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**INSTITUTE OF ENGINEERING**

**PASHCHIMANCHAL CAMPUS**

LAMACHAUR, POKHARA

A PROJECT REPORT ON

**Access Control System with Relay and**

**Smoke Sensor Integration**

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**SUBMITTED TO:**

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING

JESTHA, 2080

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Sincerely,

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**ABSTRACT**

This proposal outlines the design and implementation of an RFID-based door access control system with integrated smoke detection sensor and automatic light opener for a room. The system utilizes RFID technology to grant access to authorized individuals using a RFID tag or phone via WIFI and ESP-32 microcontroller, while the smoke detection sensor ensures the safety of the building by detecting smoke and triggering the notification. The automatic light opener is triggered by the RFID system using relay module when an authorized user enters the room, providing convenience and energy efficiency by only illuminating the room when it is occupied.

The proposed system offers increased security, safety measures and energy efficiency for any facility by implementing access control, fire prevention and automatic light opening capabilities. The integration of RFID technology is easy and can be carried out all the times while the phone-based access option can be carried with the user all the times. The smoke detection sensor and automatic light opener allows for real-time monitoring and control of the building's access points, provides a quick response in case of emergency situations and reduces energy consumption.

*Key Word: RFID, ESP-32, Smoke sensor, Relay module, Phone application*

Table of Contents

[Chapter 1. INTRODUCTION 1](#_Toc135479715)

[1.1 Background 1](#_Toc135479716)

[1.2 Problem Statement 2](#_Toc135479717)

[1.3 Objectives 3](#_Toc135479719)

[Chapter 2. BACKGROUND THEORY 4](#_Toc135479720)

[3.1 Hardware Components 4](#_Toc135479721)

3.1.1 NodeMCU ……………………………………………………..…... 4

3.1.2 RFID tag and scanner ………………………………….……….…. 4

3.1.3 Smoke Sensor (MQ-2) …………………………………………..… 5

3.1.4 RelayModule……………………………………………………..... 6

3.2 Software Components ………………………...…………………..…….. 6

3.2.1 Frontend…………………………….………………………..…...… 6

3.2.2 Database……………………….…………………………….…..…. 7

3.2.3 Visual Studio Code …………………….……………………….…. 7

3.2.4 Git and GitHub ………………………………….………………… 7

[Chapter 3. LITRATURE REVIEW 8](#_Toc135479722)

[Chapter 4. METHODOLOGY 9](#_Toc135479723)

[4.1 Block Diagram 9](#_Toc135479724)

[4.2 Project Development Life Cycle 11](#_Toc135479725)

[Chapter 5. RESULTS AND ANALYSIS 17](#_Toc135479727)

[Chapter 6. CONCLUSION AND FUTURE ENHANCEMENTS 18](#_Toc135479728)

[6.1 Conclusion…………………………………………………………...…](#_Toc135479726) 18

[6.2 Future Ehancements 18](#_Toc135479726)

[Chapter 7. SCREENSHOTS 19](#_Toc135479731)

[7.1 Register Page 19](#_Toc135479732)

[7.2 Login Page 20](#_Toc135479733)

[7.3 Home Page 21](#_Toc135479734)

[7.4 Smoke Detection Dialog Box 22](#_Toc135479735)

[7.5 Smoke Alert Notifications 23](#_Toc135479736)

[REFERENCES 24](#_Toc135479737)

APPENDIX (Software Coding) …………………….…………...…………... 25

List Of Figures

[Figure 1. NodeMCU 4](#_Toc135505760)

[Figure 2. RFID Reader 5](#_Toc135505761)

[Figure 3. MQ-2 Gas Sensor 5](#_Toc135505762)

[Figure 4. Relay Module 6](#_Toc135505763)

[Figure 5. Block Diagram 9](#_Toc135505764)

[Figure 6. Circuit layout 12](#_Toc135505765)

[Figure 7. Use case diagram 13](#_Toc135505766)

[Figure 8. Sequence diagram 14](#_Toc135505767)

[Figure 9. Activity diagram 15](#_Toc135505768)

[Figure 10. Class diagram 16](#_Toc135505769)

[Figure 11. Register page 19](#_Toc135505770)

[Figure 12. Log in page 20](#_Toc135505771)

[Figure 13. Homepage 21](#_Toc135505772)

[Figure 14. Smoke Detection Dialog Box 22](#_Toc135505773)

[Figure 15. Smoke Alert Notifications 23](#_Toc135505774)

## Chapter 1. INTRODUCTION

### 1.1 Background

With the advent of information and technology, the industry has been transformed abruptly to digital. This revolution has brought massive changes into the day-to-day life of people. Many innovations have been made to make human life easier with modern technology. Different hardware and software systems are utilized to optimize and uplift the older systems and methods. There are many systems and methods in Nepal that are quite old and require modern optimization. So, for the development of new systems to override the old systems, a lot of research and development work is required.

This project gives design and implementation of a RFID-based door access control system with integrated smoke detection sensor and automatic light opener for a room. The system aims to enhance security, safety, and energy efficiency in any facility by providing real-time monitoring, quick response in case of emergency, and reducing energy consumption. The proposed system utilizes RFID technology to grant access to authorized individuals using RFID tag or via phone with WIFI and ESP-32 microcontroller, while the smoke detection sensor ensures the safety of the building by detecting smoke and activating the alarm. The automatic light opener is triggered by the RFID system when an authorized user enters the room with the help of relay sensor, providing convenience and energy efficiency by only illuminating the room when it is occupied.

The integration of RFID technology, smoke detection sensor, and automatic light opener allows for real-time monitoring and control of the building's access points, providing a quick response in case of emergency situations and reducing energy consumption.

This project gives design and implementation of the system, including a detailed description of the components and their functions, as well as the expected benefits of the system. The project aims to provide a secure, safe and energy-efficient environment for any facility.

### 1.2 Motivation

### The motivation behind the development of the RFID-based access control system with automatic light opener and smoke alert using an MQ-2 gas sensor, along with the accompanying mobile application, stems from the increasing need for robust security systems and enhanced automation in various settings. Traditional door access control systems often rely on physical keys, which can be lost, stolen, or easily duplicated, compromising security. Additionally, manual control of lighting and limited detection of hazardous situations like smoke can lead to inefficiencies, energy wastage and potential risks.

### The use of RFID tags enables precise identification and authentication of individuals, eliminating the need for physical keys and minimizing the risk of unauthorized access. Moreover, incorporating a relay module enables seamless control of the lighting system, enhancing energy efficiency and providing customizable lighting options for different areas. The inclusion of an MQ-2 gas sensor addresses the critical concern of smoke detection preventing potential fire hazards. By integrating the sensor with the system, an alert can be sent to authorized personnel, allowing them to take immediate action and mitigate potential risks.

### Furthermore, the development of a mobile application complements the system by providing remote access and control. Authorized users can monitor the status of the door, light and smoke percentage and receive real-time notifications about the smoke detection alerts. The mobile application aims to enhance user experience, accessibility, and control, offering a modern and user-friendly interface.

