Intelligent Home Monitoring System Based on Internet of Things

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Abstract—To realize the remote monitoring and intelligent management of the home environment, intelligent home remote monitoring system is developed based on the Internet of things technology. By using RF transceiver chip and GPRS technology, a smart home system scheme for wireless networks is established. The hardware and software design of sensor nodes and GPRS wireless communication base station is completed. Sensor nodes are used to monitor the acquisition of field data. Based on GPRS technology, the wireless communication base station realizes the uploading of monitoring data. The wireless communication between the node and the base station is realized by radio frequency transceiver chip SI4432. The results show that the system reaches the aim of expected design function. Therefore, it can be concluded that the system can meet the intelligent monitoring of the home environment.

Keywords—Intelligent home, Internet of things, wireless communication network, GPRS, database

1 Introduction

With the rapid development of science and technology, living standards are gradually improving. People are constantly making new demands on their surroundings [1]. Nowadays, people are no longer simply confined to the pursuit of housing area and location. At the same time, the decoration materials, household appliances function and safety protection measures are put forward higher requirements. Especially with the development of the Internet, the network has gradually entered every household [2]. People enjoy the convenience of the network. Through the network, people can manage the home environment. In recent years, research on intelligent buildings, intelligent communities and smart homes is very popular [3]. Some research results have even been applied to engineering practice, which has a broad market prospects. Combined with the Internet of things technology, the design scheme of intelligent home remote monitoring system is put forward. Intelligent and centralized management of the residential area is realized. Householders can enjoy comfortable and convenient home life.

Compared with developed countries, the development of smart home in China is not yet mature [4]. In the design of home appliances, some companies have introduced the concept of smart home. However, they cannot form systems and networks at work [5]. In China, the concept of smart home is still very vague, and the domestic smart home system market has yet to be developed [6]. With the rapid development of Internet of Things technology, intelligent home system ushered in a new growth opportunity [7]. Although the study of intelligent community system is hot, the real success of application case is very rare. Many experts and scholars have also carried on the design demonstration. Some enterprises have introduced the concept and scheme of intelligent furniture. Therefore, the demand, cost, function and framework of intelligent community system need further study in practical application [8]. The function and structure of intelligent home remote monitoring system are very complex. It is the core component of the intelligent community system. The system can greatly enhance the function of intelligent community system and promote its development.

2 State of the art

Smart home concept originated in the United states. After nearly forty years of development, it has been widely promoted in countries all over the world. The concept of smart home has gone through a gradual process. First of all, in the late 70s of the last century, a home bus for household appliances appeared in the United states. In 1988, design standards for household appliances were drawn up. At the same time, the concept of home automation has emerged in the field of intelligent building. The formulation of these industry standards and the development of related technologies have laid the foundation for the practice of smart home. In 1984, engineers carried out a bold vision of the concept of smart home. A preliminary intelligent transformation of an intelligent building in Connecticut has been made. The transformed buildings have the ability to monitor electrical equipment such as lighting, air conditioning, elevators and so on. As a result, it opens the prelude to the development of smart home. Since then, Europe and the United States, Japan and other countries have proposed intelligent home program. Smart home industry in these countries made great progress, such as the United States X-10, Lonwork, Japan's HBS and the European Union's EIB and so on. They have high popularity in the world.

Europe, the United States, Japan and Singapore are in advanced position in this field. Smart home has been widely used in these countries. Based on the great potential of the smart home industry, many multinational companies have developed their own smart home products. The representative smart home products and service providers are NEYWELL company, HAL company, LG company, Vantage company. The Vantage home automation system treats the device group to be controlled as an organic whole. It can not only control the effective independence of one device, but also control the joint of many devices to realize the coordination and cooperation among the equipment. The whole system has realized the complete modular design. With powerful functions and highly scalable and highly flexible, it has a strong competitive edge in the smart home market. The ALdeluxe smart home system is designed and developed by HAL Corporation, and integrates all the control of the furniture equipment on the PC. The smart home system developed by HAL uses power line communication, so it does not need to layout new lines in the house, which greatly simplifies the construction of smart home system.

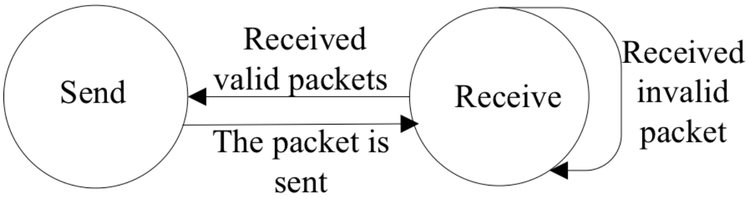
Many famous international companies have invested much effort in the development of smart home. However, the wide range of intelligent home is still a long way to go. The biggest constraint to the popularity of smart home is the lack of a unified communication protocol standard in the smart home industry, which makes the interconnection between devices difficult to implement. The only way to resolve this restrictive factor is to establish internationally agreed standards. At present, the major manufacturers and related organizations are working together to establish intelligent home system equipment within the network interface between the standard and data transmission protocol. The introduction of international standards for smart home industry will be mature.

