Design and implementation of smart home remote monitoring system based on ARM11

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Abstract: Considering the disadvantage of smart home on wiring, maintainability and mobility, a scheme for remote monitoring of smart home is proposed based on ARM and ZigBee. Building home network based on ZigBee Technology, and then gateway is developed with S3C6410 which Linux operating system is embedded, using TD-LTE wireless terminal system as external network, so that the user could see the scene of the environment. Using ultra-low power consumption and fast ARM11 processor so that real-time monitoring data is more accurate. The system can be widely used to monitor the environmental data of hospitals, factories and other places. It has good development prospects.

Keywords: smart home; remote monitoring; ARM11; ZigBee

Introduction

With the obvious improvement of people's living standard, intelligent home environment has gradually attracted people's attention. Smart home refers to the use of advanced computer network communication technology, embedded technology and sensor control technology to combine various subsystems related to home life, through integrated management, to make home life more comfortable and safe.

Smart home system can be divided into three parts: home network, home gateway and external network[2]. At present, in the design of the smart home control system, the home network is generally constructed using a wired connection method based on a bus and a power line. These connection methods all have the disadvantages of complicated wiring, corrosion of the line, inconvenient maintenance, and affecting the interior appearance.

ZigBee is a wireless network technology with close range, low complexity, low power consumption, low data transmission rate and low cost. It has been widely used in many fields. S3C6410 processor is based on ARM1176JZF-S kernel, CPU main frequency 667MHz, 256Mb/s NAND FLASH, 4 way UART serial port, I2C (Inter-Integrated Circuit) bus interface, A/D input interface, etc.[5].

This paper constructs a family network based on ZigBee technology, and then gateway is developed with S3C6410 which Linux operating system is embedded, using TD-LTE wireless terminal system as a family network, to achieve local and remote control of smart home system.

1 Structure Design of Monitoring System

Smart home remote monitoring system is mainly composed of a smart home controller and several ZigBee monitoring module. The system can communicate with each other through 4G network and ZigBee. Users can control the electrical and lighting devices through the mobile phone, and also can get the temperature, brightness and other environmental information, and alarm information such as theft prevention, fire prevention and gas leakage prevention. The smart home controller can intelligently control the electrical and lighting devices in the home according to the environmental information collected by the sensors. The specific architecture of the system is shown in figure 1.
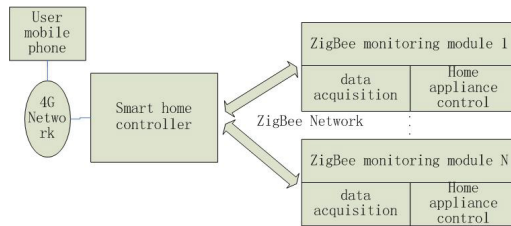
Fig. 1 System architecture diagram

2 Hardware Design of Monitoring System

2.1 Hardware design of intelligent controller

Smart home controller is the core component of the smart home system, which is composed of ZigBee coordinator, GPRS module, touch screen and sound light alarm device. Smart home controller is the control center of the whole remote monitoring system, and its hardware core is the central processor. From the aspects of function, expansibility, operation system support and power consumption, the powerful ARM11 microprocessor S3C6410 is selected as the main processor. The man-machine interface adopts touch screen to display the state information of the home equipment and the information sent by the user's mobile phone, and the user can conveniently input the related commands to control the household equipment. The sound and light alarm device uses the red light flashing by the warning lamp and the shrill alarm sound of the buzzer, so as to realize the function of the warning user. The hardware structure of smart home controller is shown in Figure 2.
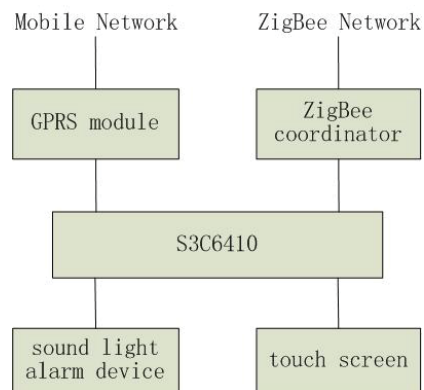

Fig. 2 Hardware structure diagram of smart home controller

The controller has two communication modules: the ZigBee coordinator and the GPRS module. GPRS module uses HUAWEI's GTM900-B and ARM for data transmission, through the AT command to complete the

control of the module, to achieve SMS transceiver. The ZigBee coordinator is responsible for building the ZigBee network and connecting all the monitoring modules to the network. After the successful establishment of the network, the environment monitoring information and alarm information from each monitoring module are collected, and data interaction is carried out with the ARM processor through the serial port.