### 1.2 Problem Statement

### The problem that this project aims to solve is to ensure the safety and security of a building by controlling access to it and detecting potential fire hazards while conserving energy and reducing costs by only turning on the lights when they are needed. The problems with traditional door locking systems such as keyed locks and security locks can be inconvenient and may not provide enough security as inadequate security and control over who has access to the building which can lead to safety and security issues. The absence of smoke detection can make it difficult to respond to fire hazards increasing property damage and injury to occupants while the absence of automatic lighting feature can cause high energy cost due to lights being left on unnecessarily resulting higher bills and wastage energy.

### 1.3 Objectives

The general objective of the Access Control System with Relay and Smoke Sensor Integration is:

* To enhance the safety and security of the room and property while efficient consumption of energy only when needed.

## Chapter 2. BACKGROUND THEORY

### 3.1 Hardware Components

**3.1.1 NodeMCU**

NodeMCU is an open-source development board that incorporates the powerful ESP8266 WI-FI chip. With its built-in WI-FI capabilities, this board is ideal for Internet of Things (IOT) projects. It offers a user-friendly platform for creating projects that require wireless connectivity without the need for additional hardware or complex wiring. The NodeMCU board supports programming in both Lua scripting language and Arduino IDE, providing flexibility and compatibility with a wide range of existing libraries and resources. Its ESP8266 chip allows for seamless wireless communication, enabling the board to connect to WI-FI networks and interact with online services effortlessly.



Figure 1. NodeMCU

(Source: https://www.amazon.com/HiLetgo-Internet-Development-Wireless-Micropython/dp/B010O1G1ES)

**3.1.2 RFID tag and scanner**

A radio frequency identification reader (RFID reader) is a device used to gather information from an RFID tag, which is used to track individual objects. Radio waves are used to transfer data from the tag to a reader. RFID is a technology similar in theory to bar codes. However, the RFID tag does not have to be scanned directly, nor does it require line-of-sight to a reader. The RFID tag must be within the range of an RFID reader, which ranges from 3 to 300 feet, in order to be read [1]. RFID technology allows several items to be quickly scanned and enables fast identification of a particular product, even when it is surrounded by several other items.



Figure 2. RFID Reader

(Source: https://quartzcomponents.com/products/rc522-rfid-13-56mhz-reader-writer-module)

**3.1.3 Smoke Sensor (MQ-2)**

The MQ-2 smoke sensor is a versatile gas sensor capable of detecting smoke, combustible gases like LPG and harmful substances (CO2). It operates by measuring changes in resistance when exposed to different gases. The sensor module includes a sensing element, heater and signal processing circuit [6]. It provides an analog voltage output that can be used for fire detection, gas leakage detection, air quality monitoring. The MQ-2 sensor is cost effective and reliable solution for detecting smoke and hazardous gases.

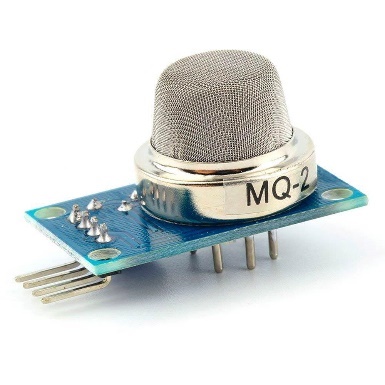


Figure 3. MQ-2 Gas Sensor

(Source: https://circuit-electronics.com/product/smoke-sensor-mq2-digital-analog)

**3.1.4 Relay Module**

A relay module is an electronic device used in projects to control high power circuits using low-power signals. It consists of a relay switch and a control circuit.

When the control signal is received the relay module can turn on or off the connected high-power circuit, making it useful for applications such as home automation [9].



Figure 4. Relay Module

(Source: https://www.daraz.com.np/products/relay-module-5v-1-channel-i123177834.html)

**3.2 Software Components**

**3.2.1 Frontend**

Flutter: Flutter is an opensource UI (User Interface) framework developed for building cross-platform mobile applications. It allows developers to write code once and deploy it on multiple platforms, including Android, iOS, web and desktop. Flutter utilizes a reactive and component-based architecture enabling fast development and providing and visually appealing user interface with native-like performance.

**3.2.2 Database**

Firebase: Firebase Database is a cloud-hosted NoSQL database that offers real-time data synchronization, allowing developers to store and retrieve data in real-time across multiple clients, such as web and mobile applications. It uses a JSON data structure and provides powerful features like offline data persistence, data security and real-time event listeners.

**3.2.3 Visual Studio Code**

Visual Studio Code, also commonly referred to as VS Code, is an open-source code editor made by Microsoft. It supports features for debugging, syntax highlighting, intelligent code completion, snippets, code refactoring and embedded Git.

**3.2.4 Git and GitHub**

Git is a version control system that lets you manage and keep track of your source code history. GitHub is a cloud-based hosting service that lets you manage Git repositories.

## Chapter 3. LITRATURE REVIEW

The use of Access Control System with Relay and Smoke Sensor Integration has been the subject of numerous studies in the literature. This Access Control System with Relay and Smoke Sensor Integration system ensures several advantages over traditional system including enhanced security, safety and conservation of energy and ability to remotely control access. A literature review for this project would involve researching and analyzing existing studies, articles, and publications related to RFID based door access control systems, smoke detection, and automatic lighting.

Numerous studies have explored the implementation of RFID technology in door access control systems. For instance, Edozie E et al. (2020) presented a detailed design and implementation of an RFID-based door access control system. Their study demonstrated the successful integration of RFID technology with the access control software, enabling efficient authentication and access management [2].

In their research, Sadeque RK et al. (2015) highlighted improved security as a primary advantage. RFID tags, with their unique identification codes, provide a higher level of authentication compared to traditional key-based systems [4].

While RFID-based door access control systems offer significant advantages, they are not without challenges. Keziah Andrew et al. (2015) identified signal interference as a potential limitation, particularly in environments with multiple RFID readers operating simultaneously [7].

The literature review reveals that RFID-based door access control systems offer enhanced security, convenience, and potential for integration with other systems. While challenges such as signal interference ongoing research aims to address these limitations. The findings from the reviewed studies provide valuable insights for the design, implementation, and optimization of RFID-powered access control systems.

## Chapter 4. METHODOLOGY

### 4.1 Block Diagram

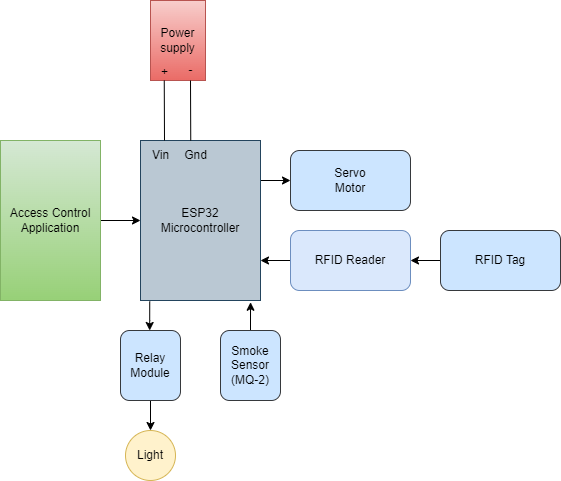


Figure 5. Block Diagram

The overall approach to developing the Access Control System with Relay and Smoke Sensor Integration will be to design and build a hardware system that includes an RFID reader, an ESP32 microcontroller, a door lock mechanism, and a mobile application. The RFID reader will be used to read RFID tags and send the tag data to the ESP-32. The ESP-32 will be connected to the internet via WIFI and will be able to communicate with a phone app. The door lock mechanism will be able to open and close the door based on signals from the ESP-32. With the implementation of smoke detection sensor (MQ-2) we will be able to verify the smoke coming from the room and automatically open the doors. With relay sensor we will be able to automatically switch the lights upon the entry of authorized users.