At present, the smart home system adopts the wired mode of communication to communicate. In this way, in building smart home systems, a lot of work is needed to pave the wiring. This system builds intelligent home system based on wireless communication. It does not require a lot of effort to build communication lines. This reduces system maintenance costs. In addition, the system adopts GPRS network. Therefore, the monitoring data can be received at anytime and anywhere through the mobile terminal, and the user can know the home environment in the process of moving. The development status of smart home is discussed, and the wireless intelligent home system is developed with GPRS technology. At last, the wireless communication function of the system is tested. It includes wireless communication transmission distance test in different environment, data communication rate test of whole system and power consumption test of modules under different working conditions.

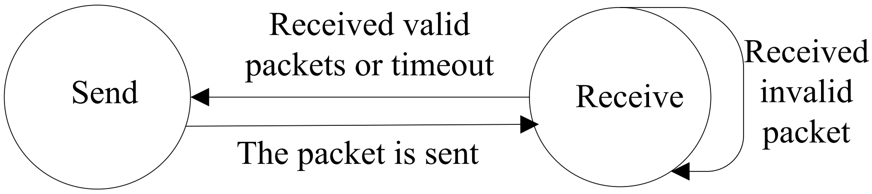
3 Methodology

3.1 Design of wireless communication protocol

Throughout the communication process, the sensor node has been in a passive query state. It is ready to receive the instructions sent by the base station. When the communication base station issues the command to the node, the node receives the command and changes from the receiving state to the sending state, and sends a monitoring data packet or a RTC synchronous request to the base station. When the monitoring data or RTC synchronization request is sent, the node is re-entered into the receiving state. The whole process is repeated until the node stops working due to malfunction or other reasons. For the sensor node, in its entire life cycle, the wireless communication module has been in the transmission and reception of the state of alternating conversion. GPRS wireless communication base station needs to send query commands to the underlying nodes constantly. After sending the command, it immediately switches to the receive state to receive the feedback information of the node. When communicating with a node, a query command is sent to the next node. The whole process is repeated until all nodes under the base station are queried. Then, the base station packs the monitoring data of all the nodes received and uploads it to the monitoring center via the GPRS function module. The activity period of the sensor node and the wireless communication base station is shown in Figure 1.



(a) The wireless communication activity period of the sensor node



(b) The wireless communication activity period of the wireless communication base station

Fig. 1. The activity period of the sensor node and the wireless communication base station

3.2 The main flow of the sensor node

When the sensor node does not receive data, the RF chip is in the listening state. The microprocessor collects and monitors the sensor data and displays the data on the spot. The process is shown in Figure 2.

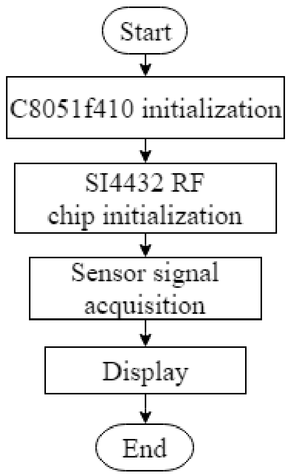


Fig. 2. The main flow of the sensor node

When the valid data is successfully received, the RF chip SI4432 in the sensor node disassembles the packet and removes the header and CRC parity bits to obtain the user data and place it in the receive FIFO. At the same time, an interrupt signal is generated. When the microprocessor receives the interrupt signal, it will generate an interrupt vector. The program will turn to interrupt the service routine.

3.3 The programming of monitoring software

The system uses TCP / IP protocol to achieve network communication. The protocol is connection-oriented for reliable transmission. Before the communication, it is necessary to establish a reliable connection with the receiving terminal. In the process of sending and receiving packets each time, the reliability of communication needs to be ensured by response mechanism. The TCP protocol segments the communication data and makes the order number for each data segment. After receiving each segment of data, the receiver needs to respond within the specified time. Otherwise, the sender needs to resend the segment data. The integrity of the transmitted data is guaranteed by this response mechanism.

