Design of IoT Sensor Terminal Based on RFID and Wi-Fi Technology

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Abstract. The Internet of Things has penetrated into all aspects of human production and life. This article has developed an Internet of Things sensing terminal based on RFID and Wi-Fi technology. This article uses the information management function provided by RFID electronic tags and the convenient networking function provided by Wi-Fi to design. We introduced the system performance requirement analysis and system architecture design. Starting from the selection of the S5PV210 processor and each module, as well as the communication interface between each module and the processor, we design the overall terminal hardware architecture. According to the Android architecture, the porting and development of related hardware module drivers, the design of intermediate programs, and the design of the JNI communication interface of the information acquisition module are introduced. The design of the Android upper-level UI program of each module and the PC upper computer GUI program and the performance test of each information collection module have been completed.

Keywords: Internet of Things, RFID, Wi-Fi, Sensor

1. Introduction
The Internet of Things refers to a huge network formed by combining various information sensing equipment, such as radio frequency identification devices, infrared sensors, global positioning systems, laser scanners and other devices with the Internet [1]. The major information systems can be interconnected to form a huge network. Items are implemented for the purpose of intelligent management such as tracking and monitoring. Generally speaking, the Internet of Things can realize the communication of information between people and things. In the “Internet of Things”, standardized and interoperable information is stored in RFID tags, which are automatically collected to the central information system through the wireless data communication network to realize the identification of items.

In developed countries such as Europe, America, Japan and South Korea, typical applications of the Internet of Things include sales and payment, public transportation services, safety supervision, telematics in-vehicle applications, repair and maintenance, home applications, industrial applications, telemetry telephone and television, etc. These applications are widely distributed in the fields of consumption, production and management [2]. For example, remote measurement is the most typical...
application of the Internet of Things. It allows energy agencies and public utility companies to implement remote meter reading and maintenance of water, electricity, and gas in users’ homes, and allows ordinary users to access household appliances and home environments. Or enterprise users can automatically collect, analyze and process data to respond to the working status of the machine tool equipment on the production line [3]. Mobile terminals are beginning to develop in the direction of being compact, portable, feature-rich, stable in performance, and professional and technical. At present, smart terminals are beginning to emerge in the fields of logistics, power, transportation, and medical care, and will play more and more roles in these fields in the next one or two years [4]. In the logistics field, with the help of mobile terminals with camera functions and identification recognition, couriers can take pictures of packages and read label information, and upload the photos directly to the express application platform, which can be saved as delivery records, eliminating the need for management [5]. The delivery driver can easily identify the package, provide real-time status information of the delivered goods, and take pictures of the damaged package as archive evidence for on-site package processing. By scanning the barcode on the delivery mail, and transmitting such information to the business system in real time, the delivery certificate is generated, which reduces the checkout cycle from several days to several hours. In addition, in the retail, storage, transportation, distribution and production links of logistics, the transportation management of vehicles or items can be realized to improve efficiency, control costs and realize warehouse fire protection monitoring [6]. The use of mobile terminals with camera and video transmission modules can provide customers of logistics and transportation enterprises with visual tracking of goods and vehicles.

The important components of the hardware module of this terminal are the smallest system of S5PV210 central processing unit, touch screen and matrix keyboard, human-computer interaction units such as audio, WIFI and 5G network data transmission unit, barcode scanning engine, UHF RFID, HF RFID and temperature and humidity sensor Modules and other information collection units. In addition, there are image acquisition module cameras and some important data transmission interfaces (USB, SIM card interface), the interface for programming Android system (TF card interface) and the software debugging interface (serial port). The seamless switching recognition function of the two types of 6B/6C tags, the read and write performance of the user storage area of the two types of tags were tested, and the storage area performance of the modified 6C tag EPC was tested. By comparing the data collected by commercial thermometers and hygrometers, the performance test of the temperature and humidity sensor module is completed.