The Access Control System with Relay and Smoke Sensor Integration will be developed in following steps:

* Research and analysis: Conduct a thorough analysis of the current access control and safety systems in the facility and research the latest RFID technology, smoke detection sensors, and automatic lighting systems available on the market.
* Design: Based on the research and analysis, design a system that integrates RFID technology, smoke detection sensors, and automatic lighting systems to meet the specific needs of the facility.
* Testing and Prototyping: Develop a prototype of the system and conduct testing to ensure that it is functioning correctly and meets the desired specifications.
* Implementation: Once the system has been fully tested and all bugs have been resolved, it is implemented in the facility. This includes installing the RFID readers, smoke detection sensors, and automatic lighting systems.
* Training: Train the staff on how to use the new system and provide them with the necessary information to maintain the system.
* Training: Train the staff on how to use the new system and provide them with the necessary information to maintain the system.
* Evaluation: Evaluate the effectiveness of the system by monitoring the access control, safety and energy efficiency, and make any necessary adjustments or improvements to optimize the system

Overall, this methodology aims to provide a secure, safe and energy-efficient environment for the facility by integrating RFID technology, smoke detection sensor and automatic light opener to meet the specific needs of the facility and by evaluating the effectiveness of the system.

### 4.2 Project Development Life Cycle

Our system was built using an agile method which is an iterative model. In this method we worked on a very small part of the project and incrementally developed the project. Different members of the team worked on different components parallelly which made work faster and easier. At the end of each cycle, we had a working system at the end after integration of the components. This made it easier for us to know about our progress and errors that were discovered in our system. We also got to know about shortcoming features of the system and it was easier for us to add new features in our system easily as needed for us.

