A Electronic Lock System Based on the Bluetooth in Smart Phone

以智慧型手機藍芽為基礎之電子鎖系統

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Abstract

Currently modern houses are filled with many appliances that can be used in cooking to enhance the quality of life or entertainment. There are many software and hardware engineers, and some of the people involved in the field of electronics proposed different control methods to control home appliances.

Many companies and research institutions have entered the field of smart appliances. Although in this area there are a lot of concepts and experimental outcomes, the results can not be achieved to the extent that the general public considers to be reliable. The price is also the reason why the concept is not universal.

As proposed by the company Zensys, Z-wave can only be applied to home automation applications. Because there is no technical specifications of international standard, it is not easy to implement. Bluetooth and ZigBee technology can be applied to many areas of industrial control, medical, security and so on. Not only it is readily available. The prices are very reasonable.

ZigBee had hoped to set a lower price to replace the Bluetooth in the control field. Because of mass production, bluetooth communication module (CSR BC-4) technology is already quite mature and price is relatively lower. The idea of replacing bluetooth technology is relatively more difficult to achieve. That is the reason why we used the bluetooth technology to be the transmission protocol between the smart phone and electronic lock.

Key word：Z-wave、Bluetooth、ZigBee、CSR BC-4

1. Introduction

Domestic guesthouse and daily rental suites are in vogue. Numerious tourists use daily rental suites, and tenant turnover also improved a lot. Thus, many people in this industry want to set access control system to be easily used. Landlord simply used a mobile phone and set a password to give specific users access through the Internet, and the user will be able to directly use their smart phone to lock or unlock the electronic lock .

We referred to the password lock of the keyboard, and changed it with the way of Bluetooth phone connection instead of a physical keyboard to enter password to lock or unlock. This way can increase the user's convenience.

This approach not only improve the efficiency, but also eliminates the inconvenience of carrying keys. Also, do not worry about the distress of losting keys. The Bluetooth pairing will be encrypted to prevent others able to obtain access privileges, and endanger security.

The purpose of this paper hopes that through readily available low-cost components to reduce the cost of smart home, we can improve the popularity of the concept of smart appliances.

2. Literature Review

This section will analyze and discuss the advantages and disadvantages for some of the Bluetooth application in home environment. [1] Some paper used a microcontroller simultaneously with embedded Bluetooth devices and multiple relays, forming a Bluetooth topology. So we can use Android phones for a variety of remote control of electrical appliances.

Although only paired with a Bluetooth module, a wired connection between the microcontroller and the device is still necessary. We needed to improve this part.

Bluetooth can also be used for data transfer between the sensor nodes. In [2], they combine sensors and Bluetooth to establish a telephone network, which can be remotely controled and monitored systems. In additions, using graphical interface can set your own DIY home security system. When the host leaves the house or a safe range, the sensors of the doors and windows will activate. when thieves broke into the house, the system will automatically dial the telephone via network to inform the police. In the mean time, the sensors transmit data to a remote computer server to achieve the effect of monitoring.

A variety of data and control signals in home environment can be transmitted via Bluetooth. Reference [3] tried to establish a Bluetooth home control network (BHCN) to provide a safe and efficient home environment. This paper used the JLC / OS-II real-time operating system to create a platform. Core BHCN is to use the embedded Bluetooth Home Server (EBHS) to achieve the centralized control of home appliances. Then, propose an improved algorithm according to BHCN's based on the needs of Bluetooth polling. The weight of each node is determined by the polling success rate (PSR) and the idle rate, and was used to determine the query sequence. Simulation results show that it can effectively reduce the average latency of packet data transmission and improve the success rate of polling.

The low cost, low power consumption and easy to set up feature such use Bluetooth is used to construct the most suitable wireless home network transport protocol. Technology mentioned in [4] to link among the refrigerator, air conditioner, audio, and lighting with each other, is created as an intelligent concept of home network. To be able to integrate into the market, the device must be compatible with equipments from different vendors to achieve the effect of plug and play. This paper proposes a home Bluetooth protocol. It can use plug and play Bluetooth method on different devices.

