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B-Lock: A Smart Door Lock System Using Bluetooth Technology

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Abstract: *The emergence of Bluetooth technology has significantly contributed to the development of secure, convenient, and efficient home automation systems. One of the most prominent applications is the integration of Bluetooth into smart door locks, allowing users to unlock doors without physical keys using mobile devices. This paper presents the design and implementation of a Smart Door Lock System Using Bluetooth. We explore the system architecture, working principles, security protocols, and implementation challenges. Additionally, we provide a basic example code for the development of such a system using an Arduino microcontroller and a Bluetooth module (HC-05/HC-06). The proposed system can enhance security by offering keyless entry and real-time monitoring while addressing potential concerns such as battery life, Bluetooth range, and security vulnerabilities.*

Keywords: Smart door lock, Bluetooth, IoT, Arduino, HC-05, Security, Mobile app, Authentication, Encryption

I. INTRODUCTION

The need for smarter and more secure access control systems has led to the development of Bluetooth-based smart door locks. These systems utilize Bluetooth communication to allow authorized users to lock and unlock doors remotely using their smartphones or other Bluetooth-enabled devices. Compared to traditional mechanical locks, Bluetooth smart locks provide greater flexibility, user convenience, and security.

This paper presents a **Bluetooth-based Smart Door Lock System**, demonstrating the integration of Bluetooth technology with embedded systems to create a more secure and user-friendly alternative to conventional locking mechanisms. The system uses a mobile app to authenticate users via Bluetooth, enabling easy access control and monitoring.

1.1 Motivation

The traditional lock-and-key system is becoming increasingly obsolete, as it relies on physical keys, which can be lost, copied, or stolen. Additionally, managing multiple users and maintaining physical keys can be cumbersome. Smart locks offer an elegant solution by replacing keys with digital, mobile-based access, providing a modern approach to door security.

II. SYSTEM ARCHITECTURE

2.1 Components of the System

Certainly! Below is a simple **System Architecture Diagram** for the **Bluetooth-based Smart Door Lock System**. It outlines the interaction between the main components of the system, including the **Microcontroller (Arduino)**, **Bluetooth Module (HC-05/HC-06)**, **Mobile Application**, and **Actuators (e.g., Servo Motor)**.

Description of the Components:

Mobile Application:

The user interface is developed as a mobile application (either Android or iOS).

The user can interact with the app to unlock or lock the door, either through button presses or proximity-based actions.

The app communicates with the Bluetooth module (HC-05/HC-06) over Bluetooth.

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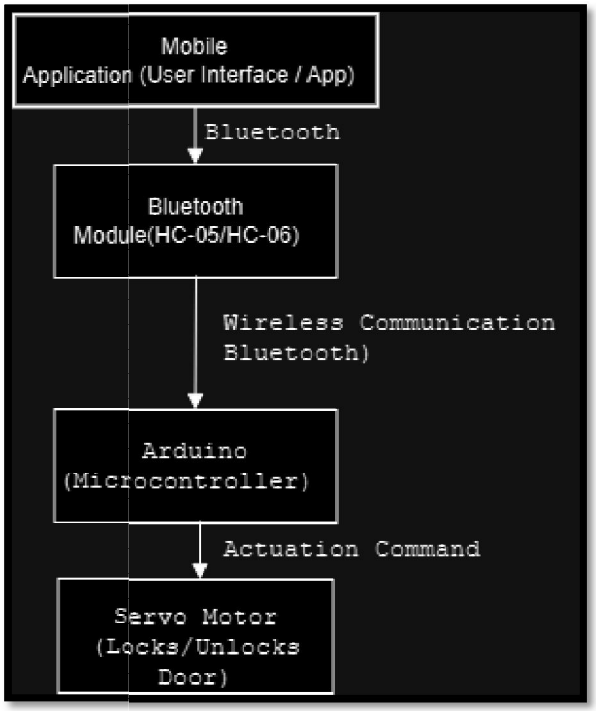

Figure 1.1. System Architecture for Bluetooth enabled Door Lock System

Bluetooth Module (HC-05/HC-06):
The Bluetooth module establishes a wireless communication link between the mobile device and the Arduino.
It listens for commands (e.g., unlock or lock) from the mobile app and transmits them to the Arduino.
Arduino (Microcontroller):
The central control unit that processes the signals received from the Bluetooth module.
Based on the received signal, the Arduino controls the actuator (e.g., Servo Motor) to lock or unlock the door.
Servo Motor (Actuator):
The servo motor is used to physically control the locking mechanism of the door.
It moves between two positions: one for the locked state (e.g., 0 degrees) and one for the unlocked state (e.g., 90 degrees).
Flow of Operation:
Step 1: The user interacts with the mobile app, which sends a signal (unlock or lock command) via Bluetooth.
Step 2: The Bluetooth module (HC-05/HC-06) receives this signal and sends it to the Arduino.
Step 3: The Arduino processes the signal and actuates the servo motor accordingly to either lock or unlock the door.

2.2 Working Principle

- **Mobile App and Pairing**: The user installs the Bluetooth app on their mobile device and pairs it with the Bluetooth module (HC-05/HC-06) connected to the Arduino.
- **Authentication**: Upon opening the app, the user enters a PIN or uses a Bluetooth-based authentication to verify their identity.
- **Lock/Unlock Command**: The app sends an unlock or lock command to the Arduino over Bluetooth.
- **Microcontroller Action**: The Arduino processes the command and actuates the solenoid or servo motor, unlocking or locking the door.