### 4.3 Circuit Layout

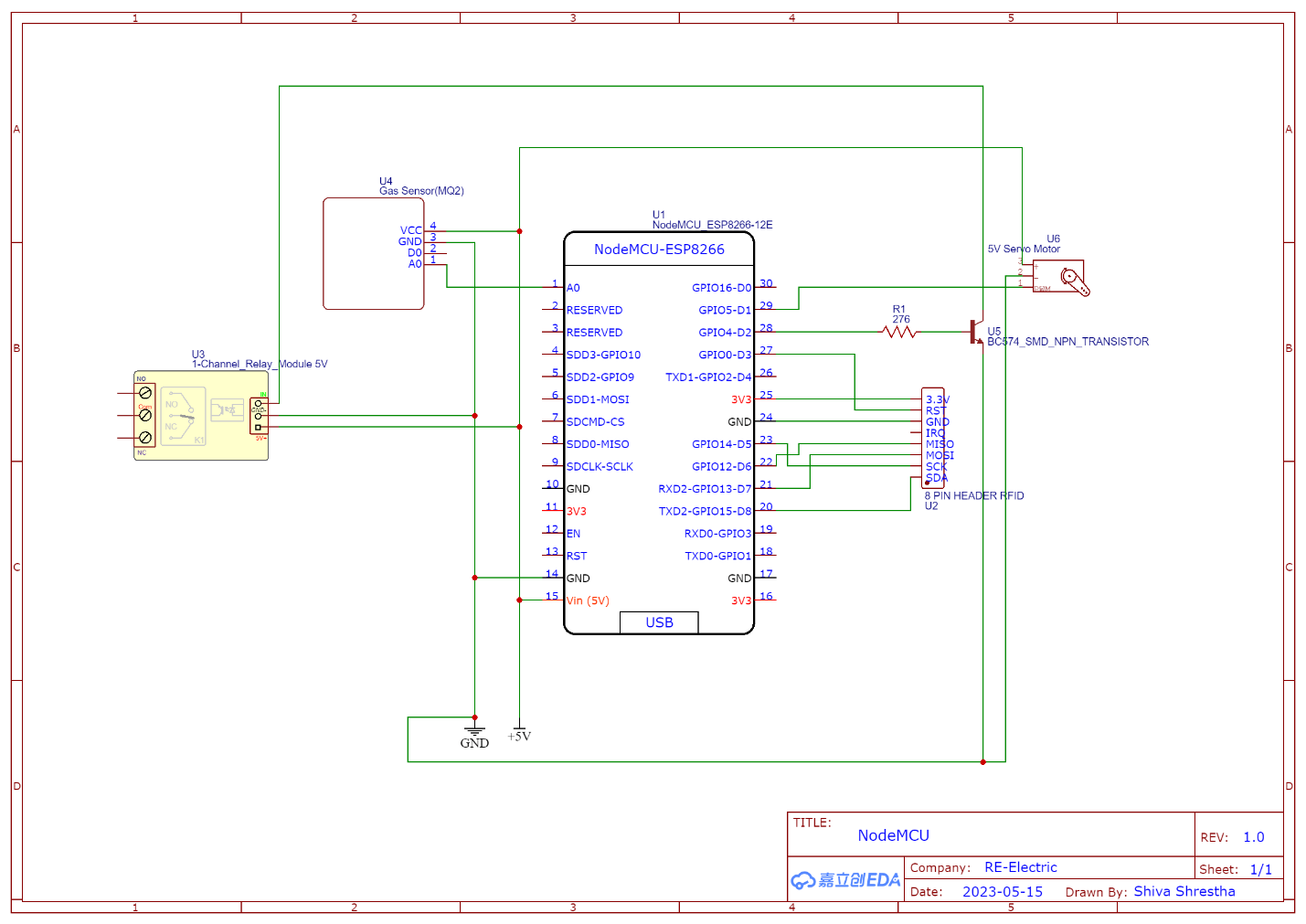


Figure 6. Circuit layout

**4.4 Use Case Diagram**

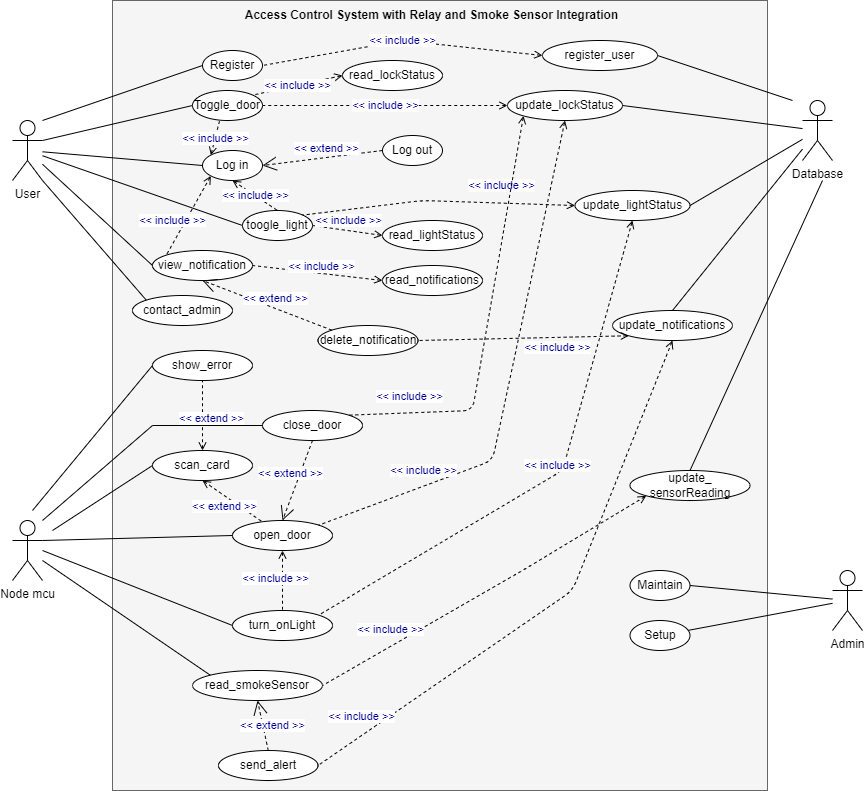
****

Figure 7. Use case diagram

**4.4 Sequence Diagram**

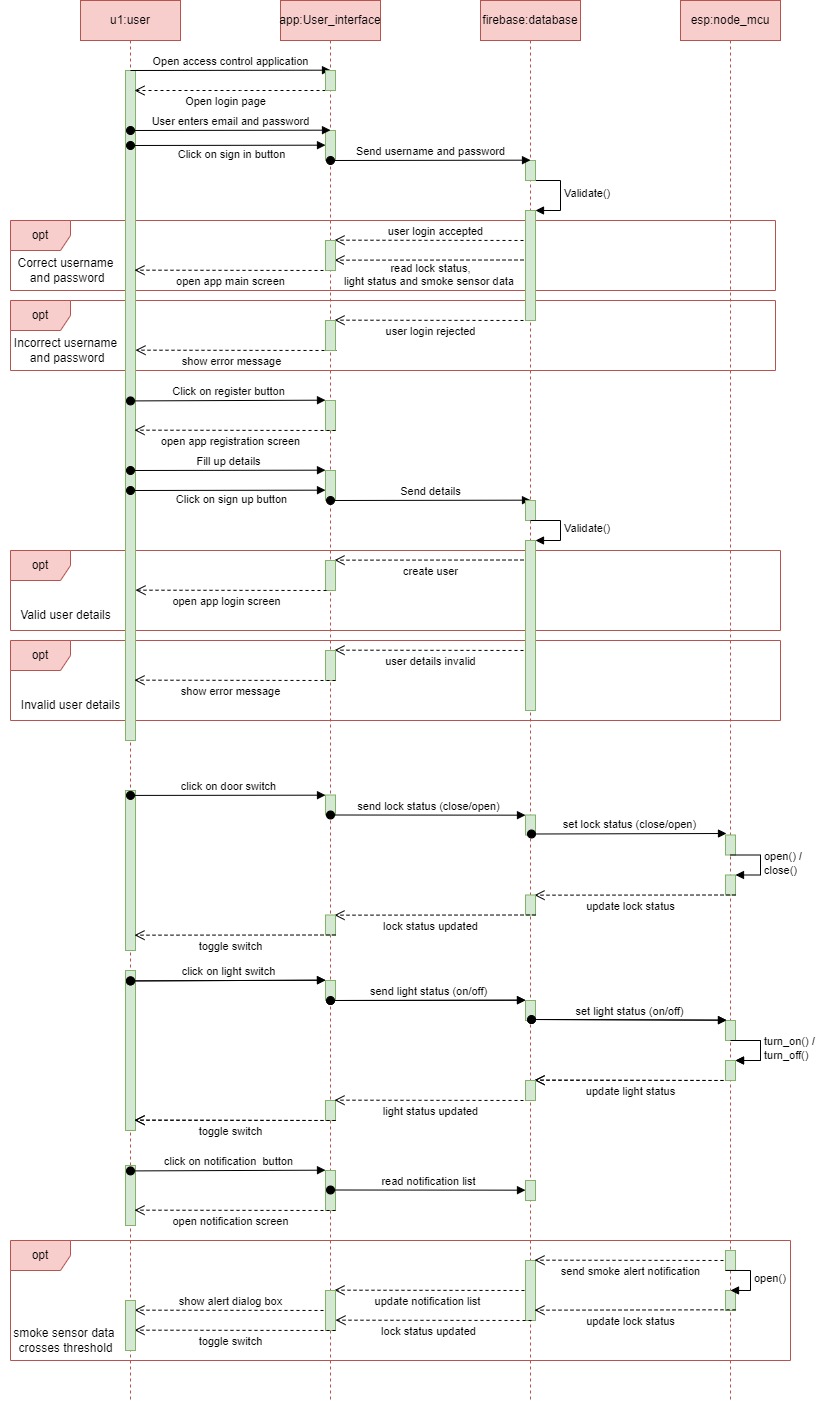
****

Figure 8. Sequence diagram

**4.5 Activity Diagram**

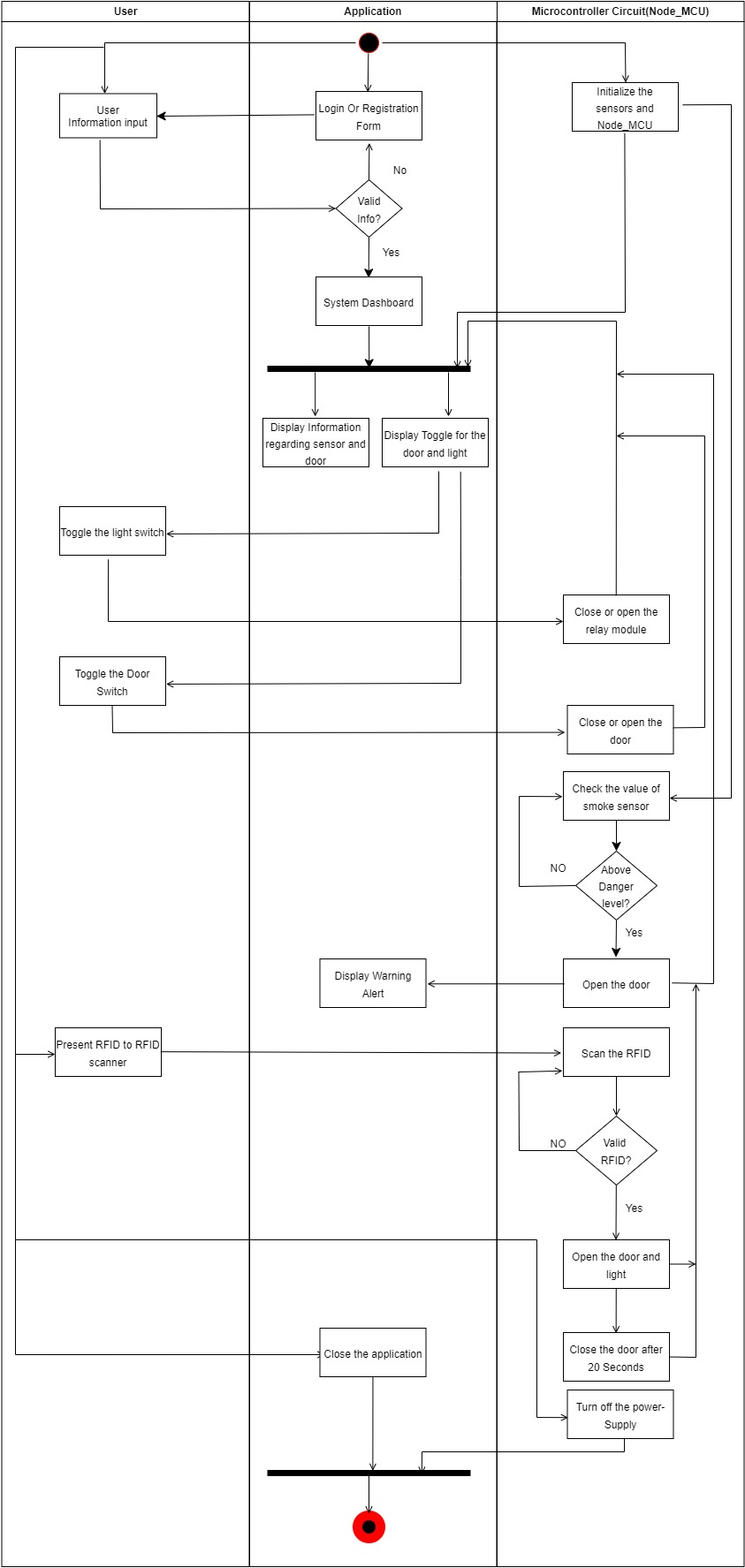
****

Figure 9. Activity diagram

**4.6 Class Diagram**

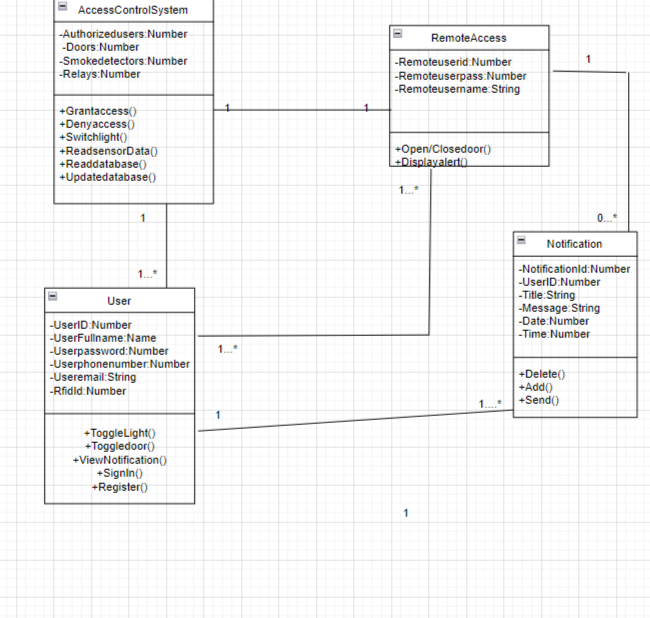
****

Figure 10. Class diagram

## Chapter 5. RESULTS AND ANALYSIS

The results of the RFID-powered door access control system project showed that the system performed with high accuracy and reliability. The system has demonstrated high efficiency in granting access to authorized individuals ensuring secure entry to the premises. During testing, the system consistently read and recognized RFID tags, effectively identifying and authenticating users in real-time. The relay sensor effectively enabled the system to control the lighting in the designated areas. This allowed authorized individuals to gain access promptly also triggering the light while denying entry to unauthorized users. Additionally, the inclusion of the smoke detector sensor ensured the detection of smoke and triggered notifications to the app, providing enhanced safety measures. Through detailed analysis of the sensor data, information regarding the frequency and accuracy of smoke detection events can be obtained, allowing prompt response and mitigation of fire hazards. The remote access feature through the mobile application allowed authorized personnel to conveniently control and monitor the system from a remote location, further improving the system's accessibility and flexibility. Overall, the project achieved its objectives of enhancing security, safety, and convenience through the implementation of these integrated features. The projects successful implementation and subsequent analysis demonstrate its effectiveness in improving security and safety measures for access control, thereby providing a solid foundation for future enhancements and optimizations.

## Chapter 6. CONCLUSION AND FUTURE ENHANCEMENTS

**6.1 Conclusion**

### The Access Control System with Relay and Smoke Sensor Integration provides efficient and secure solution for controlling access to a premise and monitoring potential fire hazards. Our project demonstrates the effective integration of various technologies, including RFID identification, relay sensors for power control smoke sensor for fire detection and remote access through a mobile application.

**6.1 Future Enhancements**

### The project has the potential for further enhancements and future expansions including the integration of advanced security features, IoT devices and data analytics capabilities. Overall, this project lays a strong foundation for a comprehensive and intelligent security system with promising applications in various domains. The area of improvement could be integration of advanced security features such as biometric authentication including facial recognition or fingerprint scanning, the addition of environmental sensors, smart locks helps to create more comprehensive and interconnected ecosystem. Our project makes the lives of people simpler and make them feel safer as it serves all parties equally because of its convenience of use and its highly monetizable framework.

