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Bluetooth and NFC Enabled Contactless Access Control System

S. Rajashree[1], S. Kaushik[2]* and K. Ravi Varman[2]

[1]Asstistant Professor, Department of CSE & IT, CIT, Coimbatore, India
[2]B. Tech (IT) Final Year, CIT, Coimbatore, India; mailkaushiksampath@gmail.com

Abstract

Technology has transformed the world in all walks of human life. However, lock and key based conventional locking systems have not been completely replaced by smart access control systems due to higher costs and complexity. So, the goal is to create a smart, user-friendly locking system which uses widespread and evolving wireless technologies. "Bluetooth & Nfc Enabled Contactless Access Control System" focuses on exploiting the full potentials of NFC (Near Field Communication) and Bluetooth for implementing an automated door locking/unlocking System, which can be locked or unlocked by holding tiny NFC tags near it. Additionally, the proposed access control system can be controlled by an android app, which is also to be developed. Such an access control system will be a boon not only to the common man, but also for differently-abled people.

Keywords: Access Control System, Bluetooth, Door Lock, Android, NFC

1. Introduction

1.1 Introduction to Bluetooth and NFC

Today, most mobile phones are smart phones, which offer a plethora of capabilities in wireless connectivity than regular cell phones. Smart phones usually support one or more short range wireless technologies such as Bluetooth and Infrared, making it possible to transfer data via these wireless connections. Home automation using smart-phones is an interesting area of evolving technology. The use of Bluetooth technology in a smart phone today is not just for the transfer of data and files. In recent years, smart home automation is one of the applications of Bluetooth technology. Bluetooth technology operate over unlicensed, available at 2.4GHz frequency, also can link digital devices within a range of 10m to 100m at the speed of up to 3Mbps but it depends on the Bluetooth device class [1].

The proposed access control system will be bluetooth enabled, so that it can be effortlessly controlled using an android smartphone through a customized android app. Near field communication (NFC) is a set of ideas and technology that enables smartphones and other devices to establish radio-communication with each other by touching them together or bringing them into proximity, typically a distance of 10 cm (3.9 in) or less [2]. Near field communication makes use of tags, being tiny electronic devices that can store little amount of data in the order of KiloBytes and can be powered passively, i.e, wirelessly [3].

1.2 Problem Definition and Goal

Emerging technologies have not had a major impact on the common man, when it comes to access control. Still, we use traditional lock and keys for securing our homes, cupboards, etc. The electronic locks available are either costly or not so user friendly. So, the researchers strive to develop a smart door locking system which makes use of both Bluetooth [1] and Near Field Communication [2], for access control.

The goal is to develop an access control system which offers the flexibility of being either controlled through Bluetooth or NFC to the end user. Also, to develop an android application to control the lock from the user's smartphone through bluetooth. The NFC feature is implemented by using NFC tags [3], which can be shown against the NFC reader/writer module in the lock, for

*Author for correspondence

Figure 1. Various forms of NFC Tags.
Image source: https://www.google.co.in/search?q=nfc+tags

authorizing a user and granting him access. When a tag is lost, the lock need not be replaced and instead we need to change the tag associated with the lock. This operation of associating a new NFC tag with the door lock is done through the android app. The visually impaired and the other handicapped people just need to carry the NFC tag along with them to control the door lock.

2. Literature Survey

2.1 Existing Access Control Systems

The existing smart locks which can be controlled wirelessly are mostly Wifi-only or Bluetooth-only or RFID based. An extended survey of journals and other research papers published in this context shows that an electronic lock which combines the features of both bluetooth and NFC is yet to be developed. Misra [4] in his paper published in the IEEE proceedings, has aimed to achieve a very simple technique of users' access control through device authentication using a microcontroller board such as Arduino that interacts with the smart device using Bluetooth technology which is almost available in every smart device. Saparkhojayev [5] in his paper has explored the use of NFC enabled phones for replacing traditional lock & key based access control systems.

