Design and Research of Embedded Gateway for Internet of Things Based on STEM32

Weixue Liu*

Chifeng University, Chifeng, 024000, China

*corresponding author email: 631862071@qq.com

Keywords: Internet of Things; Remote Control; STM32F Embedded System

Abstract: Aiming at the wide application of the Internet of Things in smart sensor control, using embedded technology and a modern high-speed development network platform, an embedded gateway serving the Internet of Things intelligent acquisition system is designed. The system of the embedded gateway is composed of STM32F embedded main device, router, GPRS module and wireless coordination equipment. The main device system uses μC / OS-II operating system, which is connected to the router through the 100M Ethernet port; through the serial port and GPRS module and wireless Coordinate equipment connection to achieve real-time data display function, historical data storage function, gateway control parameter setting and query function, Internet network remote access and control function, GPRS network remote access and control function.

1. Introduction

With the rapid development of the Internet of Things technology, an important realization in the Internet of Things technology is to transmit the data collected by various sensor control nodes to the user's mobile phone or PC through the Internet. In order to meet this demand, a Can act as a coordinator for wireless sensor networks Gateway device for GPRS transmission and network connection. The IoT gateway device should serve as a server, which is the link between the IoT sensing layer and the traditional communication network. It can realize the protocol conversion between the sensing network and the basic network and different types of sensing networks. It is interconnected and allows sensing network access, flexible conversion of communication protocols, powerful system management, and a service gateway designed using embedded systems can effectively reduce costs.

In response to the above requirements, this design uses STM32F417 as the master device control chip, runs μC / OS-II real-time system as the device management system, and uses uIP as the TCP / IP network protocol stack. The master device also has keyboard operation and display functions, which can be performed Local setting or remote setting using PC. The GPRS module in the embedded gateway is connected to the embedded host device through the serial port. The wireless coordinator uploads the collected data to the embedded host device through the serial port. The host device can also send commands to the wireless coordinator. ZigBee wireless communication protocol sends commands to sensors [1].

2. Overview of Internet of Things Technology Research

Since the concept of the Internet of Things was proposed by the Massachusetts Institute of Technology (MIT) in 1999, this emerging technology has attracted worldwide attention. It not only plans the future direction of social development, but also brings us big data, cloud computing The new research field, as an important application field of the Internet of Things technology, smart home technology is making great strides towards people[2]. Internet of Things (Internet of Things) is the use of radio frequency acquisition signals, various sensors to acquire signals, Global Positioning System (GPS), radio frequency identification (RFID), wireless sensor networks, computer networks, etc. to establish a network of objects and things to achieve unified identification

management. And control. The application field of the Internet of Things covers all aspects of people's lives. The intelligent transportation, smart home, smart fire protection, industry 4.0, etc. developed now are benefiting everyone's life. The realization of the Internet of Things technology will present people with an unprecedented world of automatic control. All objects will have a control center second only to artificial intelligence, and work automatically without human intervention. The Internet of Things is a physical world network that connects people to things and things to things on the basis of network communication between people. Its characteristics are:

2.1. Comprehensive Perception

Comprehensive perception is to let each object have its own unique identification code, and can automatically exchange information in the established wireless sensor network through its own sensor.

2.2. Reliable Transmission

The Internet of Things has universal identification standards and a reliable network that can personalize and customize network communication methods. It sends the collected identification information to the network to realize the interactive sharing of information and form a wider area Internet of Things network.

2.3. Intelligent Processing

The terminal of the Internet of Things is no longer a traditional control terminal such as a personal computer (PC). It uses a public cloud service platform to process the collected information, uses various intelligent terminals to process the information, and transmits the processing results to People or equipment that need information.

3. System Hardware Design

The embedded gateway system mainly includes embedded main equipment, GPRS module, wireless coordinator and router. The embedded master device is connected to the router through the network port; it is connected to the GPRS module through the serial port, and the AT command is used to control the GPRS module; the serial port sends instructions to the wireless coordinator to indirectly control the wireless sensor group.