## Chapter 7. SCREENSHOTS

### 7.1 Register Page

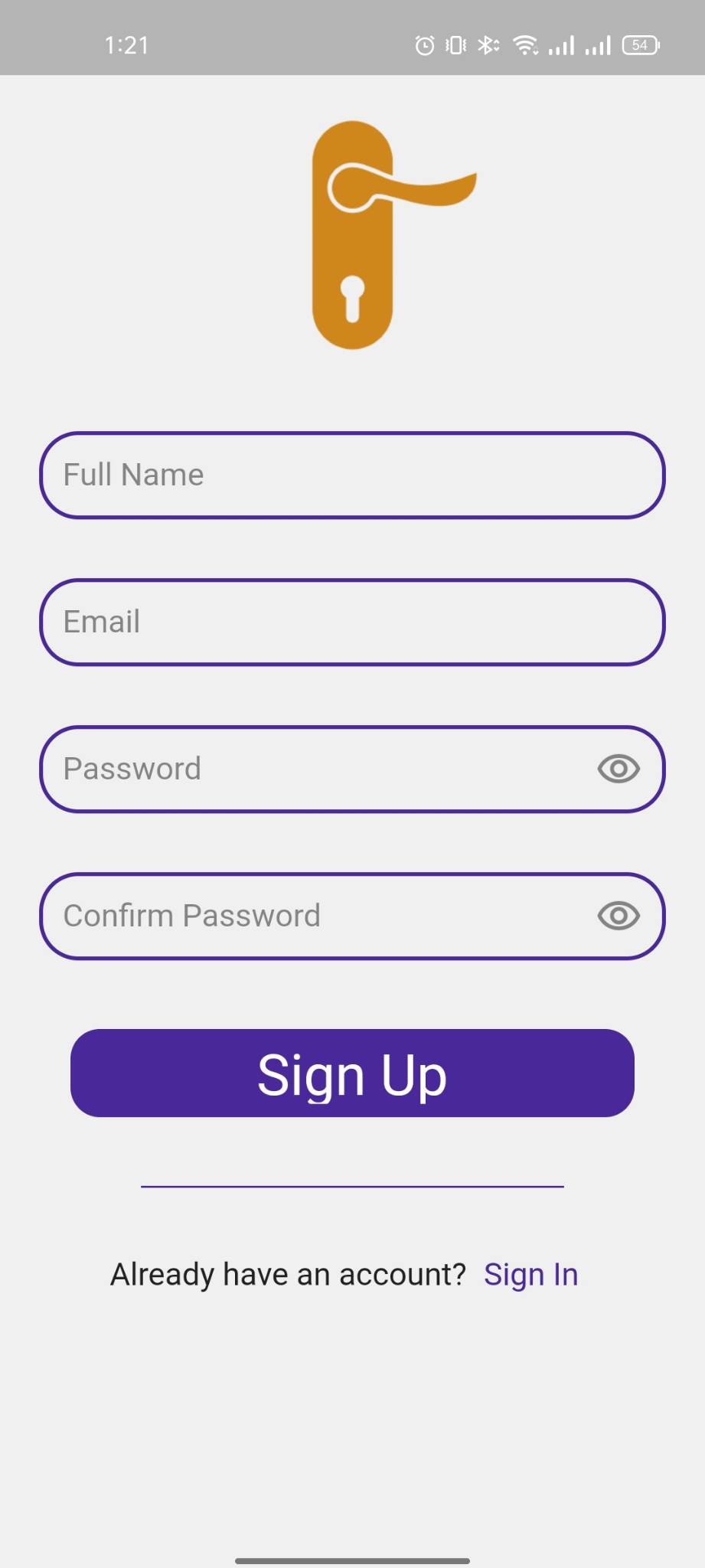
****

Figure 11. Register page

### 7.2 Login Page

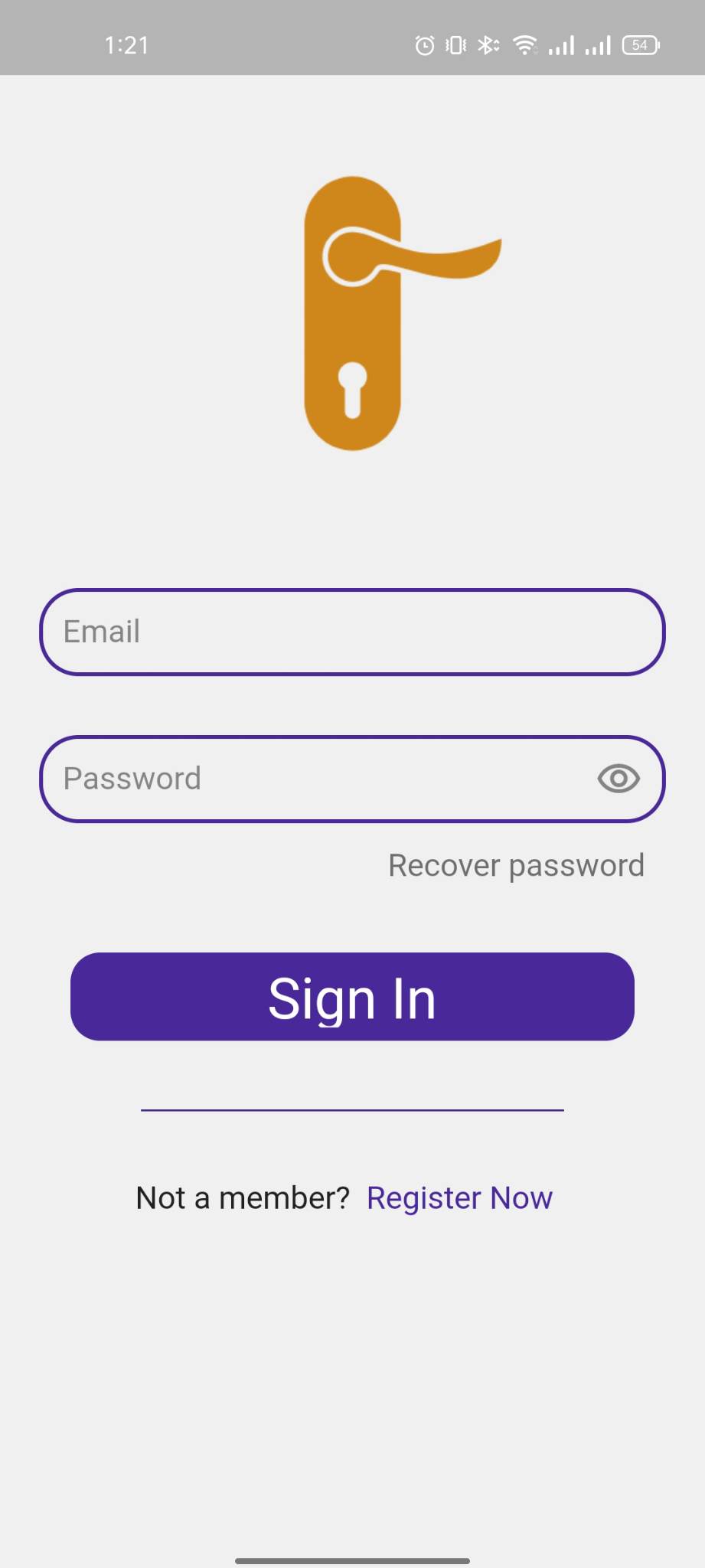
****

Figure 12. Log in page

### 7.3 Home Page

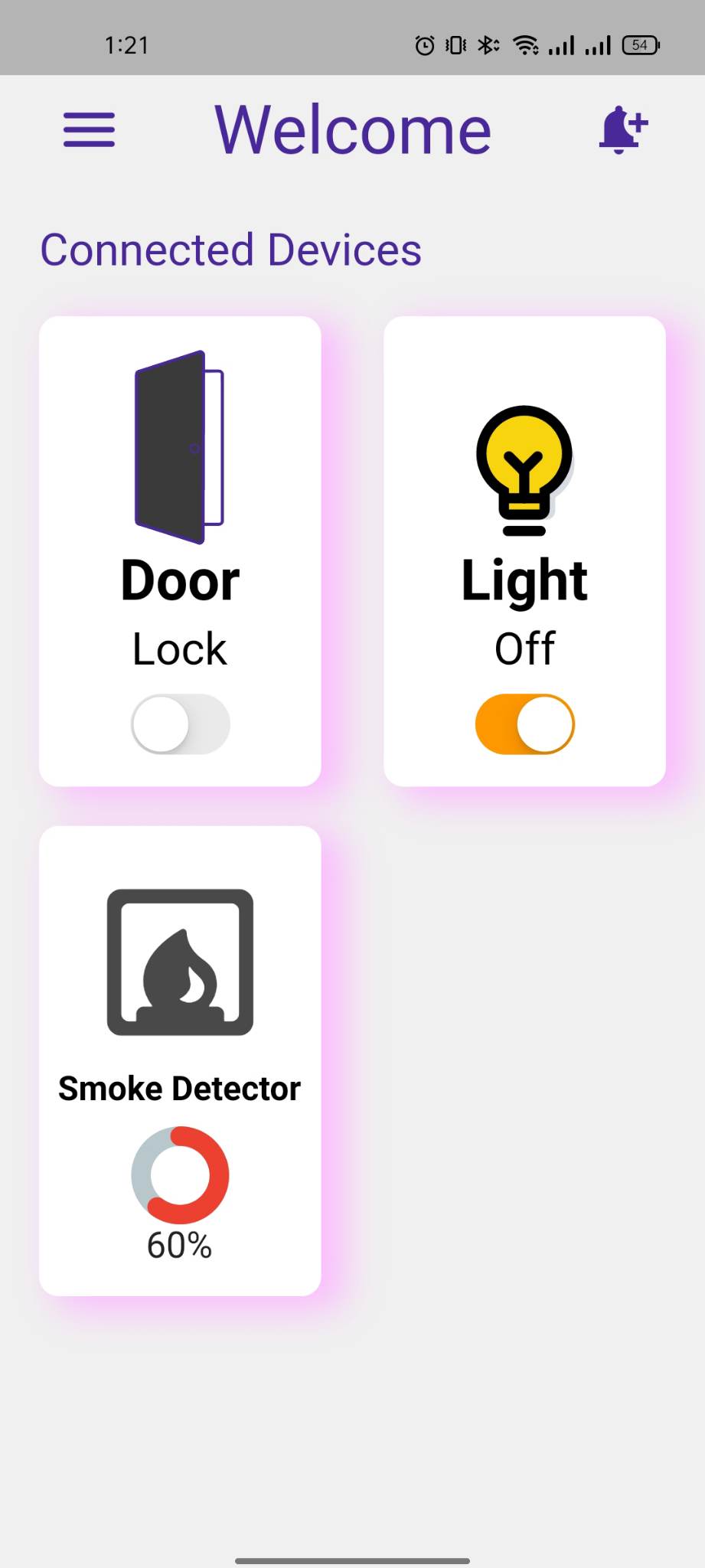
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Figure 13. Homepage

### 7.4 Smoke Detection Dialog Box

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Figure 14. Smoke Detection Dialog Box

### 7.5 Smoke Alert Notifications

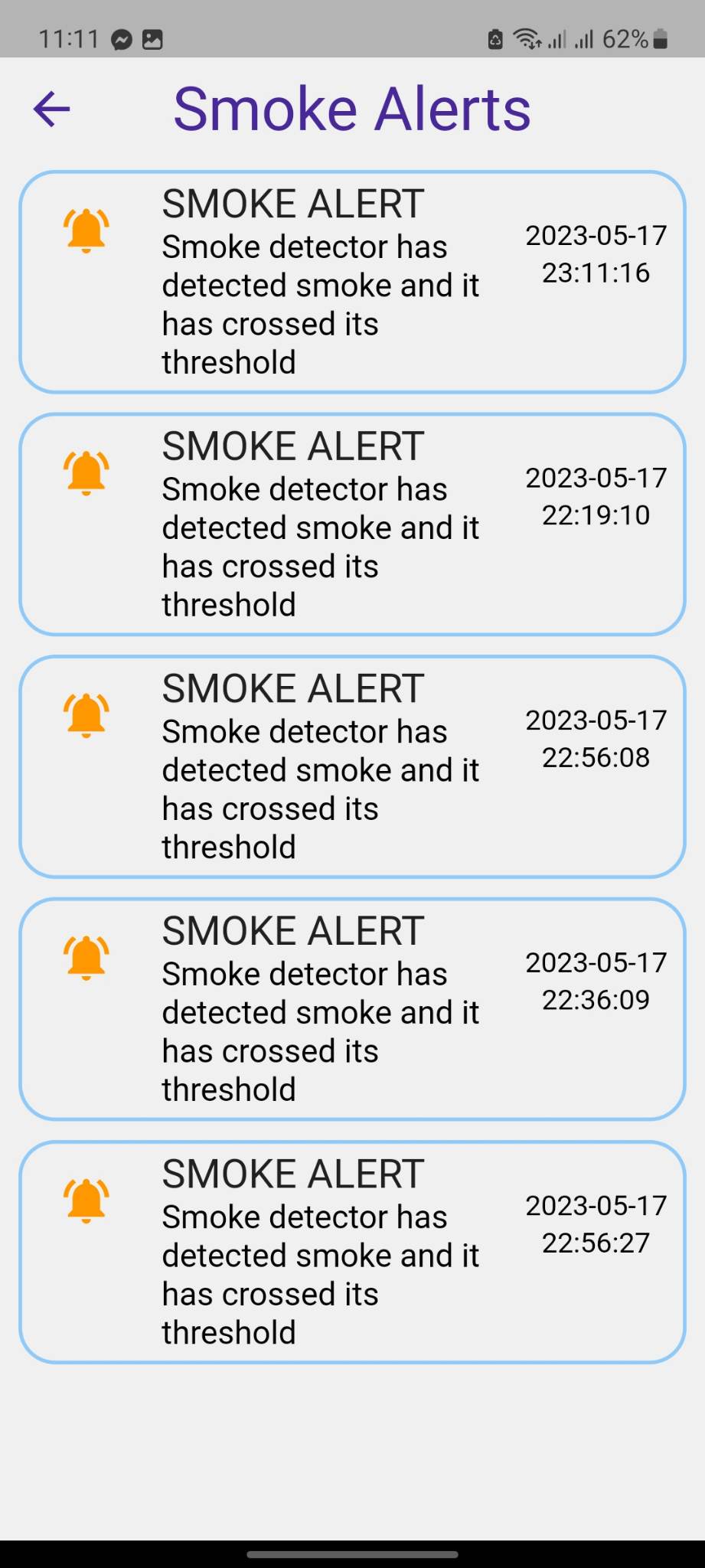
****

Figure 15. Smoke Alert Notifications

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**APPENDIX (Software Coding)**

#include<Firebase\_ESP\_Client.h>

