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Furnace temperature intelligent monitoring system based on zigbee and android

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Abstract. Under the help of intelligent monitoring system, a great deal of manpower and resources can be save in the process of industrial production. The appearance of Internet of things has brought a new solution for intelligent monitoring system. The system combines the advantages of ZigBee's low cost, low power consumption, high reliability and Android platform's highly open resources characters and good expansibility. Furthermore, it adopts ZigBee's tree topology, and selects CC2530, which establishes the intelligent monitoring system. That is helpful for the early prediction of problems before it gets worse.

1. Introduction

With the development of the technology of Internet, intelligent monitoring technology is of great importance in people's daily life, and it is playing a vital role in the society.

At present, the traditional monitoring technology can't meet the needs of users as a consequence of its passive, poor real-time, limited human-computer interaction and so on. Intelligent monitoring uses advanced network communication, integrated wiring, and multiple nodes of sensor network. Various monitoring equipment are interconnected together to build a convenient and consistent monitoring network with high safety [1].All information can be uploaded to Internet, then shared and displayed the date in a proper way.

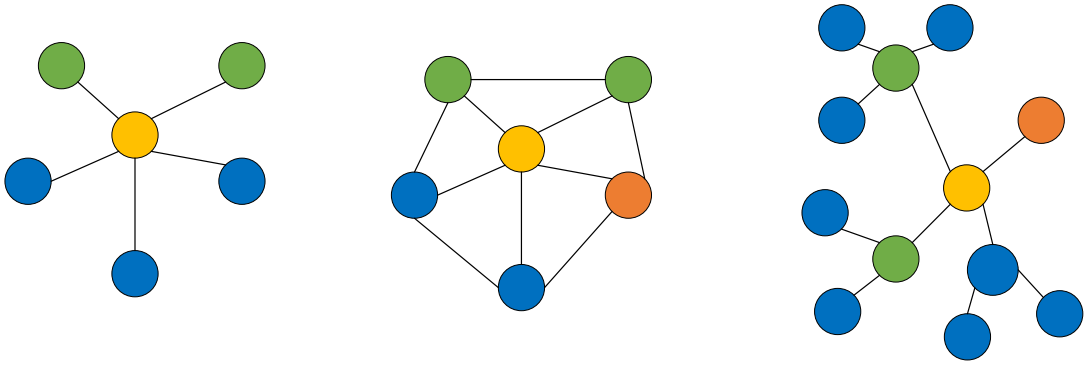
For system employing wireless data transmission, a wider variety of data transmission technology has been reported, such as the use of satellite, GSM and ZigBee. Among them, the satellite data transmission is slow, which takes about 8 to 12 minutes, and requires high installation costs. On the other hand, the accuracy of GSM's data transmission through SMS is higher, and the reliability is up to 100%. It also shows low retransmission rates and low total data loss rates, which are about 2.73% and 0.66%, respectively. The main disadvantage of GSM is that the operation cost is high, and the user needs to pay for the data transmission service. Bluetooth supports a simple wireless network, but it can only cover a short distance. Wi-Fi is another alternative technology that has high data transmission rates and supports star topology in wireless communications [2]. However, compared with Bluetooth and ZigBee, the cost of Wi-Fi devices is relatively high. In addition, power consumption is also increasing.

As a result, most monitoring systems tend to be inclined to lower cost solutions, especially ZigBee devices. Although the transmission rate of ZigBee is much lower than that of Wi-Fi, it is usually sufficient for the development of the monitoring system. Another advantage of ZigBee is that it assigns special time slots to avoid data conflicts. When the previous data is still in the buffer, ZigBee will save the input data to a special time slot, wait for the buffer to be cleared, and then retrieve data from the slot. Therefore, data conflicts can be avoided. In addition, ZigBee network topology allows other wireless nodes to integrate, enabling them to upgrade to support up to 65536 nodes' large network capacity, while

Bluetooth and Wi-Fi are 7 and 32 nodes, respectively. When running in mesh topology, ZigBee can tolerate failures such as device dropping, so that devices can create another link between the available nodes. These features make ZigBee a popular choice for data transmission in wireless applications [3].

As a wireless communication standard of low power consumption and low chip rate, ZigBee is a research hotspot in the field of wireless communication in recent years. Figure 1 shows three network topologies that are supported by ZigBee devices, which are star network topology, Mesh network topology and Mesh-tree topology [4].

It is widely used in the fields of intelligent meter reading, environmental monitoring and medical monitoring [5]. On the other hand, Android system process highly open resources characters, combining with its good expansibility. It is obvious that a great difference will be made if we can take full use of both. Taking all the things into consideration, it is necessary for us to study this intelligent monitoring system.



Star Network (Simplest) | Mesh Network (Best Reliability) | Mesh-tree Network (Large Scale Networks)

Figure 1. Topology of ZigBee wireless networks

2. System Structure

According to the idea of hierarchical design, the system divides its system requirements into three layers: perception layer, network layer and application layer, that is, data acquisition terminal, server-terminal and Android client. The above requirements are in the network which layer to achieve, we follow the flow of different layers of the network data flow logic [6], given the overall architecture of the system shown in figure 2. After collecting the data, the data collection terminal sends the data to the mobile client through the network to realize the system monitoring function

Analyzing the system from the perspective of specific design should be divided into two major aspects: hardware and software.