3.1 Embedded Host Device Hardware Design

The embedded device hardware platform is mainly composed of STM32F417 as the main control chip. The peripheral hardware circuits include liquid crystal display circuit, network port drive circuit, keyboard operation and serial port drive circuit.

STM32F417 is a controller developed by ST based on the Contex-M4 core. It supports up to 4 serial ports, and has a built-in 100M Ethernet MAC module. It can expand the FLASH memory module through the SPI bus and the EEPROM through the I2C bus[3].

In this design, a serial LCD is used. The serial LCD does not need to design a complex driver circuit. It only needs serial commands to control it. The display pages and controls can be downloaded to the FLASH of the LCD. The GUI interface is written according to the design requirements. The keyboard operation mainly provides users with the function of setting the gateway device locally[4].

The STM32F417 has a built-in MAC module. To achieve network transmission, an external PHY chip is required. The underlying network driver is the operation of the PHY chip. The TCP / IP protocol uses the uIP protocol stack. The connection to the GPRS module uses a serial port. The GPRS module is connected to the network, sending short messages, turning on and off, etc. The operation of the wireless coordinator is also controlled through the serial port and a custom protocol.

3.2 GPRS Module Hardware Design

The GPRS module mainly implements uploading the data collected by the sensor to the user's mobile phone, and the user can remotely control the sensor through the mobile phone. The GPRS module is connected to the embedded master device through a serial port. The main control chip of the GPRS module uses Philips' LPC2103, which mainly realizes the drive control of the GPRS transceiver (SIMCOM300), and connects with the embedded main device through the serial port[5].

3.3 Wireless Coordinator Hardware Design

The wireless coordinator transmits the data collected by the wireless sensor group to the embedded host device through the ZigBee network. The embedded host device sends control commands to the wireless coordinator through the serial port, and then indirectly sends to the wireless sensor group. The wireless coordinator uses the CC2430 chip developed by TI as the main control chip. The CC2430 integrates the ZigBee RF front-end, memory, and microcontroller, and supports the ZigBee wireless communication protocol. The operating frequency band is at 2.4 GHz.

4. System Software Design

The software in this design includes embedded master software running on STM32F417, ZigBee protocol stack and client software running on CC2430, and GPRS module software running on LPC2103[6].

4.1 Embedded Host Device Software Design

The embedded host software uses μC / OS-II real-time system as the device management main program framework, and also embeds the uIP protocol stack as the TCP / IP protocol. The function of the embedded host device is to achieve remote PC through the network port and Ethernet connection Machine communication; external serial LCD screen and keys to achieve local parameter settings; control GPRS module and wireless coordinator through serial port.

4.1.1 μC / OS-II System Task

μC / OS-II system establishment tasks, including system tasks, graphical user interface tasks, network processing tasks, storage data management tasks, serial port tasks, idle tasks, statistics time running tasks.

The main program is focused on the main () entry function to complete the μC / OS-II system initialization, hardware platform initialization, establish the main task, set the beat count, and start the μC / OS-II system.

The task creation is completed through the App_TaskStar (t) function, and then this function calls App_TaskCrea (t) to create other tasks. A total of main tasks, serial communication tasks, graphical interface tasks, key tasks, I2C bus read and write EEPROM tasks, SPI read Write FLASH tasks, network processing tasks, idle tasks and time slice tasks.

4.1.2 Network Management Software Design

The system network protocol stack uses the uIP protocol. The related hardware platform initialization is the initialization of the internal STM32F417 Ethernet module and the initialization setting of the DP83848PHY chip. The hardware initialization is called in the BSP_Ini (t) function, and a NetInit_Config () is used to initialize uIP. Protocol stack, configure the local IP address and port number.

The uIP protocol is a simplified TCP / IP protocol, which mainly includes network layer and transport layer protocols such as IP, TCP, UDP, ICMP, and ARP. Application layer protocols involve services such as HTTP, Telnet, and WEB. uIP protocol stack architecture. As shown in the figure, the interface function between the uIP protocol and the underlying driver is uip_inpu (t), and the function with the upper-layer application is UIP_APPCALL (). In the system start task creation function App_TaskStar (t), an IP data packet is read from the network device and the data length is returned; the TCP connection sending and receiving status is periodically queried, the ARP table is updated, and the semaphore is transmitted when the network finishes receiving.