3. Hardware Requirements

This section will introduce the hardware specifications.

3.1 The main control unit

3.1.1 Arduino UNO board：

Arduino is an open-source electronics prototyping platform. There are easy to use, scalability and strong hardware and software, built on open-source I / O interface version. The programming language used is similar with Java and C language development environment. It uses low-cost microprocessor controller ATMEGA328 [4], together with USB interface, no external power supply. In additions, it provides 9V DC power input, and supports a variety of interactive links. So, it can be very simple to connect with a variety of sensors and electronic components, as shown in Fig. 1.

Figure 1. Arduino UNO board

3.1.2 CSR BC-4：

This Bluetooth module uses CSR's BC-4 series of Bluetooth chips. It was mainly used to replace serial port, and a microcontroller to achieve Bluetooth serial port communications. Since CSR's Bluetooth chips are convenient, and suitable. It was used in the development of various software and hardware applications, as shown in Fig. 2.

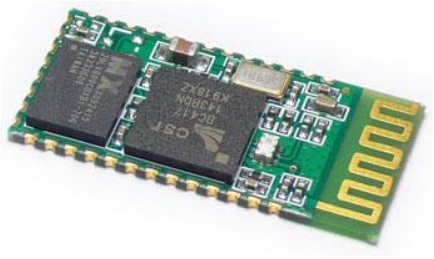

Figure 2. CSR BC-4

- **Features：**
  - The main chip：CSR BC-4。
  - Bluetooth version：Bluetooth 2.0。

- Wireless data reception and transmission.
- Built-in Flash.
- Built-in 2.4GHz antenna. Users do not need to install additional antennas.
- Automatically adapt to frequency hopping technology.
- Signal transmission range: 0 to 10 meters.
- Can be used to answer / end / reject a call, voice dialing, redial, and standby.
- Low voltage, when paired, consume about 30 ~ 40mA, when pairing is complete, transmission work consumes about 8mA.
- Can select PIO control.
- Standard HIC port.
- USB transfer protocol：Full Speed USB1.1, compliant with 2.0.
- RoHS system.
- Bluetooth power consumption：Class2.
- Volume：28mm*13mm*1.75mm.
- Storage Temperature: -40 to 80 degrees Celsius, Operating temperature: 25 to 75 degrees Celsius.
- Interference: 2.4MHz, transmit power 3dBm.

3.2 Electronic Lock：

Fig. 3 shows the electronic control keypad lock, which has been used in part of the hotels.

Figure 3. Electronic keypad lock

The lock action principle of traditional electronic control is based on a small two-wire DC motor to push locking and unlocking the door to achieve the function. We use the combination of arduino microcontroller and Bluetooth module to achieve using Android smartphones to unlock and lock function. Then, we can achieve the purpose of the smart home.

Regarding power, we continued to use the original hardware approach of battery power supply for electronic locking action. Thus, we can avoided blackouts, which not only cause inconvenience to users and also have security concerns. The Bluetooth receiver will be dormant in standby time for saving power; thus, increase the battery life.

Power supply can last for several months. When voltage is insufficient, a warning message to remind the replacement of the battery will appear.

4. Hardware prototype

This section introduces the main circuit and hardware architecture.

4.1 The control circuit

We used the Arduino microcontroller as the main control circuit, combined with a Bluetooth module, as shown in Fig. 4. It can communicate with the phone through the Bluetooth wireless modules.

