Design and Implementation of intelligent Home monitoring System based on mobile robot

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Abstract. With the aid of Alibaba Cloud platform, this system builds a cloud database server, and uses short-distance wireless communication ZigBee one-to-many networking technology, RFID technology and Android development and application technology to realize mobile phone clients’ remote real-time acquisition of indoor and outdoor parameters transmitted by mobile robots, and a monitoring system that can be automatically adjusted. The mobile robot car walks indoors according to a predetermined track, and detects the greenhouse degree, light intensity, combustible gas concentration and other environmental parameters of each indoor location in real time and transmits them to the mobile APP terminal for real-time display. By comparing the indoor terminal parameters and set values, the home lighting, fan curtains, etc. can be automatically adjusted by mobile robot or manually adjusted by mobile APP. Finally, the system has been tested as a whole, and the test results show that the system has successfully achieved the expected goal, and the operation is convenient, with a certain market practical value.

1. Introduction
In today's world, the Internet of Things has become the second largest network in the world after the Internet. With its rapid development, it has become an important technology in the information technology industry. Therefore, more and more scientific and technological products have begun to be integrated into People's Daily life [1]. Since its development in 2014, smart home has made great progress in China. Its development has completely realized a whole transition from a single intelligent product to a complete system of intelligent devices. The smart home system has also gradually come into the public's vision, and the field of smart home has been gradually paid attention to by more and more people [2].

With the aid of Alibaba Cloud platform, this system builds a cloud database server, and uses short-distance wireless communication ZigBee one-to-many networking technology, RFID technology and Android development and application technology to realize mobile phone clients’ remote real-time acquisition of indoor and outdoor parameters transmitted by mobile robots, and a monitoring system that can be automatically adjusted. The mobile robot car walks indoors according to a predetermined track, and detects the greenhouse degree, light intensity, combustible gas concentration and other environmental parameters of each indoor location in real time and transmits them to the mobile APP terminal for real-time display. By comparing the indoor terminal parameters and set
values, the home lighting, fan curtains, etc. can be automatically adjusted by mobile robot or manually adjusted by mobile APP.

2. Introduction of Internet of Things Technology

ZigBee, also known as purple bee communication, is a low energy consumption, low cost, low complexity wireless communication technology. Its standard is based on IEEE 802.15.4 standard. At present, the working frequency of ZigBee is divided into two types: 868 / 915MHz and 2.4GHz, of which 2.4GHz is the global available frequency band [3]. ZigBee standard divides the protocol standard into four layers: application layer, network layer, MAC layer and physical layer. Its standard simplifies the transport layer, session layer and presentation layer of the traditional OSI seven layer protocol standard. Each layer of ZigBee protocol is connected with each other through the interface, and the lower layer will provide services to the upper layer [4]. There are three main network topologies in ZigBee wireless sensor network, which are star network structure, tree network structure and mesh network structure [5].

RFID, also known as radio frequency identification technology, mainly uses radio waves, that is, electromagnetic waves to exchange data. Its application range is very wide, and its safety performance is very high. It can work freely in various working environment modes, and the signal is less affected by the environment, such as rain, snow, haze, paint, dust and other media, so the impact is less. It is widely used. Its frequency is generally UHF, HF and LF [6].

3. Overall Design of the System

According to the design goal, the system is mainly divided into three parts: the first part is the bottom layer of smart home, the middle gateway layer and the mobile app application layer. The bottom layer of smart home is the establishment of home network completed by wireless networking technology. In the system, it mainly completes data collection and command sending and receiving, and the middle layer is gateway layer. It mainly uses cloud service technology to store data, connect the bottom layer and application layer for communication, and connect with mobile terminal equipment through WiFi, which is responsible for transferring data to application layer. The mobile terminal device, at the same time, receives the command from the mobile terminal control device. Mobile app application layer mainly realizes the monitoring and control of real-time data of home environment. The overall scheme design of the system is shown in Figure 1.