2.2 Hardware design of monitoring module

Smart home monitoring module is used to collect and test information and send it to the smart home controller. At the same time, it receives the control instructions from the smart home controller to realize the intelligent control of household appliances. The monitoring module is composed of main control module, environmental information detection module, security information detection module, home appliance control module and power supply module. The hardware block diagram of smart home monitoring module is shown in figure 3.
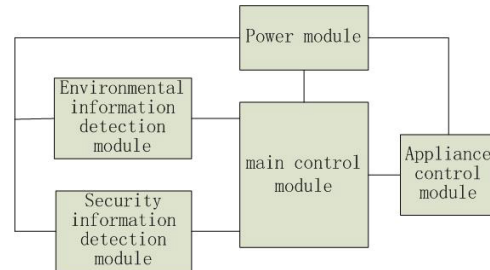

Fig. 3 Smart home monitoring module hardware monitoring chart

The core part of the main control module is a RF single chip 2.4GHz CC2530 produced by Chipcon company, which conforms to the IEEE802.15.4 specification. The chip integrates the ZigBee RF front-end, memory and microcontroller based on the 51 kernel. The hardware supports Carrier Sense Multiple Access / collision detection (CSMA/CA), and the operating voltage of the 2.0-3.6V is conducive to low power consumption of the system. Through the ZigBee coordinator module connected to the smart home controller, the wireless star ZigBee network is established in the indoor, so as to realize the indoor security and home appliances wireless ZigBee network control.

The environmental information detection module is composed of temperature and humidity detection module and brightness detection module. The function of

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temperature and humidity detection module is to collect the temperature and humidity information of the room in real time, and then transfer the information through the ZigBee module to the smart home controller by the main control module, so as to realize the intelligent control of household appliances. The core component of temperature and humidity detection module is temperature and humidity sensor AHT2M1. The sensor integrates temperature measurement and humidity measurement, and the output voltage range is wide, which is conducive to A/D conversion. Moreover, the linearity is good, the resolution and the measurement precision all meet the application requirements of smart home. The luminance detection module adopts photosensitive resistance, through measuring the change of the voltage at both ends of the photosensitive resistance, through the A/D conversion, and uses some algorithm to achieve indoor brightness acquisition and processing.

The security information detection module is used to detect indoor gas leakage and thieves' invasion, which includes combustible gas detection module and pyroelectric infrared detection module. The combustible gas detection module is composed of MQ-2 combustible gas sensor and a divider resistor and voltage amplification circuit. The threshold voltage is set by experiment. When the detected indoor combustible gas concentration reaches a certain value, the voltage exceeds the threshold voltage, the main control module will immediately transmit the information to Home Furnishing intelligent controller, the controller will inform users of SMS information, at the same time trigger alarm device, so as to realize the fuel gas leak alarm. The core component of pyroelectric infrared detection module is the pyroelectric infrared sensor LH1958. The sensor is a three pin metal package. It has the characteristics of high sensitivity, low power consumption, good concealment and so on.

The control module of household appliances is controlled mainly according to the function of household appliances. Intelligent lighting control is Home Furnishing controller lighting control instructions to achieve through the ZigBee network to send to the corresponding ZigBee control node, different home appliances set different identification code, so as to realize the intelligent recognition of different appliances Home Furnishing controller.

3 Software Design of Monitoring System

3.1 Embedded Linux operating system

The system uses ubuntu9.0 kernel version Linux2.6.28 as the development platform in the Linux system of PC machine under the need to establish a cross compiler environment for compiling, running and debugging on the processor kernel and applications, then according to the needs of the development of hardware and function, cutting and transplantation of Bootloader, kernel, file system, compile the generated image file, and download to the processor.

3.2 ZigBee coordinator setting

The ZigBee coordinator system is mainly used to set up a wireless network, ZigBee network address allocation monitoring node, control commands and receive from the environmental monitoring node information and security information to the monitoring node, and the received data are uploaded to ARM, finally to messages sent to the remote user terminal. The application layer initialization completed first coordinator, then initialize the I/O port and open the global interrupt, then the coordinator initializes a channel and build a ZigBee network, ZigBee monitoring node is added to the network through the authentication response. The program flow of the ZigBee coordinator is shown in figure 4.
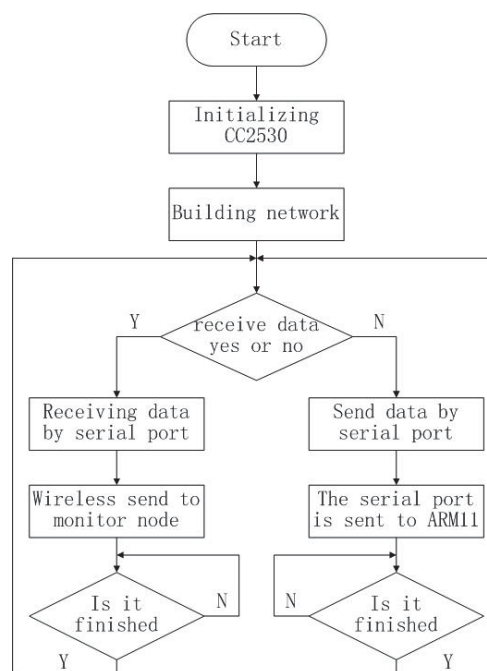
3.3 ZigBee terminal node setting

ZigBee terminal node is a wireless ZigBee node controlled by ZigBee coordinator. The initialization of the ZigBee terminal node also includes one initialization, initializing the I/O port and opening the total interrupt. Then try to join the ZigBee network, only with the ZigBee coordinator set consistent terminal node can be added to the network.