Among them, eth_pol (l) is used to periodically query the TCP connection status, and the ARP table is updated and responded.

The uipPro () function is nested in the network processing task Task_ETH () called by App_TaskCreat (), which is mainly used to implement functions such as interrupt trigger reading network reception buffer. The network receiving interrupt is implemented by the internal interrupt of STM32F417.

In the program, the device is used as a server. The local IP is set to 192.168.100.222 and the port number is 8011. During network debugging, the PC uses the TCP / UDP test tool and the PC is set as the client. The connection method is TCP. The network connection is successful.

4.2 Wireless Coordinator Software Design

The software of the wireless coordinator includes two parts, the ZigBee protocol stack and the client program. After the coordinator is powered on, it first scans the channel, selects a suitable channel, that is, a suitable network identifier, and then starts the network to allow the sensor device to connect. The master device in the gateway is then connected to the wireless coordinator through a serial port, and indirectly connected to the wireless sensor group through the wireless coordinator. The ZigBee protocol divides the 2.4 GHz radio frequency band into 16 independent channels. Each device has a default channel set. The coordinator scans its default channel set and selects a channel with the least noise as the channel of the network it builds.

5. Experimental Results

The above design gateway is applied to the current power monitoring platform. The current monitoring object is the current and voltage of the power supply. Finally, the power consumption of the power supply is calculated. The main control chip of the monitoring module collects the current and voltage through the analog-to-digital conversion channel. Digital conversion means that the object collected by AD is generally the voltage value, so the output current of the power supply needs to be converted into voltage. The monitoring module uses MAX472 to convert the current into voltage. Generally, this reference voltage is not higher than the working voltage of the chip. As shown in the figure, a simple PC user interface is designed for this platform, which realizes real-time monitoring of the output current, voltage and power consumption of the power supply, and can set the gateway remotely or locally.

6. Concluding Remarks and Future Outlook

The embedded gateway designed for the practical application of the Internet of Things has the characteristics of simple and easy environment construction, easy maintenance, and low cost. It is widely used in Internet of Things applications such as smart home, greenhouse control, equipment room monitoring, and environmental monitoring. The design concept and model of the embedded gateway can play a role in the collection and transmission of various physical quantities. The transmission medium can also be replaced according to the environment and security requirements. The transmission protocol can also be customized and embedded according to the needs. For example, with the development of the Internet of Things, the network application environment will become more and more complex, and network security and other issues will also be involved. The design of embedded gateways must also keep pace with the times and embed network security protocols. During the acquisition and processing, the transmission medium can be changed according to environmental requirements, such as using microwaves. At this time, the coordinator of the gateway needs to be replaced with a microwave receiving device, and networking with the embedded gateway can be achieved. In short, this kind of embedded gateway has a broad application prospect and flexible design, but it needs further research efforts to design an embedded gateway with strong compatibility and safe and reliable use.

References

[1]. Peng Xiaoshan. Research on the Development and Application Prospect of Internet of Things Technology [J]. Shantou Science and Technology, 2010 (1): 25-30.

[2]. Meng Song. Implementation of TCP / IP protocol stack based on embedded system [J]. Communication System and Network Technology, 2007,33 (4): 8-10.

[3]. Zhang Zuojing, Wu Xuguang.Design of Vehicle Navigation and Positioning System Based on GPS and GPRS Modules [J]. Computer Measurement & Control, 2008,16 (7): 997-999.

[4]. Liu Guoqing. Research on the main technologies and applications of short-range wireless communication. Scientific Chinese [J] .2015, 17: 65-67.

[5]. Cha Longlong. Analysis on the Development of the Smart Home in the Internet of Things. Science and Technology Information [J]. 2012, 25: 42-42.

[6]. Aruoma O I. The impact of food regulation on the food supply chain[J]. Toxicology,2006,211:119-127.