2. Hardware and Software Design of IoT Sensing Terminal

2.1. Hardware Design

The hardware includes information storage, collection and transmission equipment, which is the basis for real-time dynamic information transmission to the management center to monitor and manage the target. STM32F103ZET6 is used as the control unit. The STM32 series single-chip microcomputer is based on the ARM Cortex-M core, which is designed for embedded applications that require high performance, low cost, and low power consumption. The peripherals are very rich. STM32F103ZET6 belongs to the STM32 enhanced series of products, with a clock frequency of 72MHz, built-in 64kB SRAM and 512kB Flash, multiple timers, 3 SPI/I2S, 2 I2C, 5 serial ports, and USB 2.0 interfaces. The hardware includes LCD display screen with a resolution of 240*320 connected through the FSMC interface and LCD brightness adjusted through PMW, lithium battery power supply unit, 31 physical buttons and 2 LED indicators directly driven by GPIO, through PMW mode. The passive buzzer that can emit a variety of unused sounds is driven by the RS232, infrared transceiver module, RS485, RFID module, and wifi module connected by 5 serial ports. The W25Q16 and SD card are connected through the SPI interface of STM32. USB communicates with the host computer. It also uses the high-precision RTC chip DS3231SN, which is connected to the STM32 through the IIC interface, and is equipped with a button battery. The application mode of IoT sensing terminal is shown in Figure 1.

Flexible Static Memory Controller (FSMC) is a new type of memory expansion technology
adopted by STM32. It has unique advantages in terms of external memory expansion. It can easily expand different types of large-capacity static memory according to the application needs of the system. STM32 can be directly connected to the pins of SRAM, ROM, PSRAM, NOR Flash and NAND Flash memory through FSMC. This article uses FSMC to perform high-speed write operations on the display buffer to achieve a fast display function. FSMC is set to NOR-SRAM operation mode. They are FSMC_NE4 connected to CS, FSMC_NWE connected/WR, and FSMC_NOE connected/RD.

The terminal has 31 buttons in total. In addition to the power button and the reset button, a matrix keyboard circuit design is used to save pins. The button design fully considers the application needs, supports Chinese character input and special symbol input, and the specially designed reset button is used to reset the system after the application crashes. F1-F4 are user-defined function keys. Shortcut keys can also be customized by users.

![Figure 1 Application mode of IoT sensor terminal](image)

The radio frequency card module is also called the RFID module. It is a kind of middleware used to read and write the radio frequency card RFID. Due to the complexity of the operation sequence of the radio frequency card RFID, the radio frequency card RFID module is used directly, which can quickly launch products and save a lot of research and development costs.

The Wi-Fi module, also known as the serial port Wi-Fi module, belongs to the transmission layer of the Internet of Things. Its function is to convert the serial port or TTL level to an embedded module that conforms to the Wi-Fi wireless network communication standard. Traditional hardware devices embedded in Wi-Fi modules can directly use Wi-Fi to connect to the Internet, which is an important part of realizing wireless smart home, M2M and other Internet of Things applications. The module supports the function of binding the BSSID address of the destination network during the networking process. According to the 802.11 protocol, different wireless networks can have the same network name (that is, SSID/ESSID), but they must correspond to a unique BSSID address. Illegal intruders can establish a wireless network with the same SSID/ESSID to make STAs in the network connect to illegal APs, thereby causing network leaks. By binding the BSSID address, STAs can be prevented from accessing illegal networks, thereby improving the security of the wireless network.

The low-dropout, low-cost LDO low-dropout linear regulator chip RT9013-33 is used to provide 3.3V power to the system. It is very suitable for lithium battery-powered applications. The EN pin can easily realize software automatic shutdown and key switch. VIN is the lithium battery output voltage Vbat, and VOUT is the 3.3V output. When the EN pin is high, VOUT outputs power. When powering on, you press the Key power button EN to go high and output 3.3V. After the STM32 is powered on, the PEN pin will be pulled high, then release the button to complete the boot process. To realize
automatic shutdown, STM32 only needs to set the PEN pin to low level, and two diodes isolate the input. The function of short press and long press of Key is different. STM32 monitors whether there is a key press and release through the KeyP pin, and distinguishes whether it is a short press or a long press event by timing. If it is judged to be a long press, the PEN pin is also set to low level to realize key shutdown.

2.2. Software Design

The software design of the terminal includes basic drive, file system design, console function design, and API interface design. The basic driver mainly includes a series of device initialization and reading and writing and operation, such as clock initialization, timer initialization, serial port initialization, GPIO initialization configuration (buzzer, buttons, LED, control line), FSMC initialization and configuration, ADC initialization configuration, IIC/SPI interface initialization, LCD module initialization, SD card file system initialization. STM32 provides a rich hardware development library, users can easily program the on-chip peripherals. The overall software design framework is shown in Figure 2.

![Figure 2 Overall software design architecture](image)

The FatFs file system is used to read and write files on the SD card. It is a general file system module used to implement FAT file system in small embedded systems. The writing of FatFs follows ANSI C and does not depend on the hardware platform. To implement specific application migration, the main work is to implement the underlying drive of diskio.c according to diskio.h. The main console program is responsible for basic functions such as system settings, application loading, and file management.