The ZigBee terminal node collects the environmental information once every certain time, and uploads the information to the ZigBee coordinator. If the security information detection module detects the leakage of combustible gas or thieves invasion, the ZigBee terminal node directly enters the terminal processing flow, and uploads the alarm information to the smart home controller. For the home appliances control commands from smart home controller, ZigBee terminal nodes directly control the home appliances in the wireless data receiving interrupt processing process. The control flow of the ZigBee terminal node is shown in figure 5.
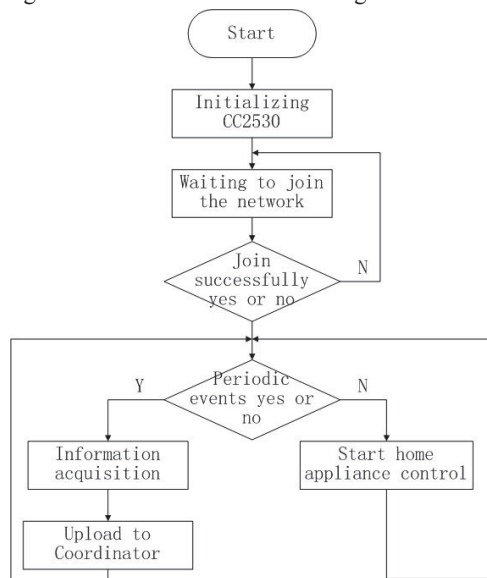

Fig. 5 Flow chart of ZigBee terminal node program

4 Performance Testing

After the system hardware and software design is completed, the selection of Tianjin University of Technology Electrical Engineering Electronics Laboratory 414 as the location of the test. The reason is that the laboratory environment is relatively stable, which is good for observing the measured data. The system consists of a star network topology by an smart home controller and three ZigBee monitoring module, smart home controller and ZigBee monitoring module of the distance of ten meters, adjacent ZigBee monitoring module for a distance of fifteen M. Specific test sites within the laboratory next to the laboratory window, heating and laboratory bench three locations. The following temperature and humidity testing as an example:

The measurement result of the temperature shown in Table 1.

Table 1 Comparison of temperature measurement result

	Method 1	Method 2	Method 3
Laboratory window	13.9℃	16.21℃	13.85℃
Laboratory bench	18.1℃	20.12℃	18.26℃
Laboratory heating	23.5℃	25.88℃	23.95℃

Method 1 in Table 1 using a temperature measuring instrument measuring the temperature and humidity, the use of Method 2 ARM9 environment monitoring system based temperature measurement, using the measurement method of 3 ARM11 and Linux environment monitoring system based on the temperature.

Above table shows that ARM11 and Linux environment monitoring system based preferably on the temperature measurement is completed, the measurement results of temperature and humidity measuring instrument is almost the same, having good reliability.

The humidity measured in this paper is the relative humidity, expressed as a percentage of the ratio of the actual vapor pressure in the air to the saturated vapor pressure at the current temperature. The comparative humidity measurement results are shown in Table 2.

Table 2 Comparison of humidity measurement results

	Method 1	Method 2	Method 3
Laboratory window	40%RH	42.41%RH	40.56%RH
Laboratory bench	31%RH	36.32%RH	31.22%RH
Laboratory heating	21%RH	22.35%RH	21.31%RH

Method 1 in Table 2 using the measured temperature and humidity measuring humidity, environmental monitoring system using the method based on measuring the humidity ARM9, Method 3 using the measured humidity environment monitoring system based on Linux

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and ARM11.

Finally, the result of the measurement comparison, the humidity measurement system designed herein with greater precision and accuracy, while the more sensitive the system can change the indoor humidity reaction. Lower humidity measurement accuracy and the temperature and humidity meter, and the reaction insensitive. After many tests, the system runs stably, the information acquisition is timely and accurate, the executive mechanism reflects the speed fast, and has the advantages of simple wiring and good mobility.

5　Concluding Remarks

This paper introduces a design of smart home remote monitoring system, Building home network based on ZigBee Technology, and then gateway is developed with S3C6410 which Linux operating system is transplanted into, through the access of the GPRS module to achieve the remote control and alarm functions. The powerful functionality of the system, low power consumption, simple and can be viewed anytime, anywhere using a mobile phone in real-time environmental data, to achieve the purpose of the preliminary intelligent management of home devices, but the design of the hardware and software extensions should be further improved, in order to achieve a high degree of system intelligence.

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