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OTP based Door Lock using Arduino and SIM800L

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Abstract

Nowadays, people prioritize security above all else, making it a more important concern in their lives. The proposed work aims to replicate the extensive literature research on OTP-based door locks, which are crucial for residential, commercial, and auto security because of ever increasing risk of theft. The existing methods include various kinds of door lock security systems, such as traditional security systems that transmit signals through alarms. Some door lock security systems are based on GSM, GPS, and biometrics like face recognition, iris scanning, RFID, smart cards, and passwords. Every system has benefits and drawbacks of its own. Overcoming the limitations of authentication mechanisms like mechanical and digital door locks is the reason why access control systems based on OTP are preferred. The user does not require the administrator's help to access the door if they are familiar with the proposed method and have the registered mobile number and OTP. The OTP is generated and sent to user's mobile number whenever the user accesses the door.

Keywords: Door Lock Security, GSM, SMS, Sensor, LCD Display, Password

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1. Introduction

Security safeguards lives and possessions. Preventing unauthorized access is necessary for protecting the lives and the valuables of the individuals. Therefore, it is crucial to prioritize door lock security in order to prevent additional issues in the monitored area. Even when mechanical locks are used, thefts still occur since it is simple to break through such locks. Therefore, it is necessary to create new types of locks that are difficult to break. Consequently, several researchers have offered a variety of digital door lock options, including software-based and password-based locks, as well as automatic door locks [1]. They are extensively utilized in homes and workplaces [2]. The main doors of buildings are secured to prevent unwanted entry using digital codes, biometrics, and standard electronically driven locks, such as finger print technology, or those that solely rely on thumb printing. In order to help people secure their homes or places of business from a distance, advanced automatic door security systems are now available. These systems use palmtop recognition, face recognition, face detection, wireless sensors, PIR sensors, RFID techniques, smart cameras, and many other features, each has its own advantages and drawbacks.

A door lock system with an OTP (One-Time Password) is a type of security system that uses a special password that can only be used once to unlock the door [3]. Compared to conventional lock systems, it offers an additional layer of security [4] [5]. Typically, the system includes door lock mechanism that is connected to a microcontroller that generates an OTP. An SMS is commonly used to deliver the OTP to the user's mobile device. After entering the OTP into the keypad, the user sends a signal to the microcontroller to unlock the door. Since the password can only be used once, an OTP-based door lock system has the advantages of increased security and ease of use.

1.1 Objectives

The primary objective of this research is to develop an OTP-based door locking system (Figure 1) using Arduino and SIM800L module that addresses the limitations of traditional access control method [2]. Specific goals include:

- Constructing a hardware configuration that includes an Arduino microcontroller, a SIM800L GSM module, an electronic door lock, and an OTP entry keypad.

- Creating firmware that can create random one-time passwords (OTPs), deliver them through SMS to users that are allowed, and validate OTPs input through the keypad.
- Establishing security measures in place to stop illegal entry.
- Analyzing the system's reliability, dependability, and defense against typical security risks.

1.2 Problem Statement and Description

The OTP based smart lock system can generate a new OTP each time someone unlocks the door, enhancing the security level more. This system is much safer than the mechanical key-based system and other door lock systems. If a key is lost or stolen, it can lead to a dangerous situation. The electronic password-based door lock is also not secure. There is a chance of forgetting the password or it being hacked. Thus, by using an OTP (One Time Password) based door lock system can eliminate all the security risks and provide enhanced protection.

The existing door locking systems often rely on conventional method such as physical keys or keycards, which are susceptible to security vulnerabilities such as duplication, loss, or theft. Additionally, these systems lack the flexibility to grant temporary access to authorized individuals remotely.

2. Existing Methods

There are some existing methods such as mechanical door lock, digital door lock, face recognition and card recognition etc.

- **Mechanical Door Lock:** This is a system that uses the physical key to open and close the door which can be frequently utilized, this system requires less installation money compared to digital door lock system. But the user always needs to carry the key. It is disadvantage if the key is lost or stolen as reissuing the key is more expensive [3].
- **Digital Door Lock:** This method is operated by using an electric control such has card recognition, number input and a biometric method which has been developed but also have some drawbacks of its own.

- **RFID based System:** The digital door lock security systems use RFID tags to ensure that only valid person can enter; these systems operate in real time. In this, the users have to place their RFID tags near the detector, which then stores the necessary user data. The latest RFID based door locks are based on Arduino technology, activating when a card is placed near the RFID module [6, 7].

