IOT Based Monitoring And Control System For Home Automation

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Dawood Zahir

Abstract

The IOT-based smart home system, which uses Urdu language, is an innovative project that leverages the NodeMCU ESP8266 device as the primary IOT component to control the triggering of electrical components within a home. This project also features a mobile application that can trigger electrical appliances using the MQTT protocol. Additionally, the project incorporates a voice module in Urdu language, enabling users to control their homes without the need to interact with button switches or touch their mobile devices. This project is being developed with the local population in Pakistan in mind, and it aims to cater to their specific needs by offering them a user-friendly interface in their native language. Future plans include expanding the project to include other local languages spoken in Pakistan, making it even more accessible to a broader audience.

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Chapter 1

Introduction

The rapid growth of technology has made day-to-day life simpler through digitization and automation. Automation is the use of machines, control systems, and information technologies to optimize productivity. It plays an increasingly important role in the world economy and daily experience. Automating homes helps save electricity, reduce manual labor, increase reliability and efficiency, and improve security. The concept of IoT-based smart home automation allows for different electrical appliances to be controlled wirelessly via the internet through methods such as mobile applications and voice modules. Interactive devices have become closely tied to home automation. The Internet of Things is a system of connected devices that can transfer data over a network without human interaction. Mobile applications for home automation connected to IoT devices give remote access to controlling electrical appliances in the home. Natural language processing is a branch of artificial intelligence that deals with analyzing, understanding, and generating human languages for interacting with computers using natural human languages instead of computer languages. Voice modules for controlling home appliances can be created using NLP.

1.1 PROBLEM STATEMENT

The use of IoT-based smart home systems with voice modules or mobile applications is widespread in Western countries for the convenience of daily activities. However, such systems are not widely available in the Urdu language, which is spoken by approximately 89.7 million people worldwide. The lack of Urdu language support poses a challenge for Urdu-speaking communities in adopting such technologies. In response to this challenge, this project proposes an IoT-based monitoring and control system for home automation that uses the Urdu language for the voice module. This approach aims to overcome the language barrier and enable Urdu-speaking individuals to access and benefit from smart home technologies.

1.2 MOTIVATION

This project aims to establish an automatic system for controlling various aspects of daily life, such as lighting, machines, heating, ventilation, air conditioning, and security door locking. The goal of this system is to simplify life, increase security, and save electricity and time. Additionally, the system will integrate with Urdu voice recognition to enable its use across Pakistan. The project will also raise awareness of energy wastage and promote ease of use by reducing human effort. Furthermore, it will be scalable and expandable for use in housing societies.

1.3 IOT Based Home Automation

In order to produce a smart home automation system, we need an IOT based system that permits user to control the electrical appliances of a home.Now, in order have control of the home, we need a smart voice assistant that will allow user to control electrical appliances of a home using their voice. Another feature of mobile application will allow user to control their home without having to be present at the home. To make all of this possible, following components will be used.

1.3.1 NodeMCU

NodeMCU is an open-source firmware and development kit that enables the building of Wi-Fi enabled IoT (Internet of Things) applications. It is based on the ESP8266 Wi-Fi chip, which provides a full TCP/IP stack and microcontroller capabilities, allowing for the development of IoT devices without the need for additional components.

The NodeMCU firmware is built on the Lua programming language, which allows developers to quickly prototype and build IoT applications using a simple and easy-to-learn syntax. It also includes a built-in file system that can be used to store configuration files and web pages.

NodeMCU development kits typically include a small board with the ESP8266 chip, as well as the necessary components for programming and communication. The board provides a USB interface for programming and power, and can be connected to other devices via its GPIO (General Purpose Input/Output) pins.

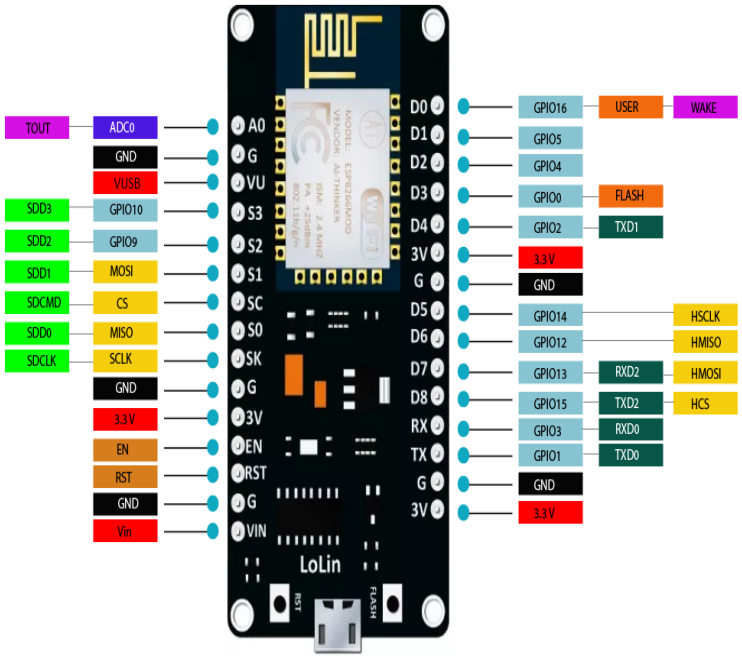


Figure 1.1: NodeMCU Pin Configuration

The figure shown in Figure 1.0 shows pin configuration of Raspberry PI 4B. The GPIO pins are divided into a voltage GPIO which are further divided into two 5V pins, two 3.3V

pins, four ground pins and thirty-two output pins.

1.3.2 Electric Switch

An electric switch is a device used to interrupt or divert the flow of electric current. It is an essential component in electrical circuits that allows the control of the flow of electricity to various devices and appliances. Switches are typically made up of a contactor, which is a movable piece of metal that makes contact with another piece of metal to complete the circuit when the switch is turned on. The switch may also have a spring mechanism that keeps the contactor in place and returns it to its original position when the switch is turned off. There are many different types of electric switches, including toggle switches,

Figure 1.2: Electric Switch

rocker switches, push-button switches, and dimmer switches, each with their own specific uses and applications.

1.3.3 Breadboard

Breadboard is a board that helps in making prototypes of the electrical circuits.

1.3.4 Jumper Wires

Jumper wires are wires that connects the electrical components with each other with the help of breadboard. The Jumper wires are of three categories.

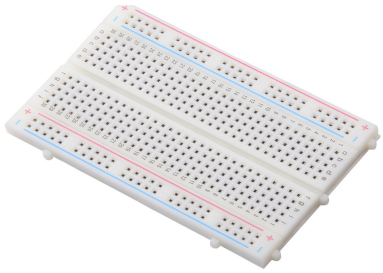


Figure 1.3: BreadBoard

1.3.4.1 Male to Male

Figure 1.4: Male to Male Jumper Wires

1.3.4.2 Male to Female

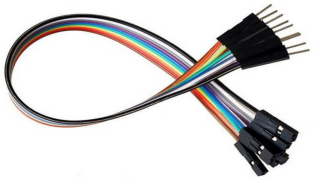
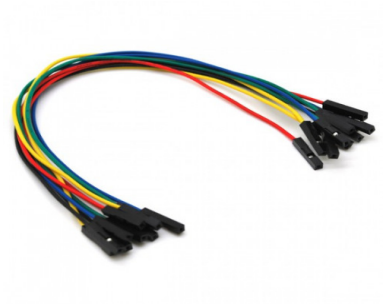


Figure 1.5: Male to Female Jumper Wires

1.3.4.3 Female to Female



1.3.5 LED lights

LED light is a small bulb that consists of a positive and a negative terminal.

Figure 1.6: LED Light

1.3.6 Motor

A motor is used in order to create a fan. A wing of fan is attached to the rotatory needle of the motor.

1.3.7 Electrical Component Integration

The hardware model described in the thesis employs various electrical components, such as node MCU, LED lights, fans, and others. Chapter 5 will provide a detailed explanation of the experimental setup and techniques used in the model.

Figure 1.7: Motor

1.4 Novelty

Many Smart Home Automation systems, including Amazon Alexa, Google Assistant, and Apple Siri, exist globally, but some lack essential features that limit their usefulness. To address these limitations in Pakistan, this product uses the national language, Urdu, to promote local cultural and linguistic sensitivity. Despite this emphasis on the local language, the product offers all the features that international companies provide, allowing it to serve as a viable alternative for Smart Home Automation in the country.

1.5 Thesis organization

The thesis is organized into seven chapters. The first chapter provides details on the Internet of Things (IoT) and the hardware used in the project. It also discusses the motivation for smart homes, the problems they can solve, and the novelty of the proposed solution. Chapter 2 reviews related research on the topic. Chapter 3 presents design and implementation diagrams, including block diagrams, flow charts, and UML diagrams, which cover use case and activity diagrams. Chapter 4 describes the methodology used to create a model for smart homes, along with the techniques implemented to achieve this. Chapter 5 outlines the experimental setup. Chapter 6 presents the results, and Chapter 7 concludes the thesis by discussing the future work needed to further develop this project.

Chapter 2

Review of Literature

This chapter provides a comprehensive literature review of some of the related work :

Smart Home Automation System using Android Application [5], This system is designed to control home appliances using an Android application. The user sends a signal from their mobile device to a Wi-Fi module connected to an Arduino board. The Arduino board controls the appliances using a relay board. The system uses different technologies like Wi-Fi, Bluetooth, and ZigBee for communication and different devices like smartphones, tablets, and laptops for controlling various appliances. The relay board acts as electrical switches, performing on/off operation through power supply, and the user can access the Android application and control the appliances. The system may be limited in terms of the range of devices it can control, as it relies on the compatibility of the devices with the communication technologies used in the system. Additionally, the reliance on Wi-Fi may pose issues with stability and reliability.

Rewiew on Amazon Alexa Devices [3], Amazon's Alexa devices are cloud-enabled wireless speakers with a conversational agent that can take voice commands from users to perform a variety of tasks. The Alexa device is built based on natural language processing (NLP), which is the process of converting speech into words, sounds, and ideas. Amazon records the user's words and breaks them down into individual sounds, identifies important words to make sense of the tasks, and carries out corresponding functions. Alexa only recognizes the English language. Some users may be concerned about privacy

and security issues, as the device records user interactions and sends the information back to Amazon's servers.

Designing A Home Automation System by Using RF Receivers [4], This project involves automating the use of conventional lighting mechanisms in a house by using RF-controlled remotes. The project requires an RF remote interfaced to a microcontroller on the transmitter side, which sends on/off signals to the receiver. The receivers are connected with loads that can be turned on/off by operating remote switches on the transmitter wirelessly. The system is implemented with a four-button key fob transmitter using RF technology. To accomplish this object, it is designed into two parts. Both parts have individual toggle-type receivers, but they work in the same frequency. One of these toggle receivers works individually with some of the home appliances, but the other one is interfaced with an Arduino Uno Rev3 microcontroller to convert the signals from toggle to latching format. The home automation system using RF module makes the home condition and utilization of appliances easy, simple, comfortable, flexible, user-friendly, secure, and saves energy. The range of the RF-controlled remotes may be limited, and interference from other devices may pose issues with stability and reliability.

Smart GSM-Based Home Automation System, [6] This system involves the use of a Global System for Mobile Communication (GSM) modem to control home appliances such as light, conditional systems, and security systems via Short Message Service (SMS) text messages. The concept of serial communication and AT commands has been applied to the development of the smart GSM-based home automation system. Homeowners will be able to receive feedback status of any home appliances under control whether switched on or off remotely from their mobile phones. PIC16F887 microcontroller with the cooperation of GSM provides the smart automated house system with the desired baud rate of 9600 bps. The proposed prototype was implemented and tested with a maximum of four loads and shows an accuracy of >=98. The system may be limited in terms of the number of appliances it can control, as it relies on the number of devices that can be connected to the GSM network. Additionally, the reliance on cellular data may pose issues with stability and reliability.