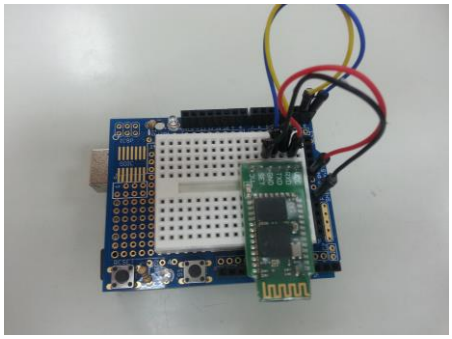

Figure 4. Arduino board and Bluetooth module

4.1.1 Electronic lock structure：

Fig. 5 shows the electronic lock structure we use, which uses a set of electronic locks miniature DC motors to push locking or unlocking the internal bodies.

Figure 5. Electronic lock structure

4.1.2 System Prototype：

We will combine the main circuit and the electronic lock, shown in Fig. 6. It will be able to use the phone to send signals via Bluetooth, and the main circuit receives signals to lock and unlock action via Bluetooth module.

Figure 6. System prototype

4.2 Mobile app

We used eclipse in Fig. 7 to develop Android software applications. Software is mainly responsible for authentication between the mobile phone and the main control unit. We use the built-in EEPROM for setting arduino group authentication code. We must enter the authentication code before using the phone with a Bluetooth connection to control the panel.

Figure 7. eclipse Interface

4.2.1 **Arduino EEPROM：**

The Arduino development board has built-in EEPROM, and provides EEPROM Library to users [5]. Compile EEPROM only using two functions as follows:

- EEPROM.read (address) - read the contents of the address.
- EEPROM.write (address, value) - address is the address to write to, and value is the data to be written (one byte, range 0 to 255)

4.2.2 Password authentication：

Before using the system, in addition to normal Bluetooth pairing, the software must also enter the authentication password into microcontroller to increase the security of the system, as shown in Fig 8.

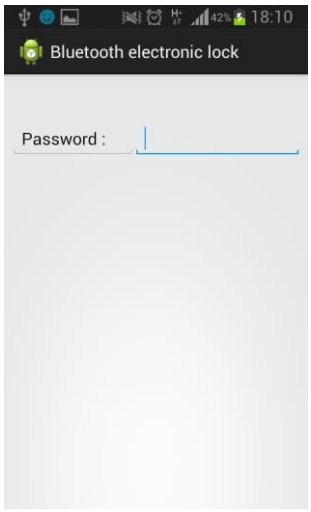

Figure 8. Android Software Certification

4.2.3 Authentication successful：

Fig. 9 is a picture of the success of password authentication. Password verification will successfully let user enter into the door lock control interface.

Figure 9. Authentication successful

4.2.4 Authentication failed：

Fig. 10 is an authentication failure, which occurs after warning screen, and can not enter the control panel.

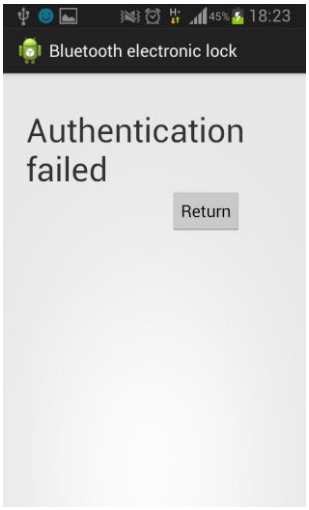

Figure 10. Authentication failed

5. Conclusion

After the experiment, the results show that the proposed method can successfully controlled the electronic lock using the Arduino with a Bluetooth device via the phone. This study proposes a Bluetooth phone to control an electronic lock and EEPROM authentication method is more convenient than traditional lock. Thus, there is a certain security.

This paper presents the process of replacing the traditional method of electronic lock keypad to enter a password to increase the user's convenience. A combination of hardware and software encryption methods also improve their safety certification.

6. Future Work

This paper present an application to manually control the operation of electronic locks. In the future, we hope that it can be designed into a hands-free device, which authenticate to unlock or lock the action via Bluetooth phone. Integrating with a network server, it can change the password for the specified device over the network for permissions. That will increase the convenience of maintenance and upgrading password authentication security.

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