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III. SECURITY FEATURES

3.1 Bluetooth Security Protocols

Bluetooth Low Energy (BLE) includes built-in security features such as encryption, pairing, and authentication:

Pairing: Secure pairing ensures that only authorized devices can connect to the Bluetooth module.

Encryption: The data exchanged between the mobile app and the lock is encrypted using AES (Advanced Encryption Standard) to ensure secure communication.

Authentication: The system can authenticate the user through a PIN, password, or biometric data, providing a multi-layered security approach.

3.2 Access Control

User Profiles: Multiple users can be given different access levels, such as admin or guest. The mobile app can be used to manage these profiles.

Temporary Access: Users can grant temporary access to others by generating one-time-use codes or time-bound permissions.

Audit Logs: The app can keep logs of who unlocked or locked the door and when, providing an additional layer of monitoring.

3.3 Anti-Tampering Mechanisms

To prevent unauthorized access, some systems use tamper sensors to detect when the lock is being tampered with physically. Alerts can then be sent to the user's mobile app.

IV. ADVANTAGES OF BLUETOOTH-BASED SMART LOCKS

4.1 Convenience

Bluetooth-enabled locks offer hands-free operation. Once the user is within range of the lock, the system can automatically unlock the door, providing a seamless experience.

4.2 Increased Security

The encryption protocols and secure pairing mechanisms make Bluetooth-based smart locks more secure than traditional locks. Furthermore, the ability to remotely manage access permissions adds an extra layer of security.

4.3 Cost-Effective

Bluetooth smart locks are relatively low-cost compared to alternatives such as Wi-Fi-based locks or locks requiring internet connectivity. Bluetooth also reduces the cost of infrastructure and installation.

4.4 Integration with Other Smart Systems

Bluetooth smart locks can be easily integrated with other smart home devices such as security cameras, lights, and alarms to provide a cohesive security solution.

V. CHALLENGES AND LIMITATIONS

5.1 Range Limitations

Bluetooth communication typically has a range of around 10 meters. In larger homes or buildings, this may limit the functionality unless Bluetooth range extenders are used.

5.2 Battery Life

The system relies on battery power, and frequent use of the lock may drain the battery quickly. Battery optimization and low-power Bluetooth variants like BLE can help mitigate this issue.

5.3 Security Vulnerabilities

While Bluetooth offers encryption, vulnerabilities such as spoofing, relay attacks, and eavesdropping still pose a threat. Stronger encryption methods and multi-factor authentication can mitigate these risks.

5.4 Compatibility Issues

Compatibility issues may arise due to the variety of Bluetooth standards (e.g., Bluetooth 4.0 vs. Bluetooth 5.0). Ensuring compatibility across different devices is critical for user adoption.

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VI. EXAMPLE CODE IMPLEMENTATION

The following is an example implementation using an Arduino microcontroller, HC-05 Bluetooth module, and a servo motor to control a door lock. The mobile app (for example, a simple Android app) sends a command to the Bluetooth module to unlock or lock the door.

6.1 Hardware Setup

- **Arduino Board** (e.g., Arduino Uno)
- **Bluetooth HC-05** (connected to Arduino via TX/RX pins)
- **Servo Motor** (connected to a PWM pin of the Arduino)
- **Power Supply** (9V battery or external power adapter)

6.2 Arduino Code

```
#include <Servo.h>
Servo doorLockServo;  // Create servo object to control the door lock
int servoPin = 9;  // Define servo pin connected to the Arduino
char receivedChar;  // Variable to store incoming data from Bluetooth module
void setup() {
 Serial.begin(9600);  // Initialize serial communication at 9600 baud rate
 doorLockServo.attach(servoPin);  // Attach the servo to the specified pin
 doorLockServo.write(0);  // Initially, the door is locked (servo at 0 degrees)
}
void loop() {
 if (Serial.available() > 0) {
  receivedChar = Serial.read();  // Read the incoming Bluetooth data
  // If 'U' is received, unlock the door
  if (receivedChar == 'U') {
   doorLockServo.write(90);  // Rotate servo to 90 degrees (unlock the door)
   Serial.println("Door Unlocked");
  }
     // If 'L' is received, lock the door
  else if (receivedChar == 'L') {
   doorLockServo.write(0);  // Rotate servo back to 0 degrees (lock the door)
   Serial.println("Door Locked");
  }
 }
}
```

6.3 Mobile App (Example)

For this project, a simple mobile app (Android or iOS) can be developed using tools like MIT App Inventor or Android Studio. The app should:
Scan for available Bluetooth devices.
Pair with the Bluetooth module (HC-05).
Send commands (U for unlock, L for lock) via Bluetooth to the Arduino.

VII. CONCLUSION

The Bluetooth-based smart door lock system offers a simple yet effective solution to modernize home security. With features such as keyless entry, remote access, and real-time monitoring, this system provides significant advantages over traditional mechanical locks. While challenges related to range, battery life, and security remain, the integration of Bluetooth with microcontroller platforms like Arduino makes this technology both accessible and scalable. Future

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advancements in Bluetooth technology, battery efficiency, and security protocols will further enhance the robustness of Bluetooth-based smart locks.

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