Design and implementation of cloud based home automation, [1] Home Automation using

cloud based system focuses on design and implementation of home gateway to collect data about data from home appliances and then send to the cloud-based data server to get store on Hadoop Distributed File System, it is process using Map Reduce and use to implement a monitoring tasks to Remote user Presently. Design and development of home automation system that use the cloud computing as service. The current system consists of three important units: the first part is cloud server, handle and controls the data and information of client and users and the status of devices The hardware interface module is the second part which implement the relevant connection to the actuators and sensing devices which give the physical service. Last part is Home Server, which construct the hardware device and gives the user interface. The current system is cost efficient, reliable and comfortable which also gives a home automation system for entire family Requires a stable internet connection to function properly. May be expensive due to the cost of cloud-based services. Potential security risks due to the storage of personal data on a cloud-based server.

Home Automation using Voice Via Bluetooth Through Raspberry PI 3. [2] Processes of speech recognition include feature extraction, acoustic modeling, pronunciation modeling and decoder. The end user gets through the application by means of an applicable input device such as a microphone. The server side is installed on Raspberry Pi whereas the client side is installed on a mobile device. The server side is created with the help of LAMP (Linux, Apache, My SQL, PHP). It has used 40 GPIO pins of Raspberry Pi through the relay circuitry for operation. All appliances are connected to relay. User has to use mobile device to access Raspberry Pi via internet. In this way home appliances are controlled by application and speech recognition. Limited range, as Bluetooth signals have a limited range. May require technical expertise to set up and maintain.Requires an applicable input device, such as a microphone, to function properly.

No	Article	Communication Technology	Control Device	Limitations
1	Smart Home Automation using Android Application and Arduino Board	Wi-Fi, Bluetooth, ZigBee	Smartphone, tablet, laptop	Network security breaches
2	Review of Amazon Alexa Devices	Natural Language Processing (NLP)	Voice command (English language only)	Limited to English language commands
3	Home Automation using RF Controlled Remote	Radio Frequency (RF)	Four-button key fob transmitter	Limited to lighting mechanisms
4	Smart GSM-Based Home Automation System	Global System for Mobile Communication (GSM)	Mobile phone	Dependent on mobile network connectivity
5	Cloud-based Home Automation System	Cloud-based data server	Hardware interface module, home server	Dependent on internet connectivity
6	Voice-controlled Home Automation System using Raspberry Pi 3	Bluetooth	Microphone	Limited to English language and accents

Table 2.1: Comparison Table of Home Automation Systems

Features	**Smart Home Automation System**	**Amazon Alexa**	**RF Controlled System**	**GSM-Based System**	**Cloud-Based System**
Communication Technology	Wi-Fi, Bluetooth, ZigBee	Wi-Fi, Bluetooth	Radio Frequency (RF)	Global System for Mobile Communication (GSM)	Wi-Fi
Control Devices	Smartphones, tablets, laptops	Amazon Alexa devices	Remote control	Mobile phones	Smartphones, tablets, laptops
Control Factors	Appliances, energy, temperature, power sockets, illumination, entrance control	Appliances, lighting, temperature	Energy, temperature, power sockets, illumination, entrance control	Lights, conditioning systems, security systems	Appliances, energy, temperature, power sockets, illumination, entrance control
Security	Possibility of network security breaches	Record and analyze voice commands	User-friendly and secure	Secure control through GSM	Cost-efficient and reliable
Limitations	Possibility of network security breaches	Only recognizes and responds to English language commands	Limited to RF range	Limited to GSM coverage	Limitations in recognizing various accents and languages other than English

Table 2.2: Functionality Comparison Table

Chapter 3

System Analysis and Design

3.1 Implementation Diagram

The following implementation diagram shows how our system is implemented using hardware.

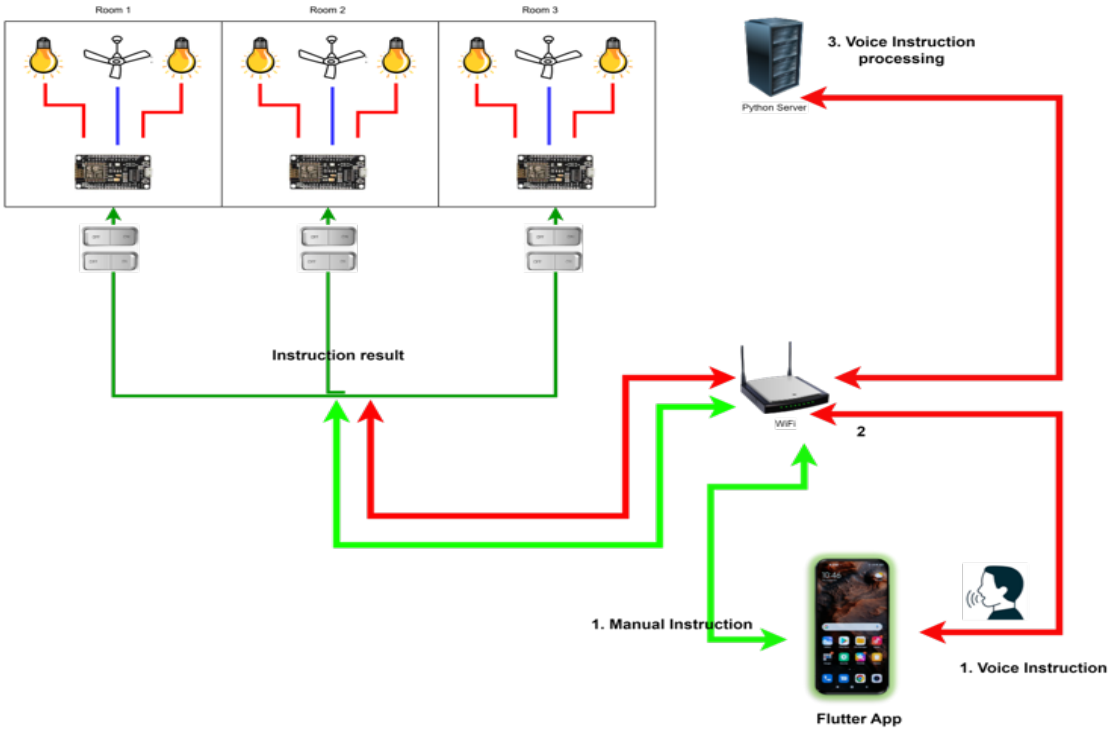


Figure 3.1: Implementation Diagram

3.2 Flow Chart Diagram

A flowchart is a type of diagram that represents a workflow or process. A flowchart can also be defined as a diagrammatic representation of a step-by-step approach to solving a task. Flow chart representing the workflow of our complete project

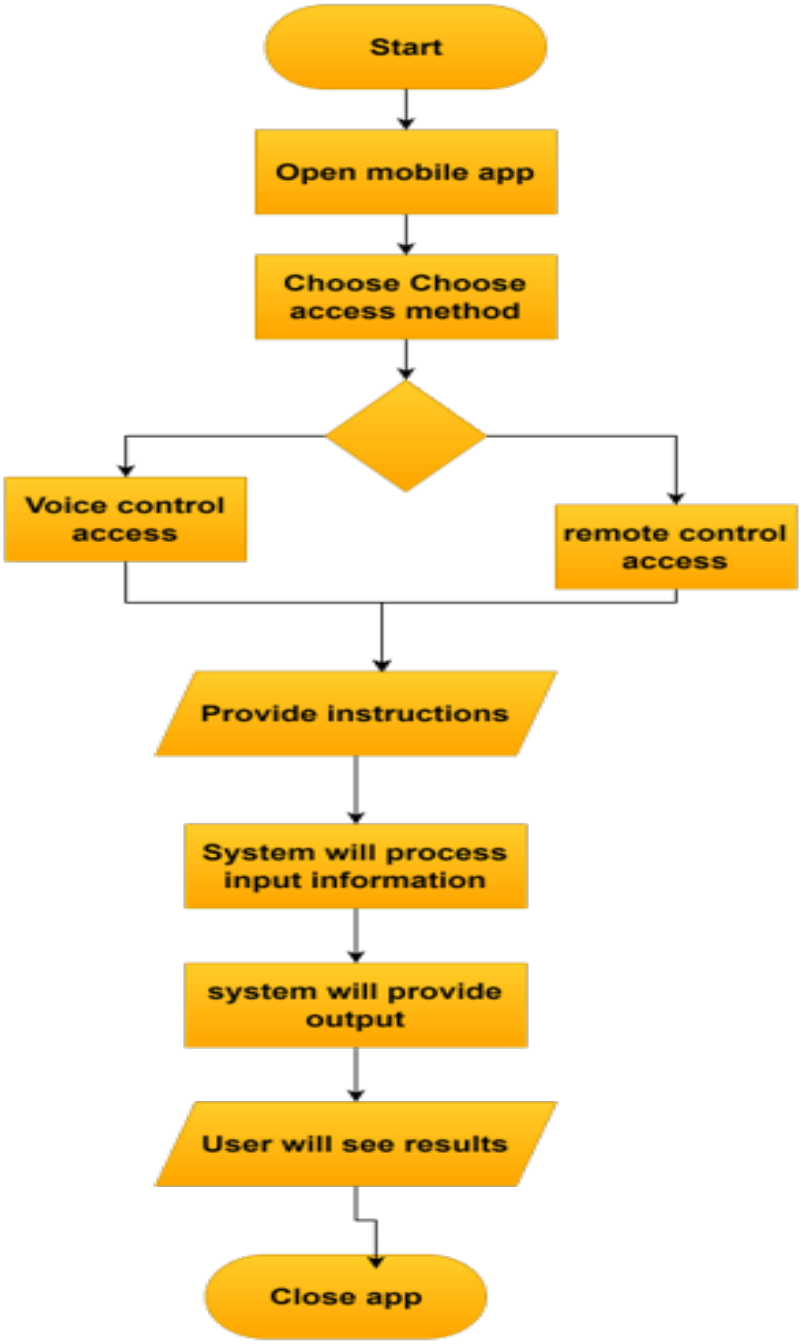


Figure 3.2: Flow Chart Diagram

3.3 Use Case Diagram

A use case diagram represents the main use case activities and the interaction of actors and the system that is under development process. It helps to identify all the main processes of the system which are then visualized in ovals, known as a use case. A use case diagram is drawn from a scenario that explains the working of the system.