2.2 How the Proposed Lock Differs from Existing Ones

As already mentioned, the proposed access control system is unique due to the fact that it combines both bluetooth and NFC under one roof. Moreover, to set or reset the NFC tags associated with the lock, one need not use any dedicated NFC Reader-Writer devices which are quite expensive. Also the user does not require any NFC enabled smartphones which are dearer. The lock's bluetooth capabilities easily interface it with the android app, so that the NFC tags can be easily reset using the NFC module available within the lock. A comparison of the features between the existing smart locks and the proposed lock is shown in Table 1.

Table 1. Comparison between existing smart locks and the proposed lock

Existing Smart Locks	The Proposed Lock
• Bluetooth-only locks exist. • NFC-only locks are under development.	• Combines both Bluetooth & NFC.
• NFC alone locks require a special tag writer device.	• Tag Writer is Integrated into the lock.
• Not User Friendly.	• User friendly and targets Android OS.
• Costly.	• Comparatively cheaper.

3. Requirements

3.1 Hardware Requirements

The major requirement for implementing the proposed access control system is a micro-controller, which co-ordinates the various functions of the access control system. Among the various micro-controllers and evaluation boards available in the market, the researchers chose the Arduino Uno R3 evaluation board containing the Atmel-Atmega 328p microcontroller, due to the extended support and reference articles available across the internet for the Arduino platform. Arduino is an open source electronic-prototyping platform, developed in Italy, 2005 [6]. The high-performance Atmel picoPower 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts [7].

To empower the lock with NFC capabilities, the researchers require the MFRC-522 NFC reader/writer module. The MFRC522 supports contactless communication and uses MIFARE higher transfer speeds up to 848 kBd in both directions [8]. The researchers use MIFARE 1K Classic tags which are available in various shapes such as stickers, tags, cards, etc., as shown in Figure 1 along with MFRC-522 module. The MIFARE CLASSIC tags have an inbuilt

memory of 1 KiloByte and carry a unique, non-erasable 4 byte hexadecimal identification number programmed by the manufacturer [9]. Next, the researchers require HC-05 Bluetooth module, a class-2 Bluetooth module with Serial Port Profile, which can be configured as either master or slave. Also required is the Transistor TIP122 [10], which can act as a switch to power the push-pull linear solenoid, i.e the lock's rod. Further required are the three different LED lights to indicate various actions taking place in the lock and a 9 volt power source, preferably a rechargeable battery.

3.2 Software Requirements

To program the micro-controller the developers need the Arduino IDE, an open source software available for free download on the arduino website, www.arduino.cc

The arduino programming language utilizes C-program style coding which is easy to learn and master. To develop the android app we need to install the latest version of the Android SDK from https://developer.android.com. Also for developing the required android app effortlessly, the open source IDE, called "B4A" i.e., BASIC for Android [11] is used which lets the developer develop android apps by writing a BASIC style code instead of the conventional Java-style code. Moreover, an android and bluetooth enabled device, preferably a smartphone to test the app is required.

4. System Design and Implementation

4.1 Design Outline

A high-level design for the proposed access control system can be seen in Figure 2. The microcontroller lies in the middle of the MFRC-522 module, the HC-05 Bluetooth module and the lock's solenoid, and co-ordinates the functioning of the lock.

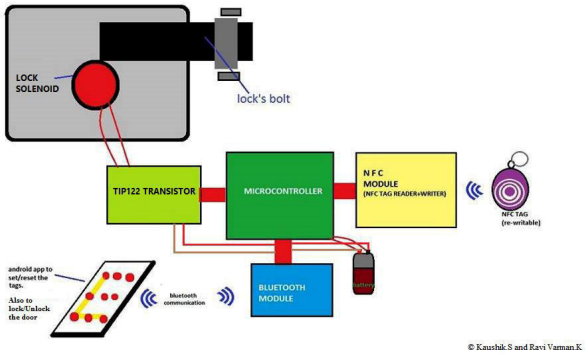

Figure 2. High Level Design of the Developed Lock.

4.2 System Implementation

The above design is implemented using breadboard and connecting wires. The connections between the Arduino Uno board and the HC-05 module are made as shown in Table 2.

