Design of a Wireless Temperature and Humidity Monitoring System Based on ZigBee Technology

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Abstract. With the development of the Internet of Things (IOT), ZigBee is more and more widely used in the field of automatic monitoring. In this study, ZigBee wireless sensor network is developed and applied in the specific field of environmental temperature and humidity measurement and control. It builds a wireless sensor network based on ZigBee technology, highlighting the technical advantages of low power consumption, safety and reliability, large network capacity and excellent topology ability, to realize the dynamic collection, analysis and processing of relevant data.

1. Introduction
A country's departments, varying from industrial and agricultural production, home life, scientific research, national defense, aerospace, environmental protection, meteorology, measurement and testing departments, have strict standards for the temperature and humidity in the environment, which need to be accurately measured and controlled. It is of great significance to actively promote the development of the Internet of Things (IOT), the planning and layout of IOT sensing facilities and the IOT open-loop applications, and to strengthen the application of IOT in urban infrastructure, production and operation. ZigBee is a group of 802.15.4 Wireless LAN protocols approved based on IEEE standard. It is a two-way wireless communication technology with "low rate, low power consumption, self-organization and multiple nodes", which has the function advantages of "low cost, short time delay, high security, high reliability", and can meet the real-time monitoring requirements of various field environments (Jiang Zhong, Liu Dan, 2014). ZigBee technology, with its advantages of low power consumption, high speed and short delay, has a wide market application prospect in WSN. It is the most likely wireless technology to be applied in sensor networks, greenhouse, environmental monitoring, medical equipment and military systems and other fields (Gao Shouwei, Wu Canyang, 2009). Therefore, ZigBee, as an effective method of wireless communication technology, is a favorable technology to build an environmental measurement and control system that meets the needs and the goal of comprehensively improving the level of information application and promoting the construction of the IOT in the world’s common information planning.

2. Overall Design of the System
ZigBee wireless sensor network of this system adopts the mesh topology structure, which is mainly composed of upper computer, coordinator, router and terminal node equipment. Among them, the router and the terminal node are responsible for transmitting the data measured by the temperature and humidity sensor to the coordinator through the network, writing a program through the IAR development environment, and then transmitting the collected data, which is aggregate progressed in
the coordinator, to the computer through the RS232 serial port, and a simultaneously receiving and relaying the controlled data sent by the computer.

Figure 1. System Frame Design

2.1. Hardware Design of the System

2.1.1. Selection of Control Chip. The system adopts CC2530 as the control chip, based on IEEE 802.15.4 standard protocol and produced by Dezhou TI company (China). CC2530 chip has a high internal integration, enabling itself to work when connecting a small number of capacitors, resistors, inductors and crystal oscillators around the chip, and to quickly realize a low-power remote wireless solution when combining with Z-stack protocol stack (Gao Xiang, Deng Yongli, LV Yuanyuan, 2014).

2.1.2. Selection of Sensors. According to the collected data information of temperature and humidity, the system selects the appropriate temperature and humidity sensors: DS18B20 and SHT11. The two kinds of sensors have the characteristics of “small size”, “simple structure”, “high flexibility”, “stable performance” and “low power consumption”. The main parameters are shown in Table 1.

Table 1. Sensor Parameters

| Sensors  | Main Parameters       |
|----------|-----------------------|
| DS18B20  | Range -10~+85         |
|          | Accuracy ±0.5          |
| SHT11    | Range 0~100%          |
|          | Accuracy ±3.0          |

2.1.3. Design of Network Layer. This system adopts mesh network topology as the network layer design of the system to be developed, and builds three modules of the sensor network, namely coordinator, router and terminal equipment. The coordinator is the core of the network, being responsible for the construction of the network and monitoring the normal operation of the network. The coordinator, router and terminal nodes employ the self-organized way to build a wireless sensor network, which is mainly composed of infrared remote control signal transceiver module, key and
indicator module, LED display module, RS232 interface module and power module. The terminal node is mainly responsible for collecting data, and sending the collected data to the coordinator through ZigBee network. In addition, the modules of router and the terminal node are same structured, and can also collect relative temperature and humidity data.