2.1 Problems on Existing Method

There are chances of RFID cards/tags getting lost. Biometric information methods require individual's fingerprints, face, iris, etc., and also need to recognize behavioral characteristics such has voice, and fingerprint. However, these methods have disadvantages such as requiring more memory for data storage and having a high installation cost.

Tables 1 and 2 illustrate the existing door lock security system, their techniques, and limitations respectively.

Table 1. Biometric Techniques

S. No	Biometrics Techniques		
	Specific Techniques	**Problems**	**Reference**
1	Face Recognition	Stronger robustness and dependability are required.	More, H.B. and Bodkhe, A. R. [8]
2	Palmtop Recognition	A scanner with high resolution is required.	Nafi, K. W., Kar, T. S. and Hoque, S. A. [9]
3	Face Recognition with GSM Technology and E-mail Facility	Variations in illumination, an individual's hair type, and whether the Someone is wearing glasses less. Issues with net connectivity brought on by unusual weather.	Sahani, M., Subudhi, S., and Mohanty, M. N. [10]
4	Iris scanner Vein Detection Unique Code	The data requires more memory to be stored.	Dutta, S., Pandey, N. and Khatri, S. K. [11]

Table 2. Specific Techniques

S. No	Password Based system		
	Specific Techniques	**problems**	**Reference**
1	Digital Code Lock	Unable to modify the password; the system will shut off in the event of a power outage.	Chanda, S., Rasaily, D. and Khulal, P. [12]
2	One Time Password	A quick timeout followed by many uses lead to multiple lockouts.	Nishad Gupte, N. and Mihir, R. [4] Snehalata Raut [13]

3. Proposed Methodology

To avoid the use of physical keys the proposed method uses an OTP (four-digit numeric code) generated in an Arduino microcontroller and delivered to the registered mobile number using the GSM module. A copy of the OTP is stored in the Arduino microcontroller's RAM, which serves as the authentication method in this case [2]. The code would then be entered using a keypad. If the entered OTP is correct then the relay module access to open the lock, Try again is displayed on the display if the OTP entered is incorrect.

3.1 Circuit Diagram

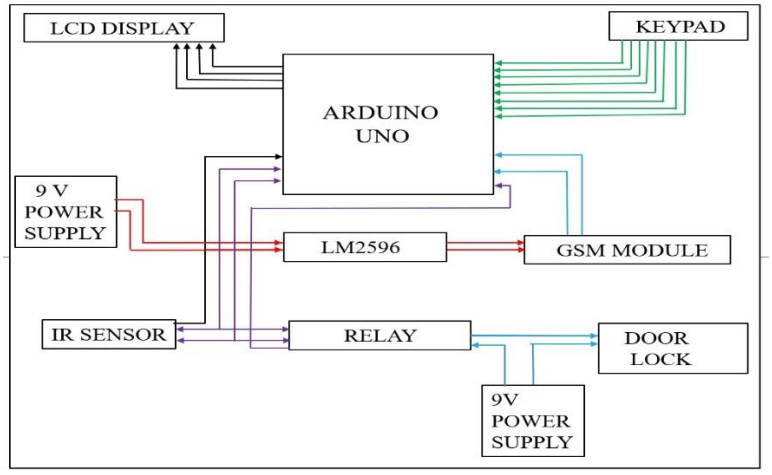


Figure 1. Circuit Diagram of OTP-based Door Locking System

3.2 Proposed Block Diagram

The central controller of the proposed system, Arduino, is responsible for OTP generation and verification. SMS communication for OTP transmission and remote access management is facilitated by SIM800L GSM module. The authentication procedure starts whenever a user is detected by an IR sensor. The relay controls the solenoid lock for physical access control, the LM2596 voltage regulator guarantees a steady power supply. The block diagram of the proposed system is depicted in Figure 2.