The communication model adopts the master-slave model of the server and the client. For this system, the monitoring center of the server has a fixed IP address. It is in a passive connection state. The GPRS base station in the monitoring site is actively connected to the server. When the connection is successful, GPRS base station can send data to the server. The master-slave mode communication mechanism is the most basic mode for LABVIEW to implement TCP / IP network communication. In this mode, the base station sends data to the server continuously, and the server receives the data continuously. The specific flow of the two-machine communication is shown in Figure 3.

3.4 The hardware design of GPRS circuit

At present, the GPRS module, which is widely used in engineering field, is the SIM chip designed and developed by SIMCOM. This module is designed as a chip, which is compact and convenient for integrated circuit design. This design uses the SIM900A chip to realize the GPRS function. In addition, the TC module produced by SIEMENS company and the Q module of WAVECOM company also have a wide range of market applications. The SIM900A chip is small in size. It has high cost performance. The SIM900A module drives the LED lamp through the output pin NETLIGHT, and visually indicates the working state of the current SIM900A module through the frequency of the flashing of the LED lamp. When the lamp goes out, it indicates that the SIM900A module does not work. When the frequency of 64ms bright /800ms is extinguished, it indicates that the module is working, but it still does not search the network. When low frequency flashes with 64ms bright /3000ms are extinguished, it indicates that the SIM900A module has been searched to the network and has been registered. The GPRS module is communicating when the LED light flashes at a high frequency rate of 64ms bright /300ms. The hardware circuit is shown in Figure 4.

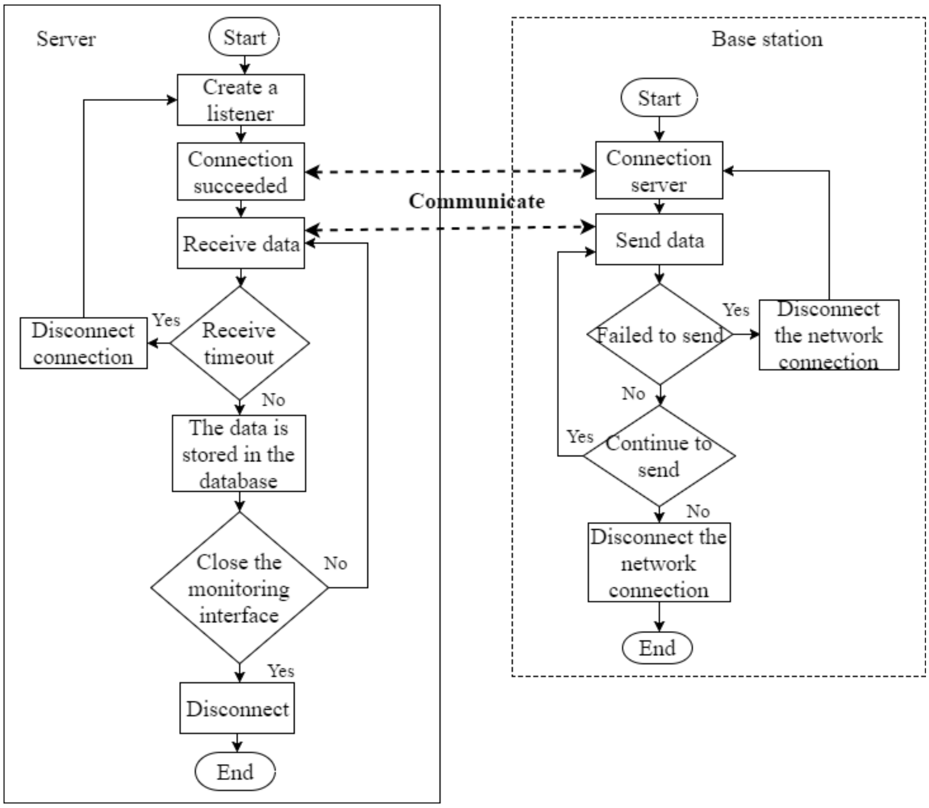


Fig. 3. The specific flow of the two-machine communication

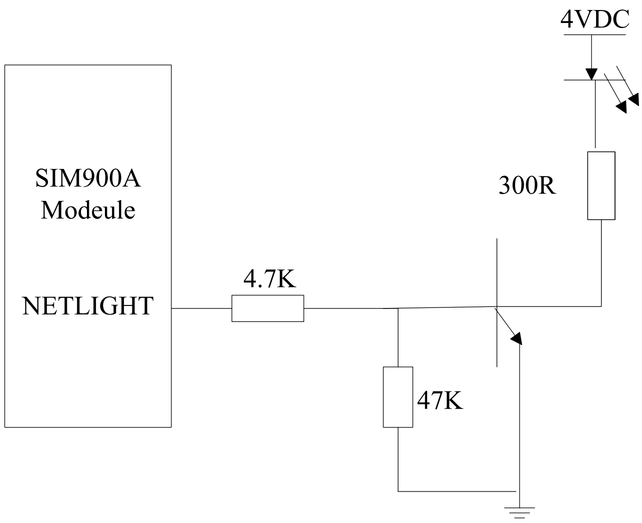


Fig. 4. Network status indication circuit

4 Result analysis and discussion

4.1 System test equipment

System experimental equipment mainly includes: GPRS wireless communication base station, four sensor nodes, DC power supply, oscilloscope, integrated temperature and humidity sensor CHTM-02, PC.