Hardware is divided into ZigBee module, Power module and GPRS module three modules. Due to space limitations, this article software design mainly introduces the client platform development and data reception processing two parts.

Figure 2. System structure

3. System Hardware Design

3.1. Data acquisition module

A sensor (also called detector) is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument [7]. This article uses thermocouples as sensors. Thermocouple temperature is converted to thermoelectric potential of a temperature sensing element, together with the millivoltmeter or other secondary instrument by measuring the thermoelectric power to determine the temperature value. Its working principle is based on the Seebeck effect, it is in direct contact with the measured object temperature is not affected by the intermediate medium, so with high accuracy.

Thermocouple is mainly used for measuring various production processes 0-1800℃ (individual high temperature level up to 2000℃ temperature of science and technology, a variety of special materials are widely used in the thermode so that the thermocouple has higher accuracy and sensitivity. Standardized thermocouple technology is more mature, widely used, excellent performance and stability, mass production, the same model can be interchangeable, unified indexing, and supporting instrumentation. Selection of thermocouple thermometer should be noted that the choice of thermocouple and millivolt meter or other secondary meter indexing the same number of measured temperature meter range should be within the scale. Thermocouple length to the working end can be inserted into the measured medium 5-15 cm is appropriate [8].

3.2. Wireless module

The design of terminal acquisition node is mainly composed of the CC2530 module, which is based on the TI and the RF power amplifier module CC2591. CC2530 is a real system - level chip that is used for 2.4GHz IEEE 802.15.4, ZigBee and RF4CE applications. It combines the leading RF transceiver with excellent performance and industry enhanced 8051CPU, which can build one powerful network is at a very low total cost of material [9]. CC2591 is a low-cost, high-performance RF front end for 2.4GHz band. It integrates power amplifier, LNA, equalizer converter and RF matching network. With CC2530, the data transmission range can be extended to 600 meters [10].

3.3. Controller module

In every monitoring system, controller plays the vital roles of handling the data, from the sensors to end users. Hence, a proper selection of the controller is paramount importance. On the one hand, it handles and calculates data and sends it to the RF module. On the other hand, it should handle the operation of the received data information radio frequency module and the control of other modules of the hardware platform [11].

The main control module is a 16 bit MSP430F149 single chip. The single chip microcomputer uses a simplified instruction set, which can be driven by a 8MHz crystal to achieve an instruction cycle of up to 125ns. In addition, MSP430 single chip also has the characteristics of low power consumption, stable work, rich peripheral equipment and so on. It is fully in line with the design requirements [12].

4. System Software Design

4.1. Data acquisition and transmission

Terminal nodes are mainly responsible for data acquisition in wireless sensor networks. It sends a network access request to the coordinator after the initialization is sent. If the request is correct, the user can access the network success. As the center of the whole sensor network, the coordinator is mainly responsible for the network of remote wireless data transmission. After initialization the coordinator node first and then enter the state of network, network monitoring. The access request from the sensor node is received after the network is received. It assigns the address to the child node and sends the network confirmation information to establish the connection [13]. The flowchart of the data acquisition and transmission is shown in figure 3.

4.2. Development of client platform

Android client development in the Eclipse integrated development environment. Because the application needs to operate on the underlying hardware, an additional compiler for the project properties needs to be configured in order to build an application compilation environment. The Java NDK and Cygwin are configured as a project compilation environment so that the project can implement C File to compile and generate library files that can be called by Java code. After the normal establishment of the Android project, create a new JNI folder in the project directory and create a C source file and an Android.mk file in the folder. Among them, the C source program uses the Linux system call to call the corresponding function of the hardware driver module, and provides a local interface for the Java code; the Android.mk file specifies the name and type of the library file generated after the C source program is compiled. In the subsequent Android application Java development, the need for hardware operations, as long as the corresponding local call library file can be [14].

Android applications are real-time monitoring, system settings and historical data of the three modules, the program uses SQLite database as a data storage tool. SQLite is an open source lightweight embedded relational database, occupy very little space, efficient and reliable operation, portability, and provide zero configuration mode of operation, so more suitable than the traditional database for embedded systems. Figure 4 shows the login, data acquisition and historical data curve interface of data monitoring software based on Android system designed in this paper.