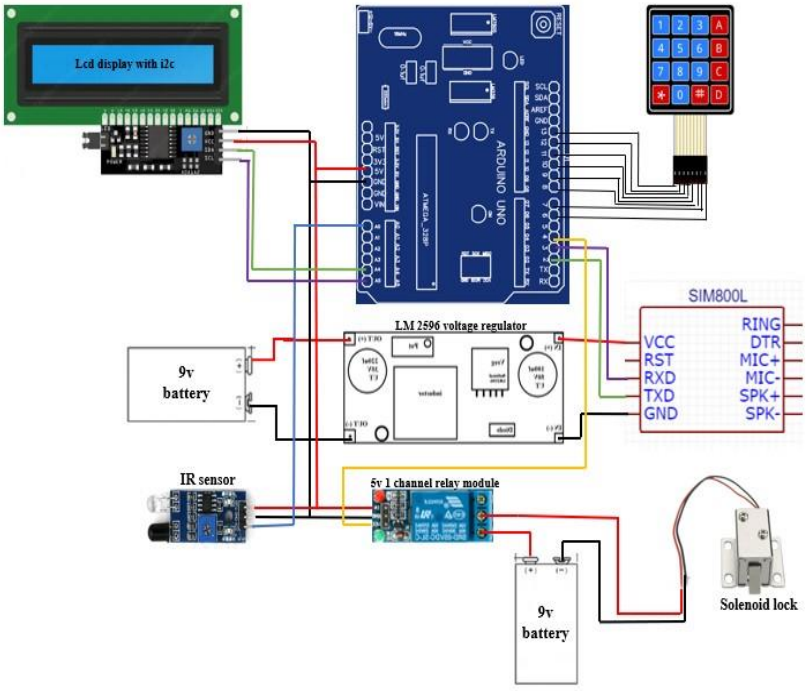


Figure 2. Block Diagram of Proposed Method

3.3 Working of Proposed Method

To increase door security, the "OTP-based Door Lock System" uses a one-time password authentication technique. The system will increase security by requiring a unique password each time if someone tries to enter on individual premises. The Arduino board, which is simply a microcontroller carries out pre-programmed commands to communicate with the SIM800L, IR sensors, LCD display, relay module, and solenoid lock. Using jumper wires, the keypad output pins are connected to any digital pin on the Arduino. With this configuration, the Arduino can identify which key is being pressed while entering OTP by scanning across each row and column. Using the I2C protocol, a 16x2 LCD can be interfaced with an Arduino

by connecting its VCC pin to the Arduino 5V pin, its GND pin to the Arduino GND pin, its SDA pin to the Arduino A4 (SDA) pin, and its SCL pin to the Arduino A5 (SCL) pin. Data pins 7 through 14 on the LCD display are used to transfer data from the Arduino board to the LCD module. The purpose of the infrared sensor is to identify objects within its detection range. The LED lights and the IR output reads low if there is an object nearby. If the LED is off and there is nothing within its range, the IR output reads high. After the IR sensor output, an LED can be controlled by a relay switch.

The SIM800L is a GSM module with a serial interface that can be used to send and receive text messages and receive phone calls as well as connected with the internet to receive FM signals. The SIM800L can be connected to a microcontroller using the serial UART interface. The module comes with a helical antenna that can be connected. The voltage ranges of 3 to 35 volts can be easily adjusted with the LM2596 voltage regulator, as this module is associated with SIM800L to step down the voltage as per the power need by the GSM module.

Solenoid lock is an Electromagnetic lock that works on the principle that a current-carrying coil produces a magnetic field near it. Here, the solenoid lock is controlled by Arduino, that in turn generates the signals so the lock turns on and off after the delay of a second. The lock is indirectly connected to the Arduino through the relay module. As the lock works with electricity so in case of power failure the lock can’t be opened or closed. So, the solenoid lock needs a 9-volts battery for its functioning.

When the motion is detected near the door by the IR sensor, the Arduino randomly generate 4-digit OTP. This OTP is then sent to the user’s mobile number via the SIM800L GSM module. The user receives the OTP and is then entered using the keypad. Then the entered OTP is compared with the generated OTP which is stored in the Arduino. If the OTP matches, the Arduino activates the relay module, which then activates the solenoid lock. An LCD interface which is used to show and instruct this process, provide instruction and information that is easy for user to understand. The system ensures that the door is remains unlocked for a period of time before locking again, ensuring security.

3.4 Software Implementation

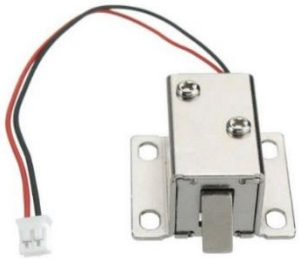
- **Arduino IDE**

Programming the Arduino board used in the OTP-based Door Lock System requires the Arduino IDE. The C++ is used to code the Arduino board to regulate the OTP generation, IR sensor motion detection, and SMS communication through SIM800L GSM. It is programmed to control LCD display instructions and to set up keypad input for OTP entry. After OTP verification, the IDE coordinates relay module activation for solenoid lock operation. It provides digital pins for sensors and relays, I2C for LCDs, and UART for GSM modules. Code reliability is ensured by debugging tools like the Serial Monitor, which makes system deployment and maintenance easier. All things considered, the Arduino IDE makes strong component integration possible, guaranteeing effective and safe door access control.