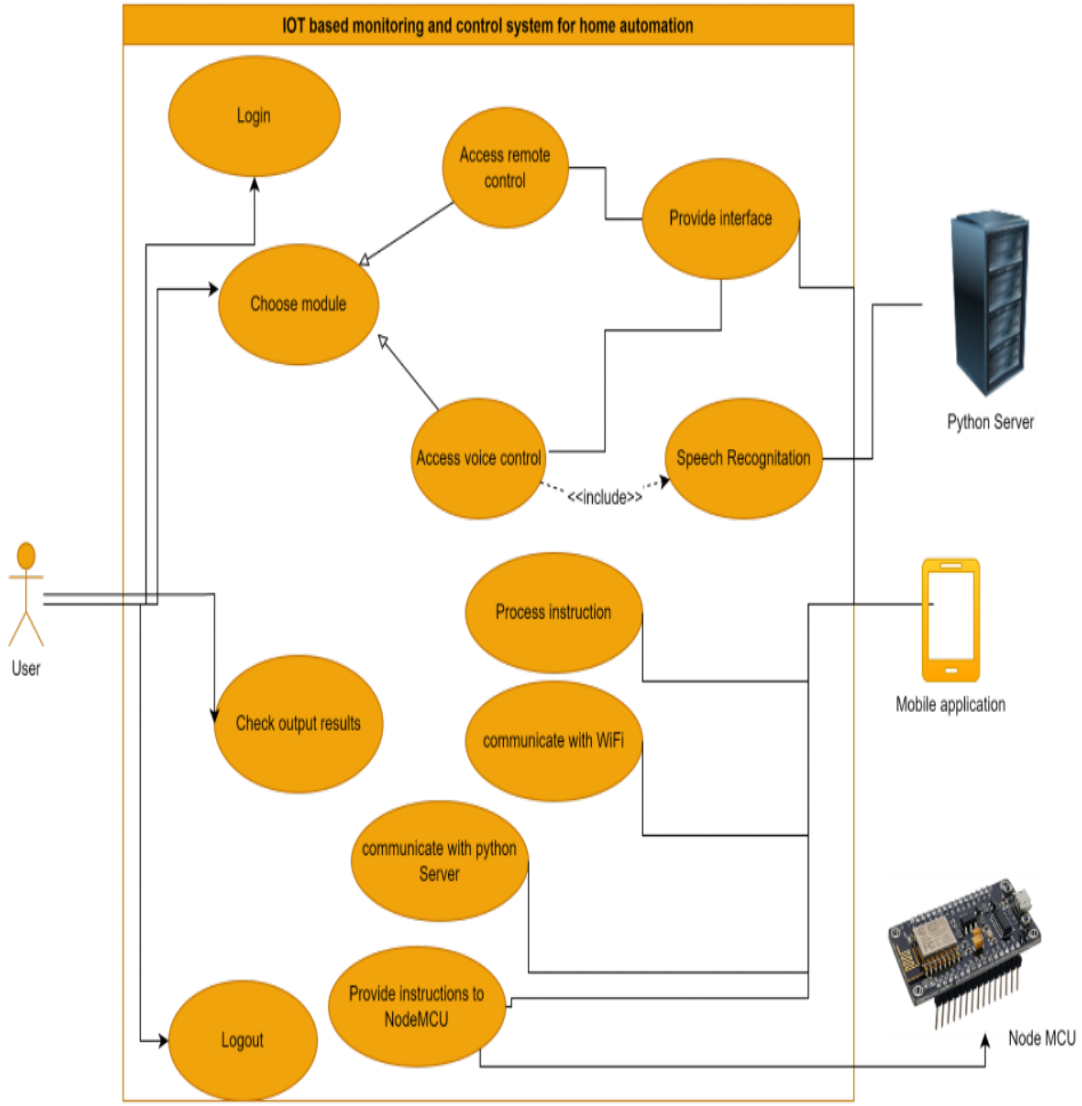


Figure 3.3: Use Case Diagram

3.4 Description of Use Case Scenario

Login	
DESCRIPTION	DETAILS
Goal	Successful login
Preconditions	User must enter username password
Successful end	User logs in
Failed end	User is unable to login
Primary actors	User
Secondary actors	System
Trigger	User clicks login button
Main flow	User enter credentials- database validate credentials – user successfully logs in
Alternate flow	User enter credentials - database validate credentials – credentials not found – the user doesn't login

Validate Login	
Goal	Correct login validation
Preconditions	User enters credentials to login
Successful end	Correct validation of credentials
Failed end	Incorrect validation of credentials
Primary actors	None
Secondary actors	Database
Trigger	User attempts to login
Main	User
Main flow	User enter credentials- system validate credentials – successful login if correct credentials
Alternate flow	User enter credentials- system server crashes – credentials do not validate

Choose Module	
Goal	Selection of a module
Preconditions	User must have login first
Successful end	a module will be selected
Failed end	Network problem
Primary actors	User
Secondary actors	System
Main flow	User enter credentials- database validate credentials – successful login - User will select a module from a given list
Alternate flow	User enter credentials- credentials not validated- user will not be able to choose a module.

Provide Instruction	
Goal	Controlling home electrical appliances using mobile application
Preconditions	Choose a module
Successful end	Provide instruction and controlling home appliances
Failed end	Network Problem – cannot control home appliances
Primary actors	user
Secondary actors	System
Trigger	User attempts to control home electrical appliances using voice or remote module
Main flow	User enter credentials- database validate credentials – successful login – provide instruction and control home appliances
Alternate flow	User enter credentials- credentials not validated- home appliances cannot be controlled

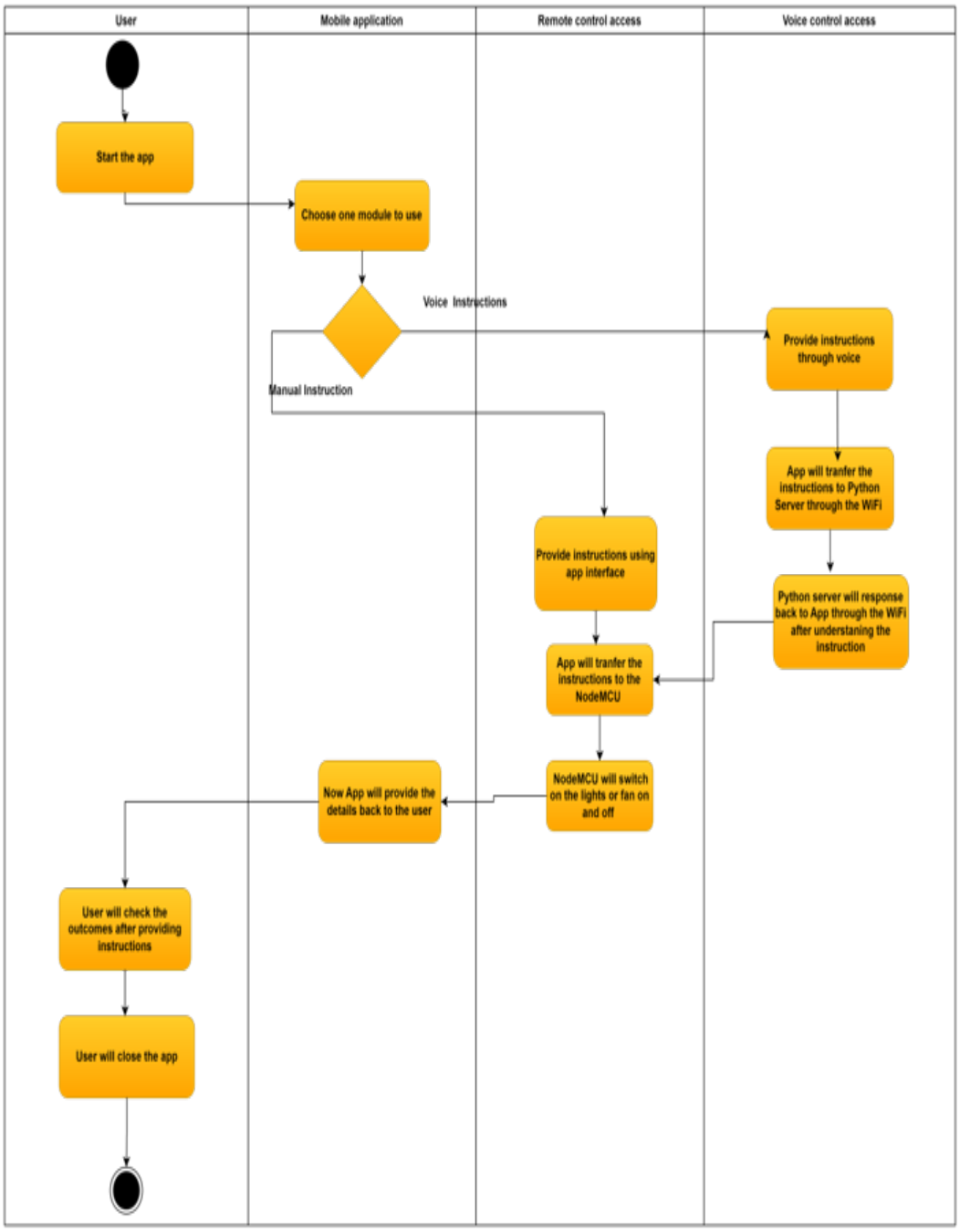
Provide voice Instruction	
Goal	Controlling home appliances via voice instruction
Preconditions	Voice successfully recognized
Successful end	Voice successfully recognized “switch off lights” - home appliances in control by voice commands (lights switched off)
Failed end	Voice not recognized – home appliances not controlled by voice commands
Primary actors	User
Secondary actors	Other users (members of home)
Trigger	User attempts to control home appliances by giving voice commands
Main flow	Voice command given by user to perform a specific task - voice successfully recognized – task performed
Alternate flow	Voice command given by user to perform a specific task - a voice not recognized – a task not performed

Provide Remote Instruction	
Goal	Controlling home appliances via remote instruction
Preconditions	Remote instruction successfully recognized
Successful end	Remote instruction successfully recognized “switch off lights” - home appliances in control by remote commands (lights switched off)
Failed end	Remote instruction not recognized – home appliances not controlled by remote commands
Primary actors	User
Secondary actors	Other users (members of home)
Trigger	User attempts to control home appliances by giving remote instruction
Main flow	remote command given by user to perform a specific task - instruction successfully recognized – task performed
Alternate flow	remote command given by user to perform a specific task - a command not recognized – a task not performed

Check output results	
Goal	Controlling home electric appliances status in mobile app
Preconditions	User must have login the app
Successful end	App will show the status of all-electric appliances either they are on or off.
Failed end	App is filed to show up-to-date status of electric appliances
Primary actors	User
Secondary actors	System)
Trigger	User attempts to see the home electric appliances on/off status
Main flow	User will select the option of checking updates result of the appliance and ap will show the status of each electric appliance
Alternate flow	System will show network error in the case of internet problem

3.5 Activity Diagram

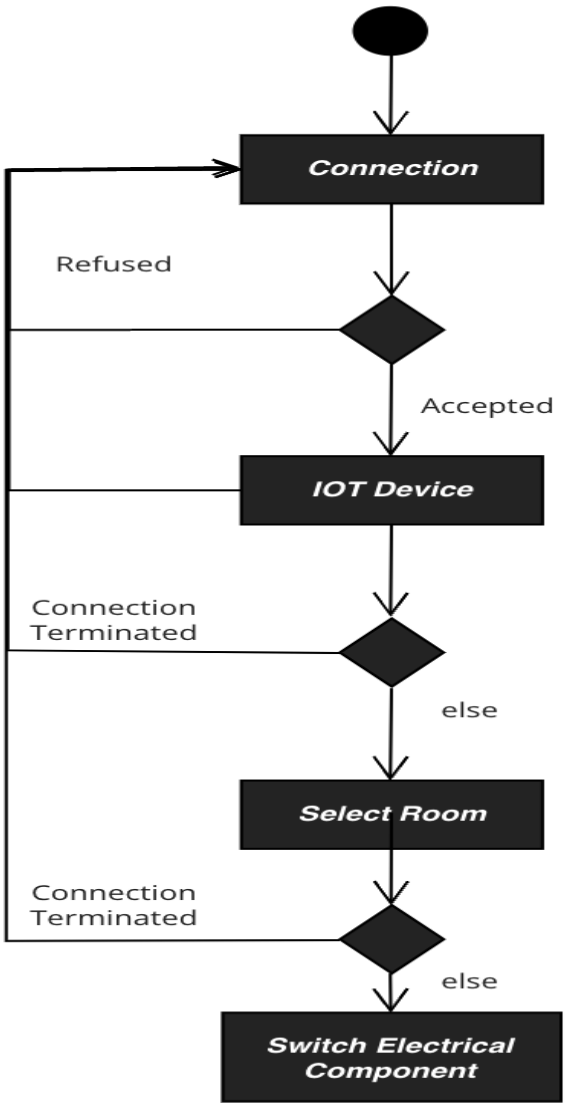
The activity diagram is shown in Figure 13.0, it represents the flow of the activities in a specific order and it explains the details and conditions at every step. This UML diagram helps in understanding the flow of activities and it can help to identify those activities that can be run parallel to make an efficient system. The given diagram represents the flow of activities in the smart home, it also explains which activity is initiated by the actor.



3.6 Interaction Overview Diagram

The initial step involves the IoT device (NodeMCU) attempting to establish a connection with the MQTT server. In the event that the connection is rejected, the IoT device will continue to retry until a successful connection is achieved. Once a successful connection

is established, the IoT device will continuously monitor for incoming instructions pertaining to specific topics, such as Room 1, Room 2, or Room 3, instructing it to turn the switch (light, bulb, or fan) either ON or OFF. Upon receiving the corresponding value, the IoT device will execute the appropriate action accordingly.