Next, the connections between the Arduino Uno board and the MFRC-522 module are made as shown in Table 3.

The connections among the TIP122 transisitor, Arduino Board and the Lock Solenoid are made as depicted in Figure 3.

The code for Arduino is written and compiled using the Arduino IDE. Further an external library called "rfid-master" available on GitHub [12] is used. Finally the compiled code is uploaded to the Arduino Board using USB serial interface and the Arduino Uno board is powered using a battery. Now the system implementation is complete and the access control system is ready for operation and can be tested.

The android app is programmed to feature the below functions:

- Establishing a connection over bluetooth.
- Lock/Unlock the door by sending a corresponding numeric code.
- Set a new NFC tag and reset an existing tag.

Table 2. Connections between Arduino Board and the HC-05 Module

ARDUINO UNO	HC-05 MODULE
3.3V POWER OUTPUT	VCC
GND	GND
TX	RX
RX	TX

Table 3. Interfacing the MFRC-522 Module with the Arduino Board

ARDUINO UNO PIN	MFRC-522 MODULE
9	RST
10	SDA(SS)
11	MOSI
12	MISO
13	SCK
5V POWER OUTPUT	VCC
GND	GND

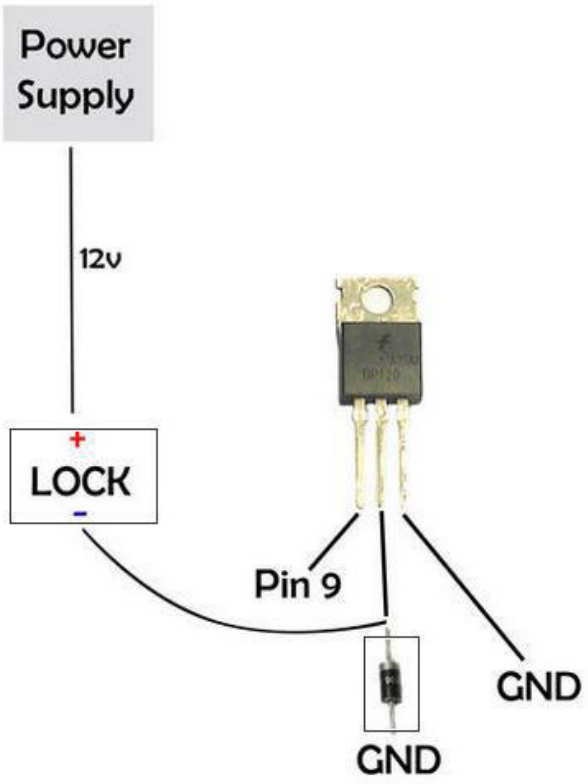

Figure 3. Connections to the Transistor TIP122.

The android app is compiled and built to obtain an ".apk" file, which is then installed on an android smartphone. The app is now ready to be used for managing the door lock. The researchers have named the app as "Door Lock Manager".

5. System Testing

The android app is tested for bugs and its interfacing with the lock is also tested. First, open the android Lock Manager app and click on "Search for Device" option. Then choose the name "HC-05" from the list of available devices. This name denotes the access control system. If it is the first time one is connecting to the lock from one's smartphone, then pairing is required. The secret key for pairing is "1234" by default. Once, the lock has been paired with a smartphone, connection is established easily and a new screen appears on the Lock Manager App. In this screen the developers have provided a button for Locking and Unlocking the Door. Also, there is a button to remove the existing tag and set a new tag for the lock.

When one presses the "Lock/Unlock" button, one of the following actions happen:

- If the lock is currently unlocked, it switches to locked state [Red LED light glows].
- If the lock is currently locked, it switches to unlocked state [Red LED light turns off].

After ensuring the successful execution of the lock and unlock functions, now try to set a new tag to the access control system. In order to set a new tag to the system, press on the "Set/Reset Tag" button. Immediately hold a new tag near the lock, within a range of 5cm. If the tag has been set successfully, the white LED light glows, indicating the same. Also to reset an existing tag with a new one, follow the same above said procedure.