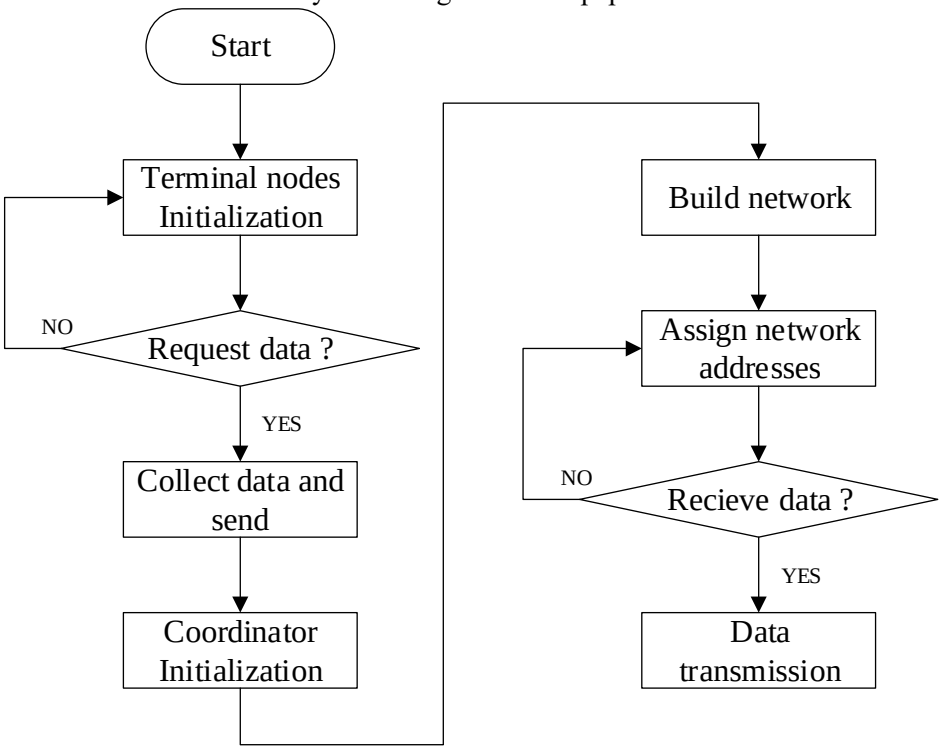


Figure 3. The flow chart of the data acquisition and transmission

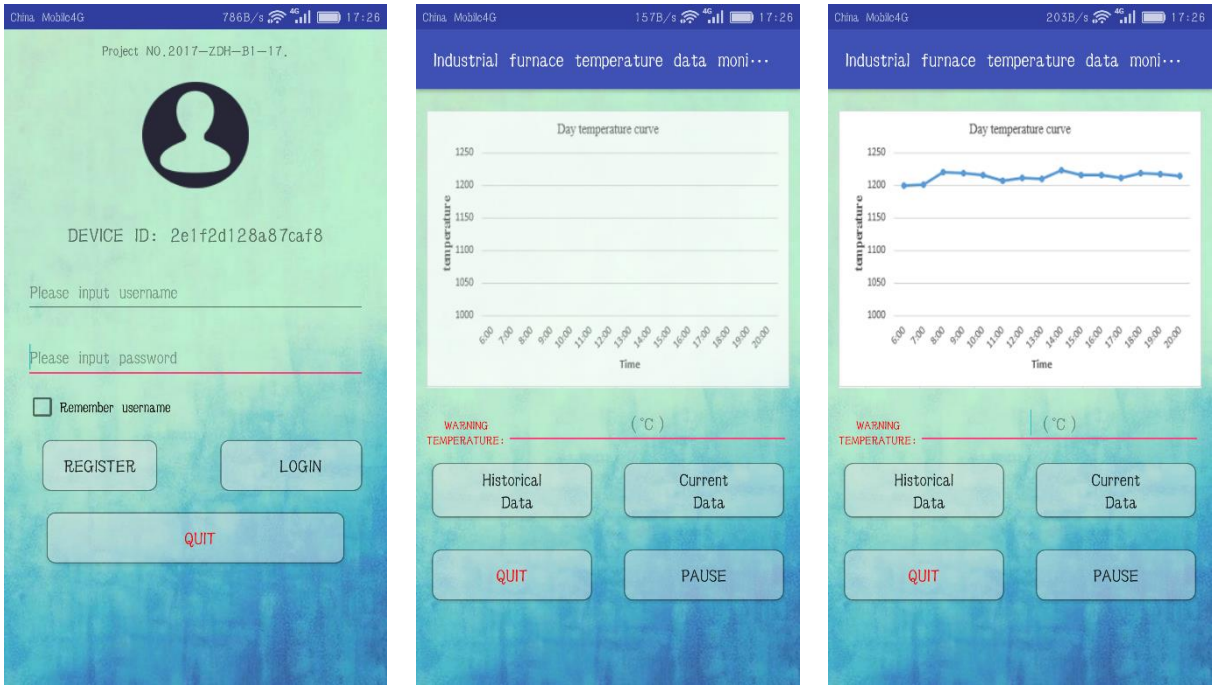


Figure 4. Client interface and the data obtained

5. Summary

In this paper, we build a wireless sensor network through reliable hardware structures and software designs with ZigBee as the core. Details on the whole process of the implementation, starting from system structure design, hardware implementation, control system programming to the development of client platform have been covered. The system is also equipped with web-based function which made it accessible at any place and any time via the internet. Implementation results show that the system is able to function with good performance.

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