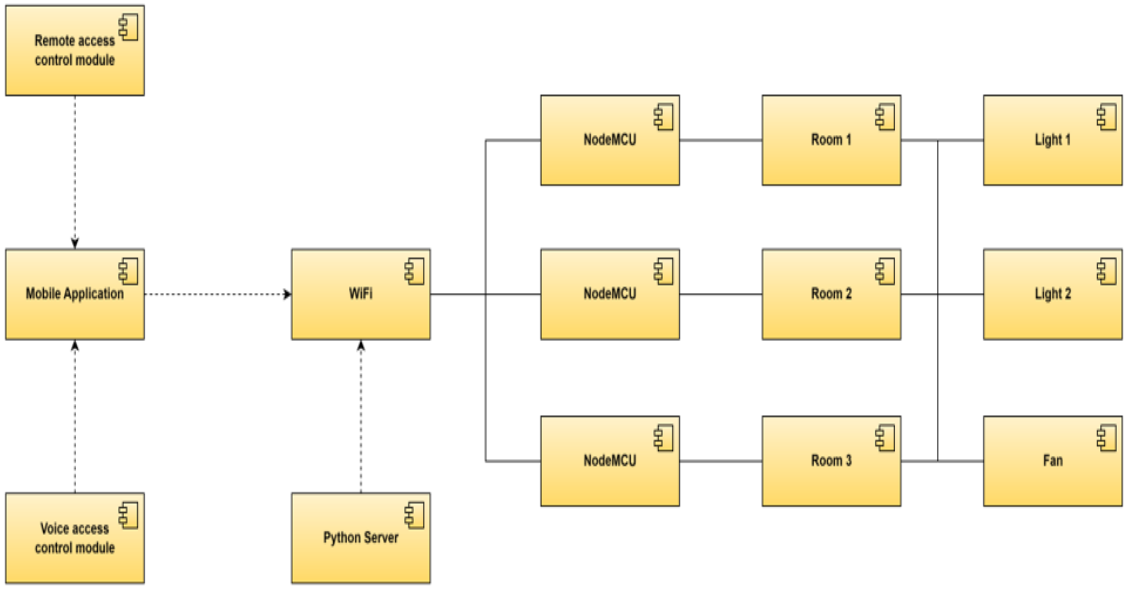


3.7 Component Diagram

We possess a mobile application that facilitates connectivity to a remote access point, providing control over switches (light, bulb, or fan) in Room 1, Room 2, or Room 3. The

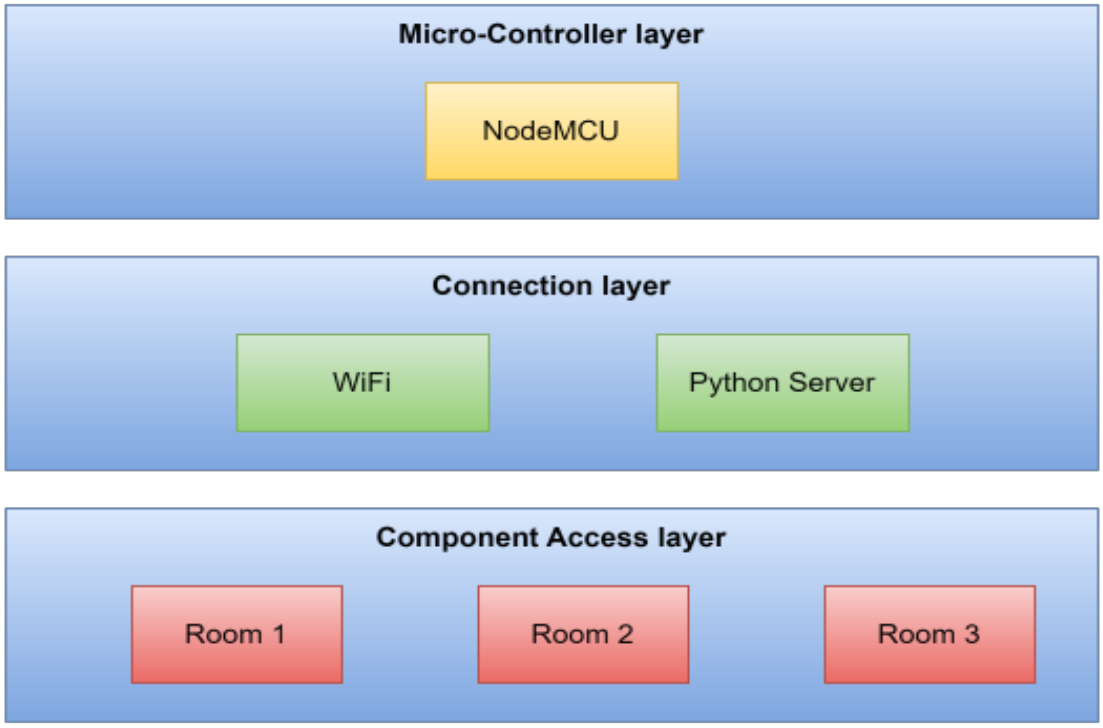
mobile application supports both button-based interaction and a voice module feature. To utilize the voice module component, the mobile application establishes a connection to a Python server via Wi-Fi.

Following the distinction and processing of commands received, the Wi-Fi connection updates the MQTT (Message Queuing Telemetry Transport) protocol. Consequently, the value of the switch in the corresponding room is updated accordingly.



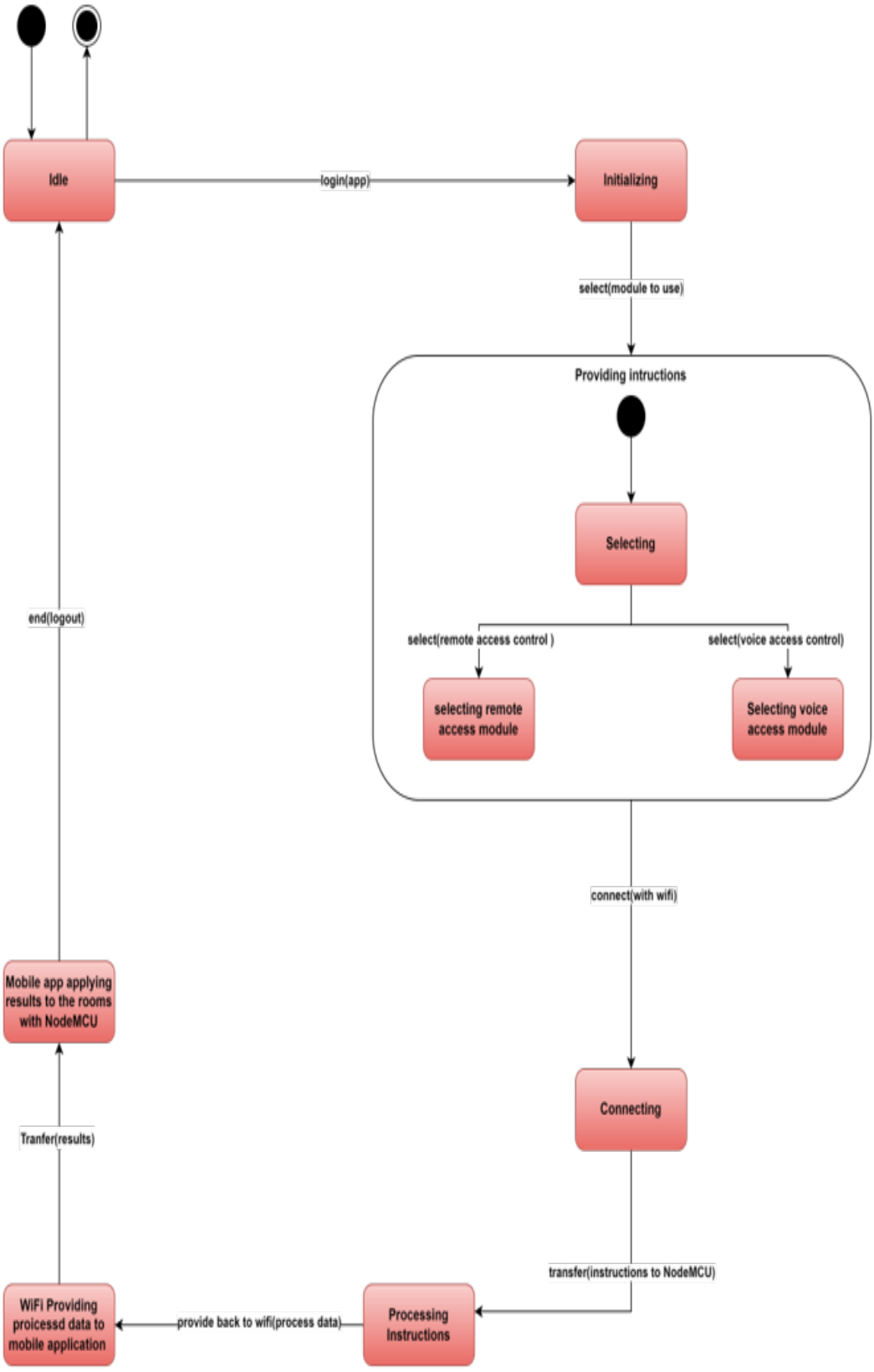
3.8 Layer Diagram

The architecture comprises three layers: the Microcontroller layer, the Connection layer, and the Components layer. The Microcontroller layer encompasses an IoT device, specifically the NodeMCU ESP8266 in our case. The Connection layer comprises two elements: a Wi-Fi connection that facilitates communication between the IoT device and external networks, and a Python Server hosting the Voice module code responsible for processing voice commands. The Components layer consists of the physical switches integrated into the hardware, which are the target of the intended changes.



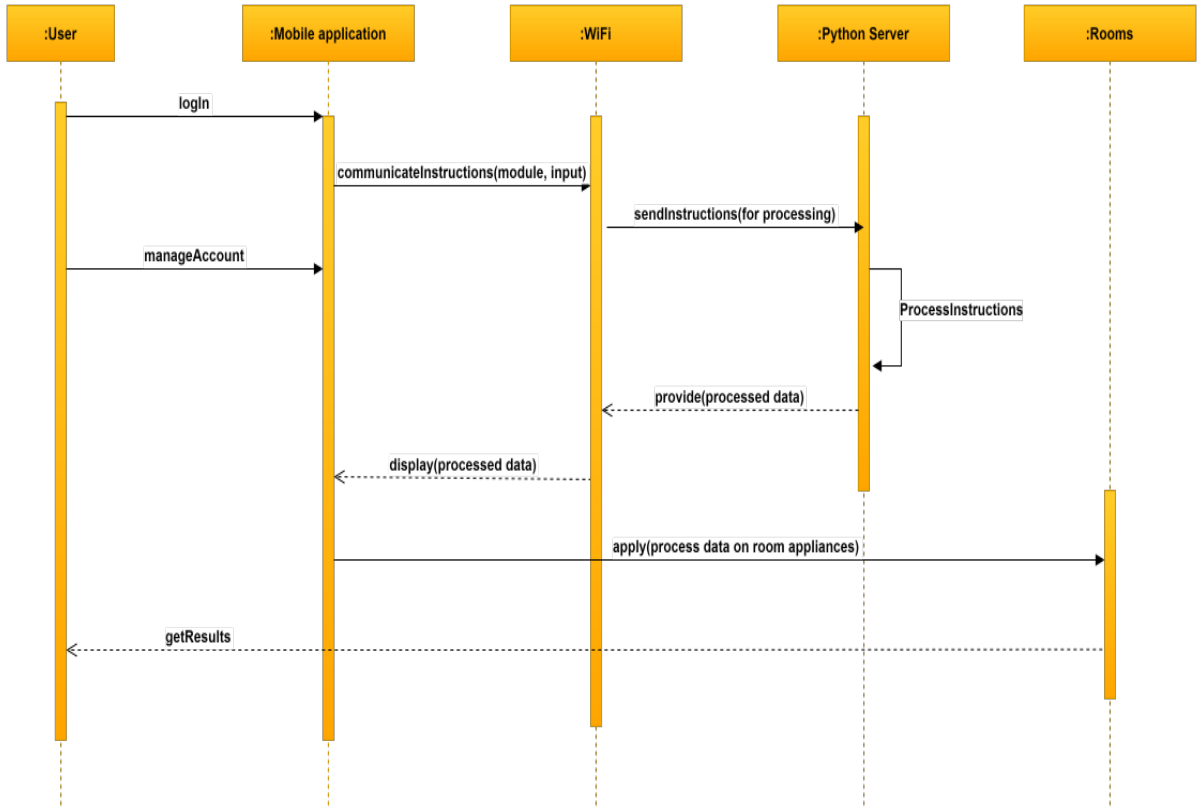
3.9 State Machine Diagram

Initially, we have the idle state where the Switches (NodeMCU) remain in a waiting state for a command to be processed. When the Mobile Application is initialized, it presents two options: Voice module or Button module. Additionally, the mobile application establishes an MQTT connection, enabling the publication of all rooms using their respective topics. Once the user selects a module and chooses a specific room switch, the NodeMCU updates the value to either ON or OFF based on the user's command. It then sends the corresponding signal back to the MQTT using the specific room topic associated with the switch that needs to be toggled. Furthermore, the NodeMCU updates the status in the mobile application, reflecting the change made.


