The communication of upper computer is realized by using MySQL to receive and write data. The selection of temperature and humidity sensor is proposed in the terminal node selection. CO₂ concentration and light intensity sensor selection needs to be further expanded in order to complete the various environmental factors monitoring. There are many kinds of environmental parameters in greenhouse, and these environmental factors also influence each other. Therefore, the multi factor intelligent control and the stability of network transmission should be taken into further studied.
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