To test the NFC feature of the lock, hold a tag which has been already set, against the lock. Immediately, Yelllow LED light glows indicating that a tag is being read. If the tag has been authorized by the microcontroller, then immediately one of the following two actions takes place:

- If the lock is currently unlocked, it switches to locked state [Red LED light glows].
- If the lock is currently locked, it switches to unlocked state [Red LED light turns off].

If an unknown tag is shown against the access control system, yellow LED light flashes indicating that the tag is being read, however the state of the lock doesn't change, as the tag will not be recognized by the system. Thus the complete working of the system is tested.

6. Conclusion and Scope for Future Work

The advantages of this access control system are:

- NFC tags are a boon to old and blind people, as they will easily lock or unlock the door by just bringing the tag near the door.
- Parental Control is possible. For instance, the master of a family can alone have the android-access to the lock and the tags alone shall be given to other members of the family.
- If a key is lost , no need to replace the lock. Just replace the tag.
- No need to carry a heavy metal key.
- A single NFC tag can be set as the key for multiple locks.

Quoting all the above features and advantages, the researchers assert that this Bluetooth and NFC enabled

access control system will be a revolutionary, user-friendly solution to today's need for replacing the conventional locking techniques.

The prototype developed supports only one tag to be associated with a lock at any instant. However, the code can be extended so that multiple tags, shall be used with one door lock.

7. References

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APPENDIX

1. Photo Images

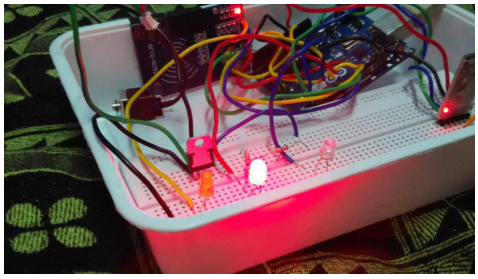

IMAGE 1. Red LED glows indicating that the system is locked.

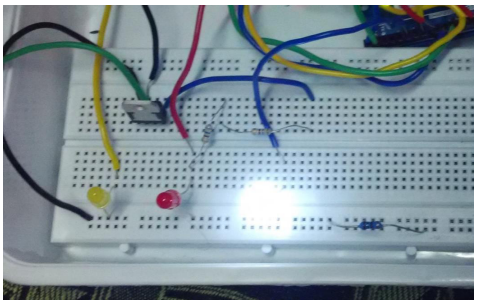

IMAGE 2. White LED glows indicating that a new tag has been set.

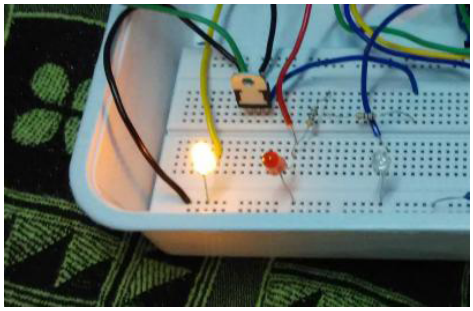

IMAGE 3. Yellow LED glows indicating that a tag is being read.

2. Pseudo Code

Arduino Pseudo Code

```
Begin
Initialize Bluetooth and NFC Module
Loop begin
If Serial Input is available then
    Glow yellow LED // to show that a card is being read
    If new card is present then
        Read card UID
        Write card UID to EEPROM
    Glow white LED //to show that a new card is added
```

```
End if
    Else if known card is present then
      If system is locked, then call Unlock()
      Else call Lock()
      End if
      Glow Red LED// to show system is being locked/
unlocked
    End if
End Loop
End
```

Android Pseudo Code

```
Begin
Initialize Bluetooth & NFC modules
Establish Connection with Lock
while connected begin loop
      If Button 1 is clicked then
        Send code to Lock/Unlock
      Else if Button 2 is clicked then
        Send code to set a new tag
End loop
Terminate Connection with lock
End
```