Idle
login(app)
Initializing
select(module to use)
Providing intructions
Selecting
select(remote access control)
select(voice access control)
selecting remote access module
Selecting voice access module
end(logout)
connect(with wifi)
Mobile app applying results to the rooms with NodeMCU
Connecting
Tranfer(results)
transfer(instructions to NodeMCU)
WiFi Providing proicessd data to mobile application
provide back to wifi(process data)
Processing Instructions

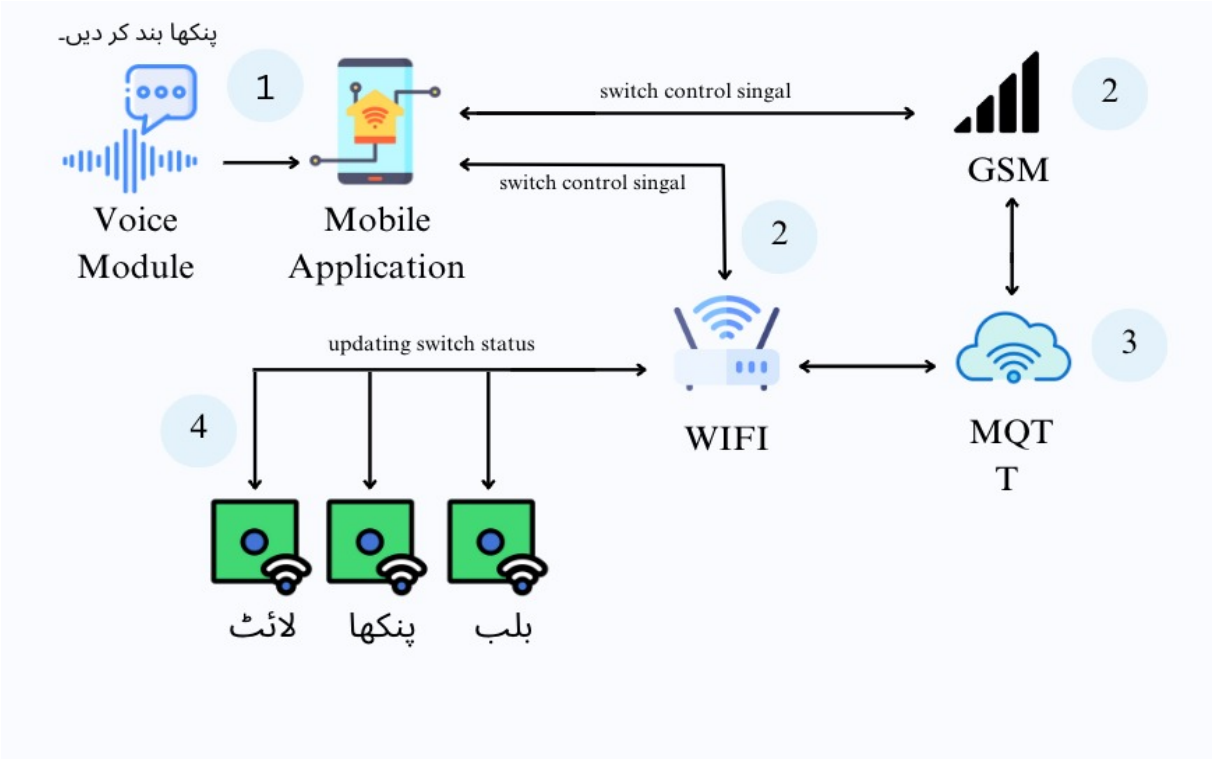
3.10 Sequence Diagram Diagram

The Sequence Diagram outlines the functionality of the Mobile Application. It begins with a login/signup page, which facilitates user authentication or registration. Upon successful login, the user gains access to control the rooms within their house. In the case of the Voice module, the mobile application initiates a request to establish a connection with the Python server implemented in Flask. This connection allows for voice-based commands to be processed and executed. On the other hand, when using the Button module, the mobile application directly modifies the values of the rooms by employing the MQTT protocol. This protocol enables communication between the mobile application and the IoT devices associated with each room. Additionally, a hardware button feature is available as an alternative to using the mobile application. This hardware module directly modifies the values of the rooms and subsequently requests the Wi-Fi connection to update the changes accordingly.



3.11 System Workflow

The system has been implemented on a hardware prototype model using an IoT device called NodeMCU. Its purpose is to automate homes by controlling electrical appliances through a mobile application built with Flutter using the Dart programming language. This system offers two modes of operation: manual control through the mobile application and voice command control in Urdu language via a voice module integrated into the mobile application. The voice commands are processed using speech recognition techniques based on natural language processing (NLP) concepts.



The workflow diagram above illustrates the system's operation. For example, if a voice command like " pankha band kar do " (which translates to "Turn off the fan") is given to the voice module, it will be sent to a Python server at the backend. The server will recognize and convert the speech into text, which will then be stored in JSON format. The server will tokenize the sentence into words and map the words to specific commands. The corresponding signal will be sent to the IoT device using the MQTT protocol. The IoT device will then perform the desired action based on the received signal. For instance, the command " kamra aik ka pankha band kar do "(which means "Turn off the fan in Room

1") will automatically switch off the fan in Room 1.

This system enables the control of appliances through voice commands and also provides remote access and manual control via the mobile application.

Chapter 4

Methodology

There are two aspects of this project : Direct manually controlling the home electrical appliances through mobile applications. The second aspect is controlling the electric appliances by giving voice commands in Urdu. Both methods are elaborated as follows.

4.1 Manual control of home electrical equipment

4.1.1 Description

The mobile application provides users with two options for controlling their IoT devices: manual instructions and voice instructions. If a user selects the manual instruction option, a signal is transmitted to the WiFi/GSM network, which then relays the signal to the appropriate IoT device, specifically the NodeMCU. The NodeMCU interprets the signal and activates or deactivates the designated appliance accordingly. For example, if a user chooses to manually instruct the application to switch on "Room 1 Light," the instruction is transmitted via WiFi to the NodeMCU, which in turn activates the light in Room 1. To get a clearer picture of how the speech is processed, please refer to the accompanying diagram.

4.1.2 Flow diagram

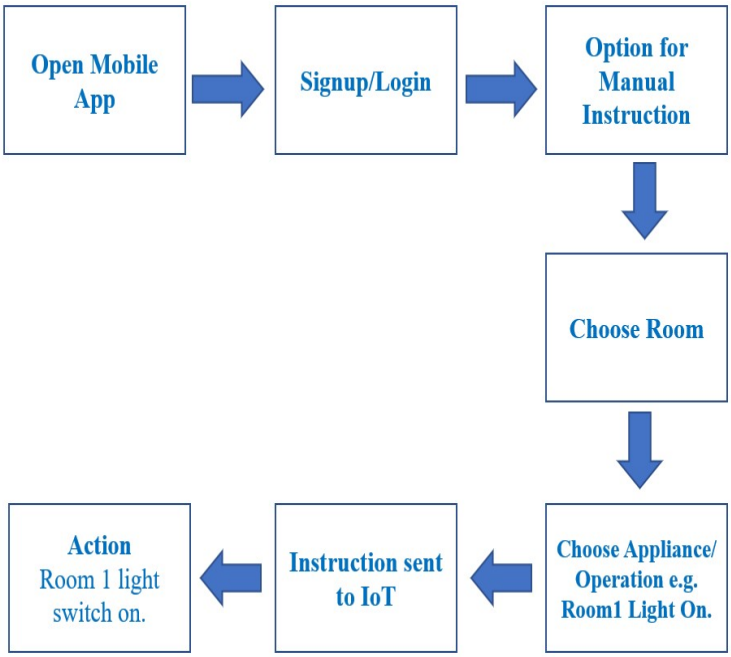


Figure 4.1: Mobile Application Flow Diagram

4.2 Control of home electrical equipment by giving voice commands

4.2.1 Description

In the second method, the user can use voice commands in Urdu with the mobile application's voice module. Once a command is issued, the application sends it to a Python server through WiFi. The Python server processes the command by converting the speech into text and responds back to the application through WiFi. The application then relays the instructions to the NodeMCU, which takes action to turn the appliance on or off according to the received command. To get a clearer picture of how the speech is processed, please refer to the accompanying diagram.