4.2 Indoor wireless communication transmission distance test

This experiment is mainly to test the wireless communication capability between sensor nodes and GPRS wireless communication base station. At a certain distance, if the two sides can communicate normally, the system has the radio frequency wireless communication capability under the condition. Because the system is to be used indoors, the sensor node and the GPRS communication base station may not be in the same room. In the transmission path, several walls are required to pass through, which cause great attenuation to the communication signal. Through testing, the transmission capacity of wireless communication is determined, and then the feasibility of the scheme is proved.

One of the SI4432 modules is placed in a room, and another SI4432 module is placed in another room. Under such conditions, the communication situation is tested. If communication is enabled, the two-module interval (increasing the transmission distance and the number of penetrating walls) is changed, and the communication test is performed again. The rest may be deduced by analogy, until the sender and receiver cannot communicate properly. The test results are shown in Table 1. By measuring, it can be seen that SI4432 has enough communication distance to meet the application situation.

4.3 Outdoor wireless communication transmission distance test

This experiment is used to test the wireless communication distance of SI4432 module in outdoor open space. The sensor nodes and GPRS wireless communication base stations are placed at a certain distance. Through monitoring center monitoring software, the sensor nodes are monitored in real time. If the monitoring center can collect the sensor node data, it can be proved that the wireless communication at this distance can be realized. The distance between the sensor node and the GPRS base station is increased to test. The test results are shown in Table 2.

4.4 Module power test

The power consumption of the GPRS base station is measured in three states. It includes GPRS data upload, node packet reception, and node data packet transmission. The power consumption of the sensor node when transmitting and receiving data is measured. The measurement results are shown in Table 3.

Table 1. Indoor wireless communication distance test

Test conditions	Test results
1 wall, spacing 5m	It can communicate reliably
3 walls, spacing 23m	It can communicate reliably
8 walls, spacing 75m	It can communicate reliably
9 walls, spacing 85m	It cannot communicate reliably. Some data packets are lost

Note: The wall thickness is 20cm

Table 2. Outdoor wireless communication distance test

Test conditions	Test results
Outdoor, no obstacle within sight distance, 50m	It can communicate reliably
Outdoor, no obstacle within sight distance, 100m	It can communicate reliably
Outdoor, no obstacle within sight distance, 300m	It can communicate reliably
Outdoor, no obstacle within sight distance, 500m	It can communicate reliably
Outdoor, no obstacle within sight distance, 1000m	It can communicate reliably

Table 3. The results of power consumption test

Test conditions	Supply voltage	Supply current	Power consumption
Base station, GPRS data upload	5V	330mA	1.65w
Base station, receiving node data packet	5V	70mA	0.35w
Base station, sending packets to nodes	5V	140mA	0.7w
Base station, no communication	5V	45mA	0.225w
Node, sending packets	9V	138mA	1.24w
Node, receiving packets	9V	98mA	0.882w

Through module power consumption test and wireless communication indoor transmission distance test, it can verify that the system can meet the actual application needs. The system can work normally and each part of the system can achieve the design goal.

5 Conclusion

A smart home system with wireless communication and integrated control is designed. The whole system collects information through sensor nodes, and realizes the wireless remote transmission of the monitoring data of the main node (GPRS base station) through the GPRS network. The monitoring center has a database to store the uploaded data and provide real-time inquiry function for the monitoring data. Aiming at the wireless communication capability of the system, relevant experiments are designed and tested. The experimental results show that the wireless communication capability of the system can meet the demand of residential networking. In addition, related experiments are designed to verify the functionality of the system.

The design of hardware and software of sensor node and GPRS base station is completed. The system can realize the main function. However, according to requirements, the functionality of the entire system needs to be improved to make it more user-friendly. Because the sensor nodes are not equipped with fixed sensors, different sensor modules can be connected to different environment parameters according to requirements. The sensor conditioning circuit is fixed, and its sensor output range is limited. Therefore, for some sensors, this node is not applicable. In order to improve the adaptability of the sensor nodes, more types of sensor signal conditioning circuits should be designed.

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