#include <ESP8266WiFi.h>

#include <NTPClient.h>

#include <WiFiUdp.h>

#include <SPI.h>

#include <MFRC522.h>

#include <Servo.h>

#include <MQ2.h>

//Firebase Definition

#define API\_KEY "AIzaSyA-UD9AkPMalYkEY6D7RQoifOZC6e2LXr8"

#define PROJECT\_ID "access-control-system-aa610"

#define UEMAIL "sammanstha@gmail.com"

#define PASSWORD "samman125"

#define FIREBASE\_FCM\_SERVER\_KEY "AAAAciY2VsE:APA91bEVPSv\_IE5GwQlK2arL\_yYu7cQRKZAxCaJsTLhLJMlp1fYP7g0QsiGTzNinjEEyY7LHq40XM6\_mluaAhVYwhCMHzEzhmcJ9aNLeiYRC2QPadbzyqAblXFu7Zm-fU78k5VxvYFjK"

#define DEVICE\_TOKEN "eYcVYnddSle4vfnocWBJyc:APA91bFAkoik2cP\_nvMNQp8pTZ0vwkLCPG6MT6Oh0cWBPElYbBeBOerZfGb8EkDEc8nbL0CSWlERKOmxiDbXrCE700BEmMyCbFTMG217\_ZIfI8rkcevxtiyWGFtBvVqQ-YsuML6hvQr4"