4.2.2 Flow diagram

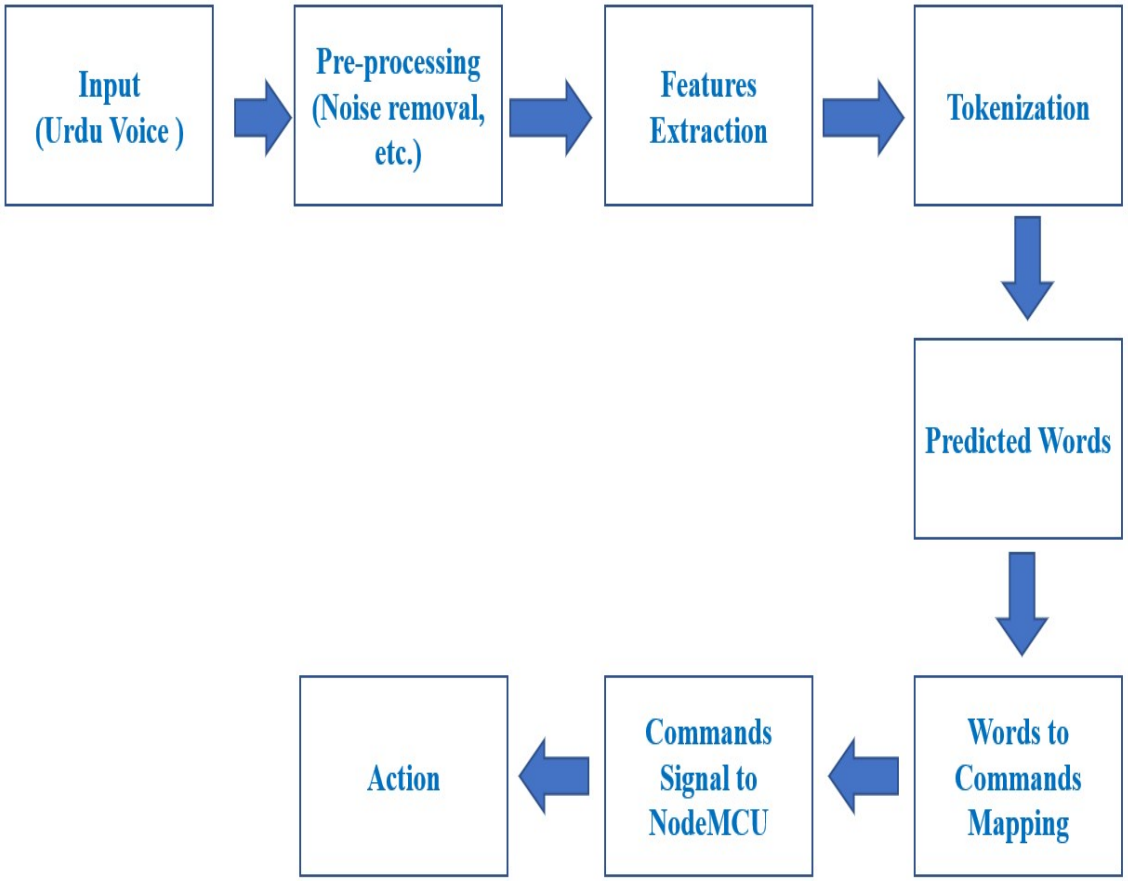


Figure 4.2: Voice Module Flow Diagram

Chapter 5

Iteration 1

Experimental Setup

5.1 Hardware Connection

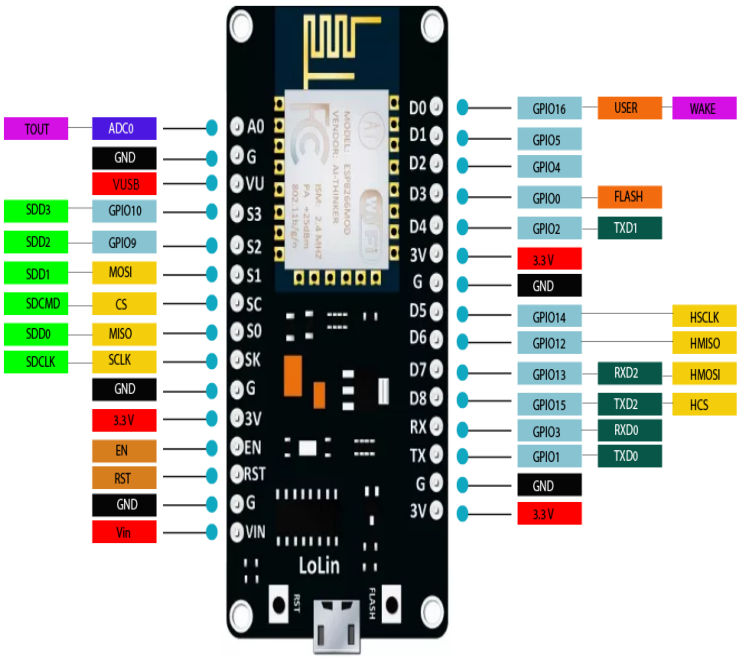


Figure 5.1: NodeMCU ESP8266

NodeMCU ESP8266 is an IoT device that provides the capability to develop code for con-

trolling hardware components. In our specific implementation, we utilized the NodeMCU ESP8266 to establish connections with LED bulbs and an L298 motor driver, enabling the functionality to toggle these components ON or OFF. This control can be achieved through two means. Firstly, hardware buttons directly connected to the NodeMCU ESP8266 allow for manual interaction, enabling users to activate or deactivate the mentioned hardware components. Secondly, a mobile application can be employed, which connects to the NodeMCU ESP8266 using the MQTT protocol. This connection facilitates the triggering of the hardware components attached to the NodeMCU ESP8266 via commands sent from the mobile application. To establish the connection between the mobile application and the NodeMCU ESP8266, a Wi-Fi connection is essential. It enables the mobile application to communicate with the MQTT protocol, thereby initiating the desired actions on the connected hardware components.

5.1.1 Electric Switch

An electric switch is a device used to interrupt or divert the flow of electric current. It is an essential component in electrical circuits that allows the control of the flow of electricity to various devices and appliances. Switches are typically made up of a contractor, which is a movable piece of metal that makes contact with another piece of metal to complete the circuit when the switch is turned on. The switch may also have a spring mechanism that keeps the contactor in place and returns it to its original position when the switch is turned off. There are many different types of electric switches, including toggle switches, rocker switches, push-button switches, and dimmer switches, each with their own specific uses and applications.

5.1.2 LED Bulb

LED bulb consists of two terminals. One longer terminal is the positive wire whereas the short terminal is the negative terminal. The positive terminal is connected to a 2 ohm resistor which is connected with the positive terminal of the breadboard using wires. The

2 ohm resistor is added as LED bulb takes only 3V. If LED bulb is replaced then we will need to use the resistor according to the LED bulb's voltage intake.To calculate this we can use: **Resistance = LED bulb's Voltage intake - Power Source Voltage**

5.1.3 Fan using DC Motor

In order to create a fan we attach a wing to the needle of a DC motor. The terminals DC motor are connected to the positive and negative terminals of the breadboard using wires.

5.2 Connection between NodeMCU and Mobile App

To establish a connection between NodeMCU and a mobile app, you can use a Wi-Fi connection and a communication protocol such as HTTP or MQTT. Here are the general steps you can follow:

Set up a Wi-Fi connection on the NodeMCU board: You can use the NodeMCU firmware to connect to your Wi-Fi network, and obtain an IP address for your device.

Install the appropriate software on your mobile device: You will need to download and install a mobile app that is capable of communicating with NodeMCU using the HTTP or MQTT protocol.

Write the code for the NodeMCU board: You will need to write the code to establish communication with the mobile app using the HTTP or MQTT protocol, and define the messages to be sent and received between the two devices.

Establish a communication link: Once the code is written and the Wi-Fi connection is established, you can establish a communication link between the NodeMCU board and the mobile app. This can involve sending and receiving data, such as sensor readings or control signals.

Test the communication link: Finally, you can test the communication link between the NodeMCU board and the mobile app, to ensure that the data is being sent and received correctly.

5.3 Hardware setup output

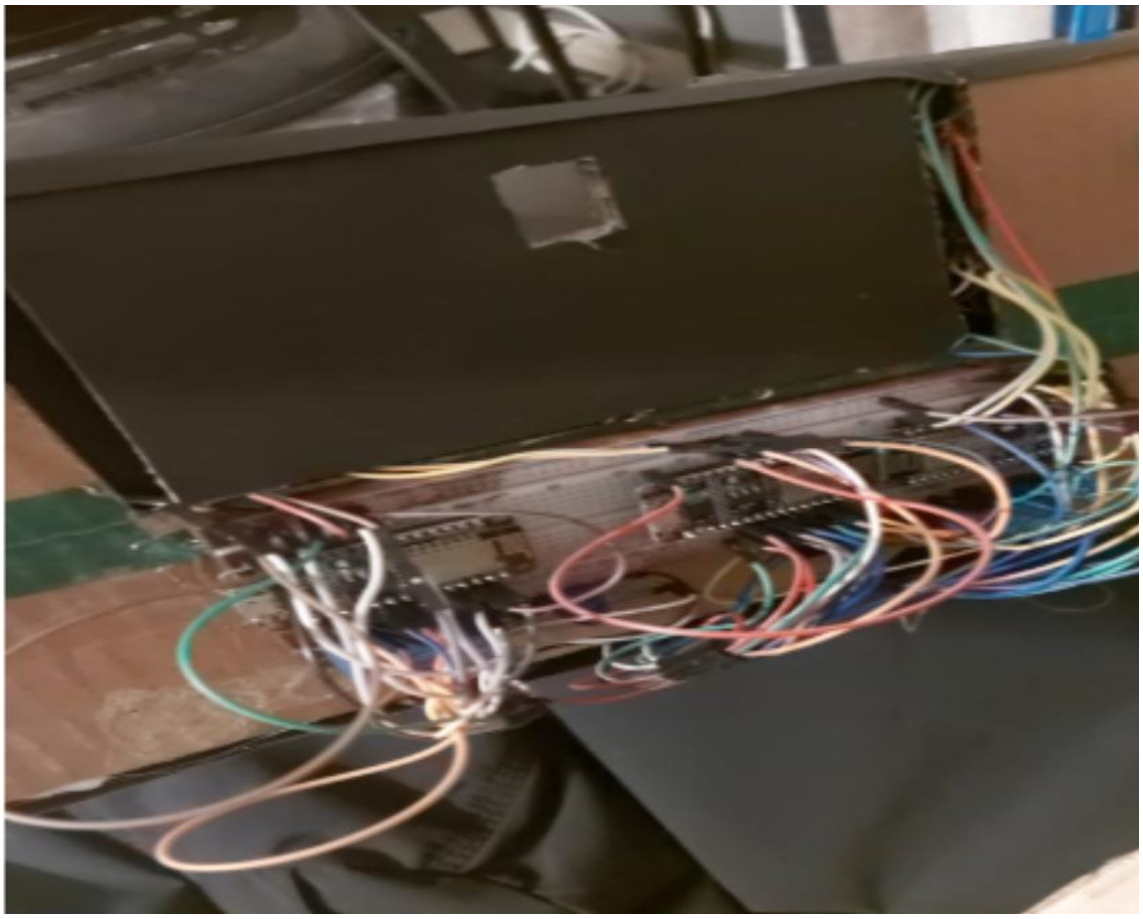


Figure 5.2: Hardware Setup

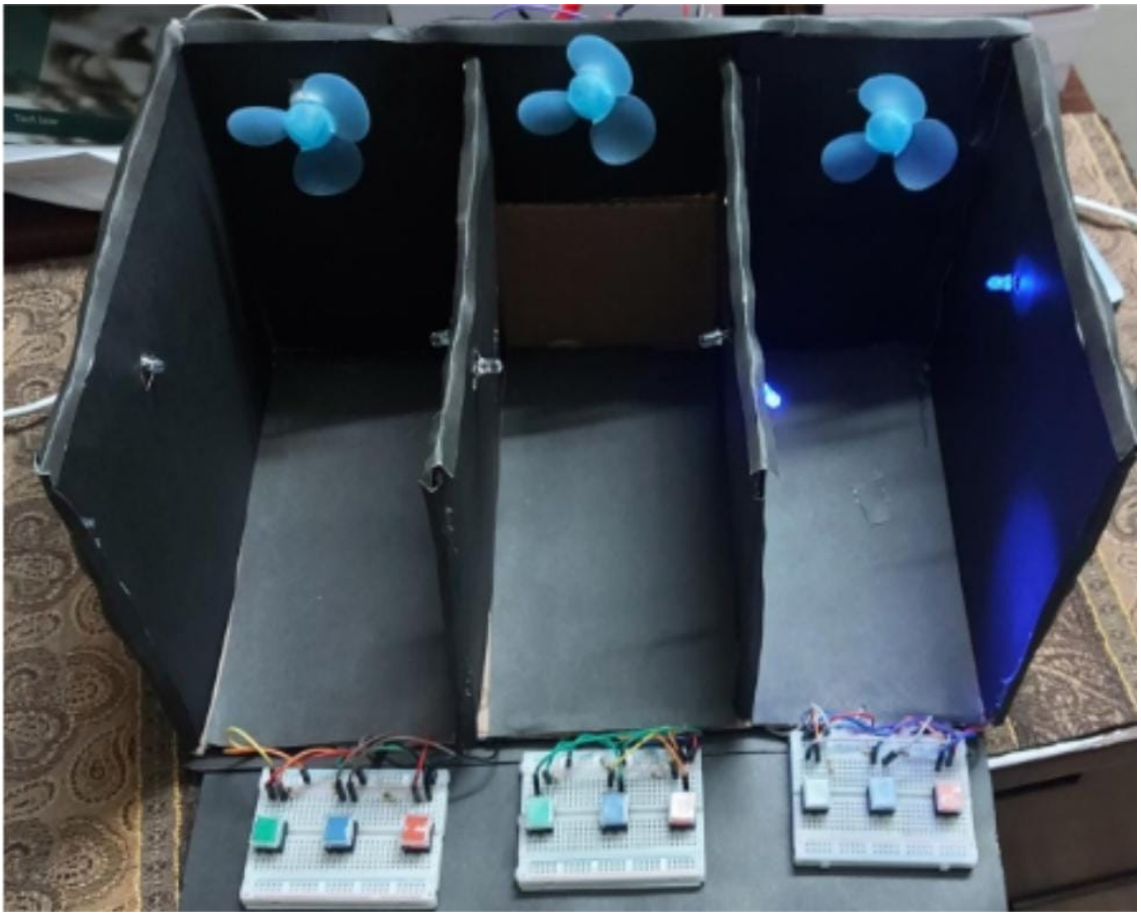


Figure 5.3: Complete Hardware Model

Chapter 6

Iteration 2

Mobile Application Development

6.1 Framework

The Mobile Application is developed using the Flutter framework, which utilizes the Dart programming language. The choice of Flutter as the development framework stems from its cross-platform nature, allowing the creation of mobile applications for both iOS and Android platforms. Furthermore, Flutter is a framework developed by Google, providing developers with access to a wide range of libraries and tools that streamline the development process, reducing effort and saving time.