3.5 Hardware Required

Table 3. Hardware Components

Actual Uses	Components
Arduino Microcontroller: Arduino UNO serves as the core processing unit in charge of organizing how the entire system works. Produces OTPs, or one-time passwords, for authentication. Regulates how the device interacts with its accessories and other hardware parts.	 Arduino Board
GSM Module SIM800L: Makes it possible to send and receive SMS messages using mobile networks and also easier for OTPs to be sent to the mobile phones of authorized users for authentication	 GSM Module

IR Sensor: Detects presence or motion near to the door. Also detects motion and initiates the authentication process.	 IR Sensor
LM2596 Voltage Regulator: Control the voltage given to the system in order to ensure steady operation. It Convert an input voltage usually from power source into an output voltage that is regulated and appropriate for powering the components	 Voltage Regulator
Solenoid Lock: Locking mechanism that is powered by electricity. Depending on whether the relay is activated, engages or disables the lock bolt to secure or release the door.	 Solenoid Lock
Keypad: Used for entering the OTP	 Keypad

16x2 LCD Display with I2C: Gives the user visual cues during the authentication process, such as prompts, instruction and Confirmation messages. Makes use of the I2C communication standard to facilitate simple Arduino Interface.	 LCD Display with I2C
Relay: Serves as a switch that the Arduino may control. Determines the solenoid lock's power supply according to the authentication output.	 Relay

3.6 Flow Chart

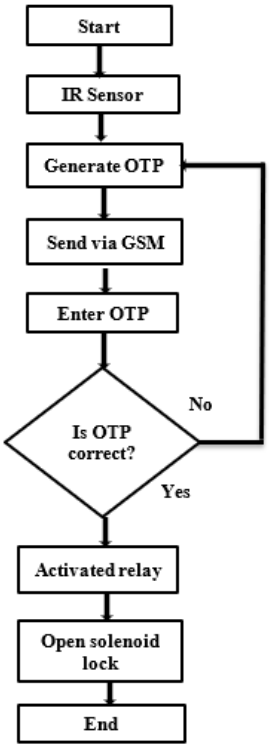


Figure 3. Flow Chart of OTP-based Door Locking System

3.7 Flow Chart Process

Figure 3 depicts the flowchart of the proposed.

- **Start:** The flowchart starts.
- **IR Sensor**: Detects presence of motion close to the door.
- **Prompt uses for OTP:** Arduino request that the user to input their OTP.
- **Enter OTP:** Using a keypad, the user inputs their OTP.
- **Verify OTP:** Arduino verifies validity by comparing the entered OTP and generated OTPs.
- **Send Confirmation:** Arduino uses the SIM800L GSM module to transmit a confirmation message if the OTP is validated.
- **Activate Relay:** To regulate the solenoid lock's power supply, Arduino triggers the relay.
- **Solenoid Lock:** The solenoid lock is powered by activated relay, which allows the door to be unlocked.
- **End:** The flowchart concludes.

3.8 Benefits

The OTP-based Door Lock System offers enhanced security compared to conventional key-based or fixed code locks due to unique and time-limited OTPs, reducing the risk of unauthorized access. OTPs are sent through SMS, eliminating the need for physical keys and simplifying access management, especially for multiple users. Integration with the SIM800L module enables remote access control, allowing authorized users to generate OTPs from anywhere with cellular network coverage. Real-time monitoring facilitated by an infrared sensor detects motion near the door, initiating the authentication process. Battery packs serve as backup power for Arduino boards, ensuring system reliability during power outages.

3.9 Disadvantages

The OTP-based Door Lock System faces challenges such as dependency on cellular networks, which can impact system reliability during network outages or in areas with poor coverage. Limited accessibility may pose difficulties for users without cell phones or

familiarity with SMS technology. The system's installation and maintenance require technical expertise and time due to software development, hardware integration, and configuration complexities. Regular maintenance is essential to ensure system security and optimal performance.

OTP-based door lock systems using Arduino and SIM800L modules still have a lot of benefits in terms of simplicity, security, and versatility even with these possible drawbacks. It is accessible to develop a reliable and efficient access control system that is appropriate for a range of applications such as residential areas, commercial buildings etc. and situations by addressing these issues through appropriate design, implementation, and maintenance.