![Figure 1. overall scheme design of the system](image-url)
4. System hardware design
The main purpose of the hardware system design is to use ZigBee wireless communication technology to form the bottom layer of smart home wireless sensor network. The parameters and commands are transmitted to the gateway layer. The core chip of ZigBee networking is completed by CC2530 chip. The whole hardware part is mainly divided into one ZigBee coordinator module and two parameter detection terminal node modules, including one mobile terminal node consists of two ZigBee terminal nodes placed on the mobile robot module for real-time parameter detection; three ZigBee control terminal node modules are used to control the terminal node module. The parameter detection terminal node module is mainly related to temperature, humidity, illumination, human body, PM2.5, smoke transmission. The sensor builds peripheral circuit for parameter detection; the control terminal node is mainly connected with the electric fan and bulb, and carries out automatic or manual control according to the parameters. The overall structure of the hardware design is shown in Figure 2.

![Diagram of hardware design](image)

Figure 2. Overall structure diagram of hardware design

The bottom wireless sensor network is mainly composed of coordinator and terminal node. Coordinator is the core of the whole system, responsible for the construction of the whole smart home network, as well as data transmission and processing functions. The main control chip used by the coordinator is also CC2530, which has the smallest system. The coordinator is connected with the
embedded device through the serial port. The coordinator receives the parameters or commands from the terminal node to the gateway layer. It also receives the data from the gateway layer through the serial port, and then transmits it to the terminal node for control through ZigBee wireless network. It is mainly connected with the embedded device serial port of the gateway layer[7].

After joining the network, the parameter detection terminal node is responsible for the data collection, sending and receiving, and command receiving process in the system network. All data collection in the system is realized by various sensors. The parameter detection terminal is also connected with each sensor module by CC2530 module, which is divided into a fixed parameter terminal node and a mobile terminal node. The control terminal is mainly used to control some equipment in the home, such as fans, lights and curtains. The control terminal and the hardware system of the detection terminal equipment are all using CC2530 module. Then connect other modules to complete the control function. The mobile parameter detection terminal is mainly equipped with DHT11 digital temperature and humidity sensor, gy-30 light sensor and hc-sr501 human body detection sensor, which are used to detect indoor temperature and humidity, illumination and whether there is or not. DHT11 pin mainly follows the P0 of CC2530. The gy-30 light sensor mainly uses A0 pin to get the illuminance value, which is connected with IO pin P0 of CC2530. The hc-sr501 human body detection sensor and IO pin P0 of CC2530 module_6 pins are connected to complete the detection function of moving parameters.

The fixed parameter terminal is mainly equipped with mq-2 smoke sensor and laser particle sensor to detect the concentration of combustible gas in the kitchen and PM2.5 concentration in the atmosphere. When mq-2 smoke sensor is connected with CC2530, its aout output pin is mainly used to get the correct value of smoke concentration, which is connected with IO pin P0_6 connected. When the laser particle sensor is used, RX and TX pins are cross connected with the serial port interface of CC2530 module. The control terminal is mainly used to control some equipment in the home, such as fans, lights and curtains. The control terminal and the hardware system of the detection terminal equipment are all using CC2530 module. Then connect other modules to complete the control function. The control curtain uses the steering gear module, the steering gear module and CC2530 mainly follow P1. When it is set to 1, the steering gear module rotates clockwise and the curtain is closed. When it is set to 0, the steering gear module rotates clockwise, and the curtain is opened. The lighting control and fan design in the bedroom are also controlled through the terminal node. The module used is also the CC2530 module. Because the lamps and fans used are DC, one end of their pins is connected to 5V, and the other end is directly connected to the IO port of CC2530. Through the output of high level, the lamp and fan can be directly controlled. The electric fan mainly follows P0_6 pin, the bulb is mainly connected with P0_7 connected.

The mobile robot mainly carries two terminal nodes and adds sensors to act as the mobile parameter detection terminal node. According to the established track, it can detect the sensor information of each room in the home in real time, and join in the wireless sensor network of the home to complete the transmission of the detected data, reduce the transmission of data, and make the home system more stable. This makes it more intelligent. The design of mobile robot is based on C51 series single chip microcomputer as the micro controller of the system. The AT89S52 chip is selected in the system, and four groups of QTI infrared sensors are used in the tracking module to detect the black track on the ground[8].

In the gateway layer, embedded devices are mainly used. Considering the cost of equipment, the arm processor which is widely used is finally selected. There are many series of ARM processors, and there are many different models, and different types of processors have different performance, and the cost is more selective. The system is equipped with a 4G core memory of Samsung, which is equipped with a 4G core memory and is equipped with an emynb hard disk. The working voltage is 2.65 ~ 5.5V. In terms of operating system, it can support linux-qt / Android 4.2/ubuntu and so on, and has 320 external lead-in pins to meet users' various expansion requirements.
5. System design software
The system software design is divided into three parts: the design of the bottom network, the middle layer and the application layer of mobile phone app. The underlying network design is composed of system parameter detection terminal node, control terminal node and coordinator, which mainly collects and sends parameters and receives control commands.