6.2 Implementation

The Mobile Application consists of a Login and a Sign-up page. First the user has to sign up. The user data goes into the Firebase database which is then used by the login page to authenticate the user. After the user is authenticated by the Firebase database, the mobile application features a bottom app bar that offers four distinct options to the user.

1. Home: Upon selecting this option, the user is presented with a page displaying three buttons, each representing a different room. Upon selecting a specific room, the cor-

responding page opens, providing options to control the associated light, bulb, and fan buttons.

2. Mic Page: This option directs the user to a page containing a microphone button. Upon pressing the microphone button, a new page opens, facilitating voice input. This allows the user to speak commands in Urdu.

3. About Page: Selecting this option navigates the user to an information page containing details about the developers involved in the project.

4. Logout Page: By selecting this option, the user is logged out of the application using Firebase authentication, ensuring secure and controlled access to the mobile application.

6.2.1 Login Page

The Login page incorporates a username and password field, providing a means for user authentication. The entered credentials are verified using Firebase authentication, ensuring the secure and reliable authentication process for users accessing the application.

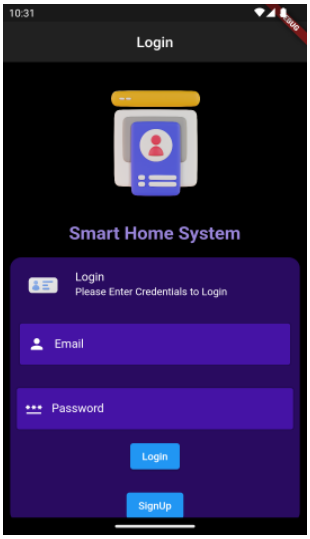


Figure 6.1: Login Page

6.2.2 Sign-Up Page

The Sign up page includes fields for username and password, enabling users to create an account if they provide a valid email address. The validation of the email address is conducted using the Firebase authentication module. If the email address is determined to be valid and does not already exist in the system, an account is created for the user. The credentials associated with the newly created account can then be utilized to log in from the Login page.

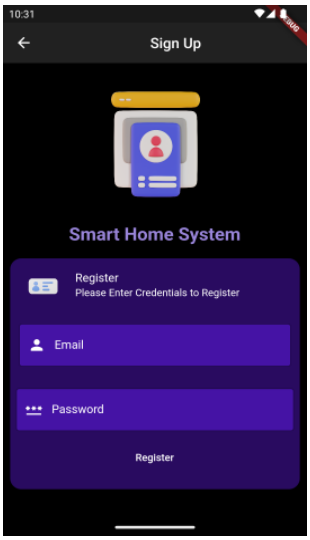


Figure 6.2: Sign Up Page

6.2.3 Home Page

Upon selecting this option, the user is directed to a page that exhibits three distinct buttons, with each button symbolizing a different room. Upon choosing a specific room, the corresponding page unfolds, granting the user access to various controls for the associated light, bulb, and fan buttons. This interface empowers the user to manipulate and manage the functionalities of the respective room's components.

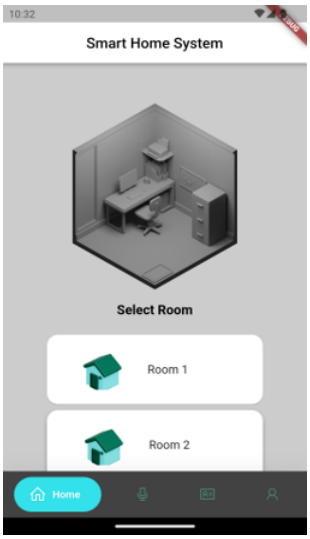


Figure 6.3: Home Page

6.2.4 Mic Page

The Mic page features a button adorned with a microphone logo. Upon tapping this button, a new page emerges, displaying a central mic button. Beneath the mic button, a text in Urdu provides instructions to the user, explaining the expected output of the spoken command once the mic button is pressed. This setup allows the user to interact with the application using voice commands, enhancing the usability and convenience of the system.

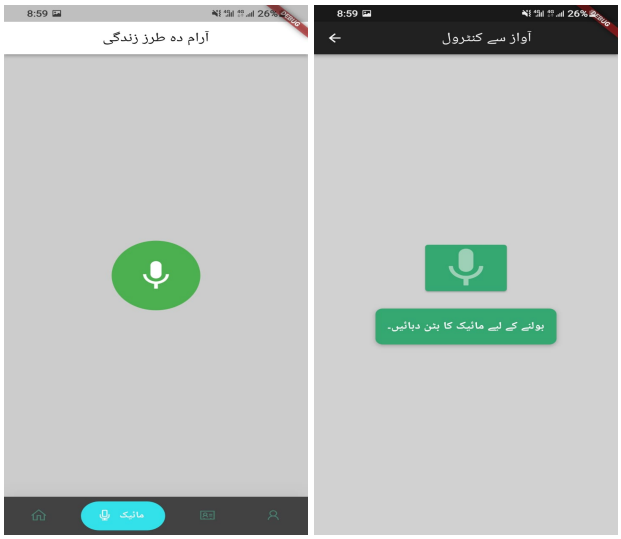


Figure 6.4: Mic Module

6.2.5 About Us

Selecting this option redirects the user to an information page that offers comprehensive details about the developers involved in the project. This page serves as a valuable resource, providing insights into the individuals who contributed to the development and implementation of the application.

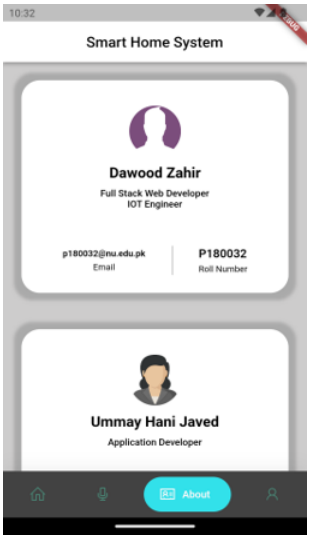


Figure 6.5: About Us Page

6.2.6 Logout

By selecting this option, the user undergoes a logout process within the application, facilitated by Firebase authentication. This mechanism ensures that the user's access to the mobile application is securely terminated, guaranteeing controlled access and safeguarding sensitive information.

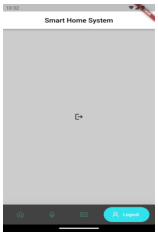


Figure 6.6: Logout

Chapter 7

Iteration 3

Integrating Voice Module

7.1 Voice Module

The voice module encompasses a Python server implemented in Flask. This server receives audio input from the Mobile Application, developed using the Flutter framework, and subsequently undergoes a series of steps to perform Natural Language Processing (Speech-To-Text) operations. After processing the audio input, the server generates a JSON-formatted array consisting of three distinct elements.

The first element involves checking whether it is not empty and if it specifies a particular room.

The second element contains the name of the switch being referred to, such as a Light, Bulb, or Fan.

The third element comprises the value to be applied to the switch, denoting either "ON" or "OFF".

These elements within the JSON array provide crucial information for further actions and control over the corresponding switches, allowing for seamless voice-based control of the hardware components.

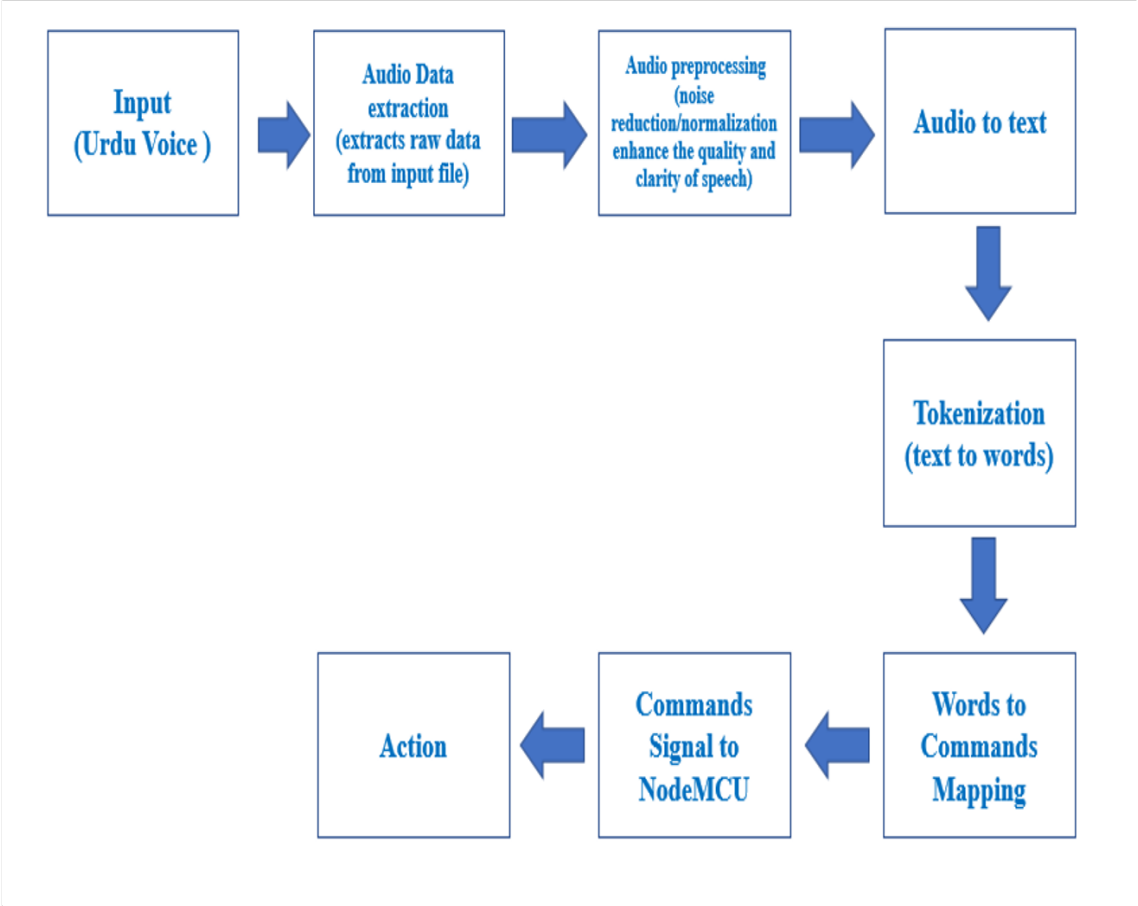


Figure 7.1: Voice Module Flow Diagram

Chapter 8

Technologies and Frameworks

The IOT Based Monitoring and Control System for Home Automation was developed utilizing the following technologies:

Flutter Framework:

Flutter, a cross-platform mobile application development framework, was employed for creating the user interface and functionality of the mobile application.

Arduino IDE:

The Arduino Integrated Development Environment (IDE) served as the primary platform for programming the IoT hardware devices, such as NodeMCU or other Arduino-based microcontrollers.

Flask:

Flask, a lightweight web framework for Python, was utilized for developing the Python server that handles various backend functionalities, including the voice module and interaction with the MQTT protocol.

MQTT:

The MQTT (Message Queuing Telemetry Transport) protocol was implemented for enabling communication between the mobile application, Python server, and IoT devices. It facilitated the seamless transfer of messages and control commands.