2.2. Software Design of the System
The software design includes coordinator node software design, router node software design and terminal node software design. To realize the software design of the whole system, it employs ZigBee protocol stack, which is freely supported by CC2530 of Dezhou TI company (China), C Programming Language and the compiler system of IAR Embedded Workbench C/C++compiler, which supports many microprocessors and integrates development environments, real-time operating systems and middleware, development kits, hardware emulators, and state machine modeling tools.

2.2.1. Software Design of Coordinator Node. The coordinator node is mainly to configure the channel and establish ZigBee wireless network, allocate network address and send the network access response, and send the received temperature and humidity data to the PC through the serial port. The software workflow is as shown in the Figure 2. For different terminal nodes, different IDs can be given to the terminal to distinguish different monitoring areas. In the process of cyclic detection and processing, the coordinator integrates the data from different areas and then sends them to the PC.

![Figure 2. Coordinator Workflow](image)

2.2.2. Software Design of Router Node. Routing node is the basic part of the data collecting scheme of temperature and humidity. In the terminal node, data collection and simple packaging are mainly carried out, and then the data is transmitted to the routing node for data addressing and forwarding. The process of ad hoc network is easy, but power consumption is involved because of the data hugeness (Ding Fei, Lu Zili, 2018). After finishing the initialization, router nodes join the network of gateway nodes, and send information to inform the neighboring sensor nodes that they need to start the function of searching, joining and system binding.

2.2.3. Software Design of Terminal Node. The terminal node is mainly responsible for collecting data and sending the collected data to the coordinator through ZigBee network. When the data collection task needs to be performed, an event can be set to realize the collection and transmission of sensor
data in the event processing function. The terminal node is in a low power consumption state after sending data, as it can still receive and process the wireless data although in a circuit off state. When receiving the collection instruction, the terminal node starts to collect data, and can even decide to interrupt the collecting work according to the sleep timer’s overflowing. At the same time, the threshold value of detection environment parameters should be analyzed, and the corresponding processing tasks should be identified and controlled according to the threshold state.

Figure 3. Terminal Node Workflow

2.3. PC Software Management Platform
PC software management platform is to collect and monitor the temperature and humidity of the environment. The management platform is based on the web mode. The user management and parameter setting can be realized when a user enters the platform by inputting his/her account and password for the platform. The platform interface can show the collected data in real time, and can also intuitively display the data in the way of a curve chart.

3. Experimental Results and Analysis
After the coordinator node, router node and terminal node are arranged according to certain requirements, each node is powered on and the system is debugged. After debugging, the terminal node joins the wireless network to collect data, and sends temperature and humidity data to the management platform through the wireless network and RS232 serial port every 10 minutes. After the management platform establishes the connection with each detection point and collects the data, it starts to process the data. The data processing process will be displayed on the system interface in real time. In order to ensure the real-time data, it will refresh the data processing interface regularly. By watching the curve chart and the change of temperature and humidity, the environment can be monitored.

4. Conclusion
This system uses ZigBee technology to establish a low-cost, low-power, high-precision environmental temperature and humidity monitoring system, and try to change the technical defects of the traditional environmental temperature and humidity monitoring method of "low efficiency, large measurement error, random improvement effect". The key to solving this problem lies in how to change the problems of "short distance, multi node, wiring redundancy" and other field monitoring problems of
wired transmission. ZigBee wireless sensor network can solve those problems perfectly. Currently, it lacks the IOT application to develop system products, especially based on ZigBee's research on environment temperature and humidity wireless transmission system. This study attempts to combine the ZigBee with monitoring technology in the development of the environment temperature and humidity wireless transmission system.

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References
[1] Ding Fei, Lu Zili. [J]. sensor and micro system of fully mechanized mining face spray and dust suppression system based on wireless sensor network and CAN bus technology, 2018, 37 (10): 105-107+110.
[2] Gao Shouwei, Wu Canyang. ZigBee technical practice course [M]. Beijing: Beijing University of Aeronautics and Astronautics, 2009.
[3] Gao Xiang, Deng Yongli, LV Yuanyuan, et al. Research on ZigBee network energy saving algorithm based on protocol stack [J]. Journal of sensor technology, 2014, 27 (11): 1534-1538.
[4] Jiang Zhong, Liu Dan. ZigBee technical and practical training course [M]. Beijing: Tsinghua University Press, 2014.