#define WIFI\_SSID "ROBOTICS CLUB WRC"

#define WIFI\_PASSWORD "robointernetauth"

const long utcOffsetInSeconds = 20700;

//MCq2 ko lagi

#define mq2Input A0

float smoke;

//RFID

#define SS\_PIN 15

#define RST\_PIN 0

String MasterTag = "7374B9E";

String tagID = "";

MFRC522 mfrc522(SS\_PIN, RST\_PIN);

//Relay

#define relay\_pin 4

//servo

#define servo\_pin 5

#define close 0

#define open 90

Servo myservo;

//defined for delay

unsigned long previousTime;

unsigned long currentTime;

unsigned long delayInterval = 600000;

// Define NTP Client to get time

WiFiUDP ntpUDP;

NTPClient timeClient(ntpUDP, "pool.ntp.org", utcOffsetInSeconds);

FirebaseConfig config;

FirebaseData fbdo;

FirebaseAuth auth;

void doorStatusClose(){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  FirebaseJson content;

  content.set("fields/doorStatus/stringValue","Close");

  Firebase.Firestore.patchDocument(&fbdo,PROJECT\_ID,"",documentPath.c\_str(),content.raw(), "doorStatus");

}

void doorStatusOpen(){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  FirebaseJson content;

  content.set("fields/doorStatus/stringValue","Open");

  Firebase.Firestore.patchDocument(&fbdo,PROJECT\_ID,"",documentPath.c\_str(),content.raw(), "doorStatus");

}

void lightStatusOn(){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  FirebaseJson content;

  content.set("fields/lightStatus/stringValue","On");

  Firebase.Firestore.patchDocument(&fbdo,PROJECT\_ID,"",documentPath.c\_str(),content.raw(), "lightStatus");

}

void lightStatusOff(){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  FirebaseJson content;

  content.set("fields/lightStatus/stringValue","Off");

  Firebase.Firestore.patchDocument(&fbdo,PROJECT\_ID,"",documentPath.c\_str(),content.raw(), "lightStatus");

}

void smokeDataUpdate(float x){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  char smokeValue[5];

  dtostrf(x, 0, 2, smokeValue);

  FirebaseJson content;

  content.set("fields/smokePercent/stringValue",smokeValue);

  Firebase.Firestore.patchDocument(&fbdo,PROJECT\_ID,"",documentPath.c\_str(),content.raw(), "smokePercent");

}

boolean readDoorStatus(){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  // Read existing document data

  FirebaseJson documentData;

  if (Firebase.Firestore.getDocument(&fbdo, PROJECT\_ID, "", documentPath.c\_str(),"doorStatus, lightStatus")) {

    {

      documentData.setJsonData(fbdo.payload());

      FirebaseJsonData doorStatusData;

      documentData.get(doorStatusData, "fields/doorStatus/stringValue");

      if(doorStatusData.success){

        if(doorStatusData.to<String>()=="Close"){

          return 0;

        }

        else{

          return 1;

        }

      }

    }

  } else {

    return 0;

  }

  return 0;

}

boolean readLightStatus(){

  String documentPath = "users/RUVXqXwcahPXjtXMEgqq1vDjTWv2";

  // Read existing document data

  FirebaseJson documentData;

  if (Firebase.Firestore.getDocument(&fbdo, PROJECT\_ID, "", documentPath.c\_str(),"doorStatus, lightStatus")) {

    {

      documentData.setJsonData(fbdo.payload());

      FirebaseJsonData lightStatusData;

      documentData.get(lightStatusData, "fields/lightStatus/stringValue");

      if(lightStatusData.success){

        if(lightStatusData.to<String>()=="Off"){

          return 0;

        }

        else{

          return 1;

        }

      }

    }

  } else {

    return  0;

  }

  return 0;

}

void sendMessage()

{

    timeClient.update();

    String time = timeClient.getFormattedTime();

    FCM\_Legacy\_HTTP\_Message msg;

    msg.targets.to = DEVICE\_TOKEN;

    msg.options.time\_to\_live = "1000";

    msg.options.priority = "high";

    msg.payloads.notification.title = "Smoke Alert";

    msg.payloads.notification.body = "There is smoke alert";

    FirebaseJson payload;

    // all data key-values should be string

    payload.add("title", "Smoke Alert");

    payload.add("message", "Smoke detector has detected smoke and it has crossed its threshold");

    payload.add("time", time);

    msg.payloads.data = payload.raw();

    Firebase.FCM.send(&fbdo, &msg);

}

void setup() {

   WiFi.begin(WIFI\_SSID, WIFI\_PASSWORD);

   while (WiFi.status() != WL\_CONNECTED)

    {

        delay(100);

    }

  auth.user.email = UEMAIL;

  auth.user.password = PASSWORD;

  config.api\_key = API\_KEY;

  Firebase.begin(&config, &auth);

  Firebase.FCM.setServerKey(FIREBASE\_FCM\_SERVER\_KEY);

  //Hardware codes

  SPI.begin();

  myservo.attach(servo\_pin);

  pinMode(relay\_pin, OUTPUT);

  digitalWrite(relay\_pin, LOW);

  pinMode(mq2Input, INPUT);

  mfrc522.PCD\_Init();

  delay(4);

  //for delay

  previousTime = millis();

}

void loop()

{

  //For Smoke sensor

  smoke = analogRead(mq2Input);

  smoke = smoke/1024;

  smokeDataUpdate(smoke);

  if(smoke>=0.5){

    //for delay

    unsigned long currentTime = millis();

    if (currentTime - previousTime >= delayInterval) {

    sendMessage();  // Perform action here

    previousTime = currentTime;  // Reset the previousTime variable

    }

  }

  //Door and Light

  //rfid

  while(getID()){

    if (tagID == MasterTag){

      digitalWrite(relay\_pin, HIGH);

      myservo.write(open);  // move servo to 90 degrees

      lightStatusOn();

      doorStatusOpen();

      delay(10000);  // wait for 10 second

      myservo.write(close);  // move servo to 0 degrees

      doorStatusClose();}

  }

  //app

  //for door

  if(readDoorStatus()){

      myservo.write(open);

  }

  else if(!readDoorStatus()){

    myservo.write(close);

  }

  //for relay

  if(readLightStatus()){

      digitalWrite(relay\_pin, HIGH);

  }

  else if(!readLightStatus()){

    digitalWrite(relay\_pin, LOW);

  }

}

boolean getID()

{

  if ( ! mfrc522.PICC\_IsNewCardPresent()) {

    return false;

  }

  //Since a PICC placed get Serial and continue

  if ( ! mfrc522.PICC\_ReadCardSerial()) {

  return false;

  }

  tagID = "";

  for ( uint8\_t i = 0; i < 4; i++) {

  //readCard[i] = mfrc522.uid.uidByte[i];

  // Adds the 4 bytes in a single String variable

  tagID.concat(String(mfrc522.uid.uidByte[i], HEX));

  }

  tagID.toUpperCase();

  mfrc522.PICC\_HaltA(); // Stop reading

  return true;

}