After the system is turned on, the device is initialized first, and then enters the main menu, displays the main menu, and jumps to each functional module according to the user's choice. The display and operation methods of the functional modules are the same as the main menu. Different processing is performed after the button is detected in the blocking mode. The “application selection” module lists the application files in the SD card through the file system interface. After the user selects one, the program file is written from the SD card to the application area of the STM32's internal Flash and jumps to execution. When the menu interface is running, three types of interrupt processing will be executed in the background: timing tasks, serial port reception, and USB drive processing.
3. Prototype Test Experiment and Analysis

3.1. Barcode Scanning Module Performance Test
In the Internet of Things terminal function selection interface, we select the barcode scanning button to enter the barcode type selection interface, the scanning engine is aligned with the center of the barcode, and the scanning engine is about 20cm away from the scanned object. We press the one-dimensional barcode scanning button to enter the one-dimensional barcode scanning interface, and then press the scan button or pull the trigger to call the barcode middleware scanning program. After the middleware program accesses the underlying driver, the scan will be triggered. After the barcode is scanned, the scanning engine SE4500/PL4507 will be shut down immediately and the Socket communication mechanism is transmitted to the upper interface of Android for display.

The one-dimensional and two-dimensional bar code display interfaces designed in this paper are separated. When the one-dimensional bar code is tested, 100 notebook test samples are selected. When scanning the two-dimensional barcode, 100 train tickets are selected, and the data length obtained after scanning the two-dimensional barcode pattern on the train ticket is 144 bits. When testing, we scan the one-dimensional code first, then return to the upper interface to select the two-dimensional code, and start the scanning of the two-dimensional bar code. The time-consuming bar code scanning is shown in Figure 3.

![Figure 3 Barcode scanning time-consuming test chart](image_url)

3.2. Performance Test of High Frequency RFID Module
When testing the performance of the high-frequency RFID module, it is important to identify the UID of the tag corresponding to the protocol and to read and write the data storage area of the corresponding tag. Finally, the test of the high-frequency protocol tag is the polling switch identification function. On the IoT terminal function selection interface, we select HF RFID to enter the HF RRRD function selection interface, and enter the corresponding interface according to the following performance tests.

Another major performance test of the high-frequency RFID module is that the tags of the high-frequency protocol can be polled and switched for identification. When a random high-frequency protocol tag is placed in the identification area of the high-frequency antenna, it will be quickly detected by the handheld terminal. The detected tag type and UID will be displayed on the Android application HF RFID multi-protocol inventory interface. Figure 4 shows the tag polling switching recognition accuracy rate of the high-frequency protocol.
3.3. Performance Test of Temperature and Humidity Acquisition Module

In order to determine the accuracy of the temperature and humidity data collected by the handheld terminal, a commercial temperature and humidity sensor with very high measurement accuracy was purchased from the market. By comparing the difference between the two test data, the performance of the software, software and hardware of the temperature and humidity sensor module is judged.

The measurement environment is indoors. First we use the temperature and humidity meter to measure the data, then open the temperature and humidity measurement interface of the handheld terminal. After powering on the temperature and humidity acquisition module on the bottom layer, it starts to work, reads the temperature and humidity information through the serial port, and compares the collected temperature and humidity information with the measured data. The measurement comparison result is shown in Figure 5. Through comparison, it is found that the measurement of the temperature and humidity sensor module of the handheld terminal is very accurate.

4. Conclusion

RFID technology can significantly improve operational efficiency, shorten the circulation cycle, improve the level of humanized service, and give full play to public service functions, thereby improving operational efficiency. This project makes full use of the role of RFID in management, combined with Wi-Fi functions. Utilizing the information management function provided by RFID electronic tags and the convenient networking function provided by Wi-Fi, it can be applied in many public places, such as libraries, scenic spots, industrial plants, etc., and has great application value. However, the handheld terminal designed in this article only performs simple local storage and processing of data. As the process of industrial production requires a large amount of data to be accessed and processed, the subsequent need to use a database to manage the collected data, and use the SQLite that comes with the system on the handheld device. The database manages the data...
collected by the handheld terminal. The PC upper computer can use My Sql database to manage the information data uploaded by the handheld terminal.

**Acknowledgements**

Department of Education Anhui Province Natural Science Foundation of China: “Research of three-dimensional removable WSN topology control for space monitoring” (KJ2020A0803)

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