4. Results and Discussion

Figure 4 given below represents the working setup of the proposed.

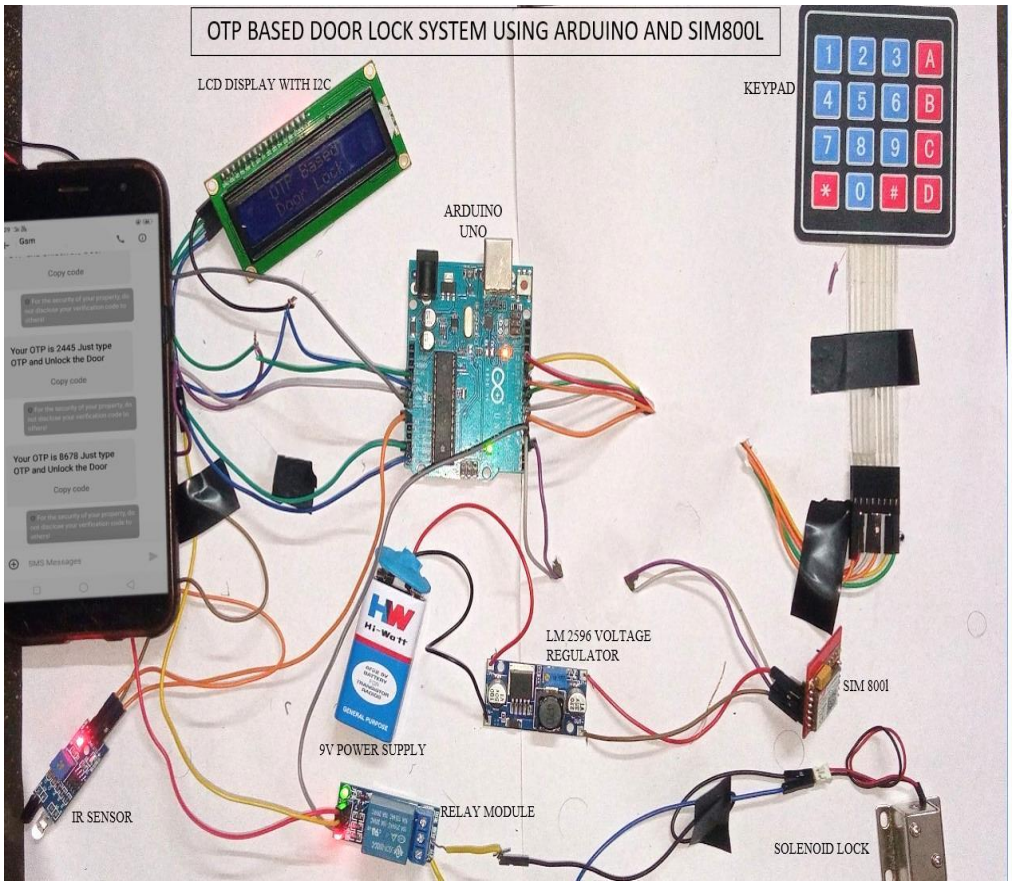


Figure 4. Working Setup

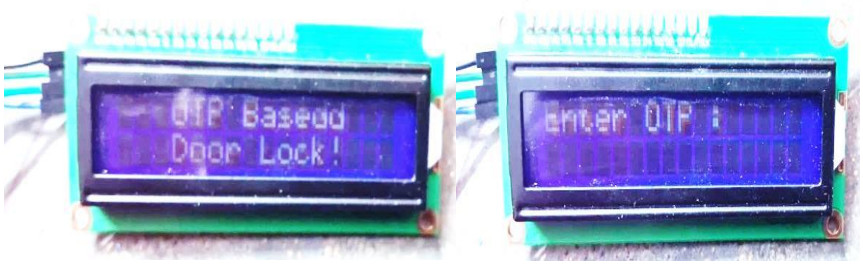


Figure 5. a) OTP based Door Lock and b) Enter OTP

The above Figure 5 (a and b) represents the LCD displayed by the system.

Figure 6. Access Failed Try Again

If the entered OTP is incorrect, then it displays the above message as shown in Figure 6

5. Conclusion

To summarize, the OTP-based door lock system is a major development in access control technology, providing a cutting-edge and dependable means of protecting buildings and limiting access in a world that is becoming more and more digital. This system has the potential to completely transform the way to safeguard the individual residences, places of business, and institutions through continued innovation and cooperation, opening the door to a safer and more accessible future.

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