The middle layer mainly includes gateway and cloud server. The bottom layer of smart home sends the collected data to the gateway through serial port. The gateway then forwards it to the database in the cloud platform of the alicloud server for storage, and the middle layer communicates with the application layer, so that the mobile app can receive the data sent from the bottom layer for display, and can also send commands to control the system terminal.

The application layer is mainly the design of mobile app, which receives the data from the underlying terminal sensor transmitted from the cloud server for detection. At the same time, the application layer can automatically send command data to the cloud server to complete the control of the bottom terminal node, and realize the manual and linkage functions.

The bottom layer, the middle layer and the application layer constitute the whole system, which is also an important part of connecting the whole system in a network environment. The overall system diagram is shown in Figure 3.

![Overall system block diagram](image)

The coordinator program starts to run first, and after execution initializes the Z-Stack protocol Stack, the coordinator will create the Zigbee wireless sensor network. Devices in the same network can join or exit the network at any time. When the device joins or leaves the network, it will trigger events that change the network. The coordinator in the whole network, in addition to being responsible for the establishment of the network, accepts the 9-byte protocol data collected by multiple sensors from the terminal and sends it to the 4412 development board through serial port. At the same time, it can also receive commands sent from the mobile APP terminal and send commands to the terminal node via broadcast.

The terminal node of parameter detection is mainly a mobile terminal built on the robot and a terminal fixed in the kitchen, which is equipped with sensors to detect various indoor environmental parameters. Each sensor collected data using the previous design the nine byte data from the data protocol will be sent to the coordinator, the coordinator to send the data to the middle tier gateway, the gateway via remote connect to the database, the data parsed and stored in the database, and finally,
mobile phone APP remote connect to the database, you can access to the underlying terminal sensors to collect information.

After the control terminal node joins the network, it is mainly to respond to the commands sent by the mobile APP. Mobile phone APP to send commands to control data, the data stored in a remote database command table, gateway scanning command table in the database, see if there's any data changes, if any, to get the data, and then sends the data to the coordinator, the coordinator in the data sent to the control by means of radio terminal node, when the control terminal node order to receive the data from the coordinator, and the lamplight of the sitting room and bedroom to fan on operation.

Gateway devices communicate with cloud servers through Socket programming, and ZigBee coordinators communicate with each other through serial ports. When the gateway device is powered on, the program is initialized, and the gateway enters the state of data monitoring, waiting for the arrival of data. After receiving the data, the access data should be judged. If it is from the underlying Zigbee network, it means that it is the received household environment parameter data, and the data will be uploaded to the cloud server. In case of Socket data, it means that the cloud server sends control instructions to the home control terminal and transmits the data to the coordinator through a serial port. If the data is illegal message data, directly discard, re-enter the listening state.

Mobile APP is mainly divided into three interfaces, namely login interface, monitoring interface and control interface. The login interface is mainly used to realize the login of users. There are two ways for users to log in the system. One is that users log in according to the account password provided; the other is that users log in after registration. The mode selection interface is used to select the specific working mode of the system. Different working modes can be set according to the actual needs of users, such as night mode and day mode. The design of detection interface is divided into two, one is the home monitoring interface of the whole system, the second is the interface to a specific room.

6. Conclusion
This topic mainly combines ZigBee wireless communication technology, in combination with sensor technology, radio frequency identification technology, cloud services and the Android technology try to complete the smart home monitoring and control, increase the mobile robot to reduce the data real-time transmission, using the cloud server technology to store and transfer data in real time, remote terminal control device can automatically adjust the function, the user mobile phone APP to household environment parameters in real time display, and manual to control the smart home environment.

Through the overall test, the system can well complete the monitoring function of each parameter of the smart home system. In view of the current needs of people and the development of smart home, the design of the system has a large space for improvement. For example, more functions can be added to mobile robots, or a camera in the system, which can be real-time display of surveillance family pictures through the mobile phone. Multiple alarm functions are added at the same time to better improve the whole system.

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