Firebase:

Firebase, a cloud-based platform by Google, was employed for user authentication and secure data storage. It ensured a reliable and scalable backend infrastructure for the system.

By leveraging these technologies, the IOT Based Monitoring and Control System for Home Automation was successfully developed, delivering a robust and user-friendly solution for home automation management.

8.1 Mobile Application Development

The Mobile Application was developed using the Flutter framework, which employs the Dart programming language. Flutter offers a powerful cross-platform solution for building mobile applications that can run seamlessly on iOS, Android, and web platforms. Being developed by Google, Flutter integrates smoothly with various libraries and tools, streamlining the development process. Another notable advantage of Flutter is its compatibility with Firebase, a Google cloud-based database. Leveraging Firebase eliminates the need for writing or creating new code for database functionalities. Firebase provides a range of features and services that can be easily integrated into the application, enhancing its functionality and efficiency. By utilizing Flutter and Firebase together, the Mobile Application benefits from the capabilities of both frameworks, resulting in a robust, versatile, and efficient solution for cross-platform mobile application development with seamless database integration.

8.2 Arduino IDE

The Arduino IDE serves as the development environment for creating code tailored to IoT devices, specifically the NodeMCU ESP8266 in our case. By utilizing the Arduino IDE,

developers gain access to a comprehensive set of libraries and functionalities that facilitate the seamless connection between hardware components. This environment simplifies the development process, allowing for efficient communication and interaction with IoT devices such as the NodeMCU ESP8266 or other compatible devices.

8.3 Flask

Flask is a Python framework designed for developing web applications utilizing the Python programming language. Within the context of the IOT Based Monitoring and Control System for Home Automation, Flask serves a vital role by enabling the creation of a server. This server acts as the connecting bridge between the voice module of the mobile application and the Python server developed using Flask. The Flask framework provides the necessary tools and capabilities to establish this connection, facilitating seamless communication and data transfer between the mobile application and the Python server.

8.4 MQTT

MQTT enables users to sign in using the same credentials generated during the account creation process, facilitating the connection of devices to the associated account. Upon signing into the account, the mobile application code subscribes to specific topics corresponding to different rooms, such as Room 1, Room 2, or Room 3. This subscription allows the mobile application to receive updates and messages related to the subscribed topics. Likewise, the mobile application can also publish messages to the designated topics, allowing for two-way communication and control between the application and the connected devices associated with Room 1, Room 2, or Room 3.

8.5 Firebase

Firebase is a Google Cloud database that provides a range of user authentication functionalities, including sign-in verification, sign-up procedures, and secure storage of values in

the database. With Firebase, developers can seamlessly integrate robust authentication mechanisms into their applications, ensuring secure and reliable user identification and access control. Additionally, Firebase offers various features and capabilities for storing, retrieving, and managing data, empowering developers to efficiently store and retrieve user-related information within the database.

8.6 Code

The code is available in the GitHub repository:
https://github.com/dodzcf/Final-Year-Project

float

Chapter 9

Results

9.1 Hardware Setup and Connectivity:

The hardware components were set up and connected effectively, ensuring seamless communication between the IoT devices and the control system. This allowed for real-time monitoring and control of the electrical appliances.

9.2 Mobile Application Development:

The mobile application, developed using Flutter, provided a user-friendly interface for controlling the home automation system. It facilitated remote access, enabling users to monitor and control their appliances from anywhere using their smartphones.

9.3 Voice Module Integration:

Incorporating a voice module enabled users to control the system using voice commands in Urdu. The system accurately interpreted the commands, allowing for the hands-free operation of the connected appliances.

9.4 Functionality Testing:

Thorough testing was conducted to evaluate the system's functionality and reliability. The system consistently responded to commands, effectively controlling the appliances and providing real-time feedback on their status.

9.4.1 Testing results:

The Flutter application was tested using flutter.test, and here are the outputs of the tests conducted:

Room 1:

Voice/Manual Command:"kamra aik ka pankha band kar do" (Turn off the fan in Room 1)

Outcome: The test successfully switched off the fan in Room 1 as expected. Voice/Manual Command: "kamra aik ka bulb jala do" (Turn on the light in Room 1)

Outcome: The test successfully turned on the light in Room 1 as expected. Voice/Manual Command:" kamra aik ka pankha chaalo kar do" (Turn on the fan in Room 1)

Outcome: The test successfully turned on the fan in Room 1 as expected. Voice/Manual Command: "kamra aik ka bulb band kar do" (Turn off the light in Room 1)

Outcome: The test successfully switched off the light in Room 1 as expected.

Room 2:

Voice/Manual Command: "kamra do ka pankha band kar do "(Turn off the fan in Room 2)

Outcome: The test successfully switched off the fan in Room 2 as expected. Voice/Manual Command: "kamra do ka bulb jala do" (Turn on the light in Room 2)

Outcome: The test successfully turned on the light in Room 2 as expected. Voice/Manual Command: "kamra do ka pankha chaalo kar do" (Turn on the fan in Room 2)

Outcome: The test successfully turned on the fan in Room 2 as expected. Voice/Manual

Command: "kamra do ka bulb band kar do" (Turn off the light in Room 2)

Outcome: The test successfully switched off the light in Room 2 as expected.

Room 3:

Voice/Manual Command: "kamra teen ka pankha band kar do" (Turn off the fan in Room 3)

Outcome: The test successfully switched off the fan in Room 3 as expected. Voice/Manual Command: "kamra teen ka bulb jala do" (Turn on the light in Room 3)

Outcome: The test successfully turned on the light in Room 3 as expected. Voice/Manual Command:" kamra teen ka pankha chaalo kar do" (Turn on the fan in Room 3)

Outcome: The test successfully turned on the fan in Room 3 as expected. Voice/Manual Command: "kamra teen ka bulb band kar do" (Turn off the light in Room 3)

Outcome: The test successfully switched off the light

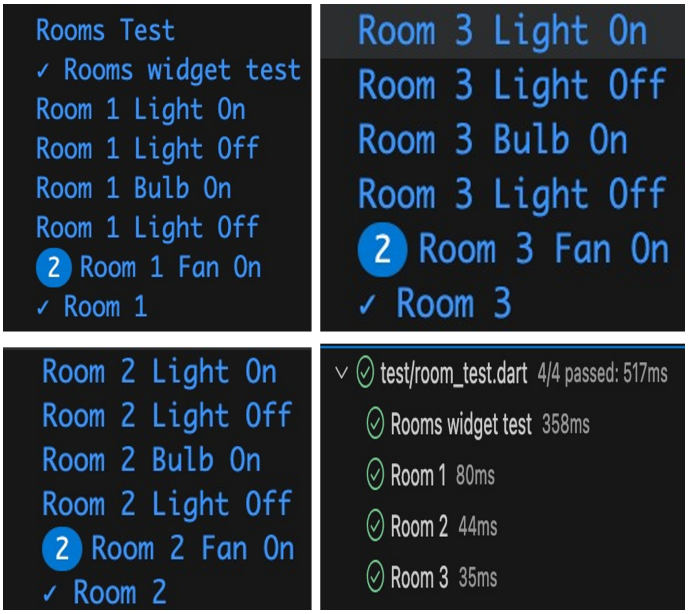


Figure 9.1: Testing Result

The system is also tested by a user on a hardware working prototype model for the same test commands above. As shown in Fig below:

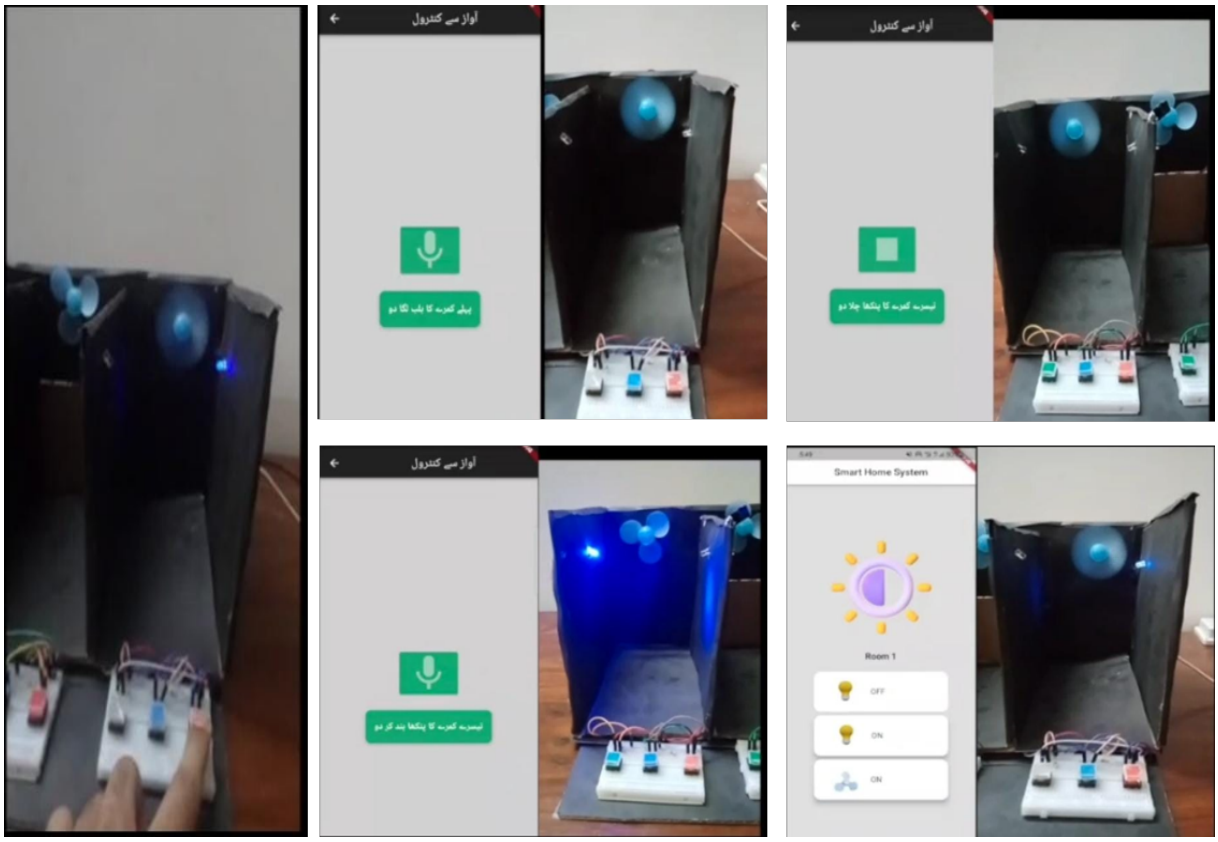


Figure 9.2: Live testing

9.5 Confusion matrix and statistical representation for performance measure of system

In the confusion matrices below, the rows represent the actual state of the devices (fan, light, bulb), and the columns represent the predicted state of the devices. The values in the matrix represent the number of occurrences for each combination of actual and predicted states. Based on this confusion matrix, we have calculated accuracy, precision and recall for our system.

1. TP: Number of true positives (correctly predicted positives)

2. TN: Number of true negatives (correctly predicted negatives)

3. FP: Number of false positives (incorrectly predicted positives)

4. FN: Number of false negatives (incorrectly predicted negatives)

	Fan (On)	Fan (Off)	Light (On)	Light (Off)	Bulb (On)	Bulb (Off)
Fan (On)	18	2	0	1	1	0
Fan (Off)	0	18	1	2	0	1
Light (On)	0	1	18	0	2	0
Light (Off)	1	0	0	18	0	0
Bulb (On)	1	0	1	0	18	2
Bulb (Off)	0	1	0	1	0	20

Figure 9.3: Confusion matrix for room 1 appliances

	Fan (On)	Fan (Off)	Light (On)	Light (Off)	Bulb (On)	Bulb (Off)
Fan (On)	18	2	0	1	1	0
Fan (Off)	0	18	1	0	0	1
Light (On)	0	1	18	0	2	0
Light (Off)	1	0	0	18	0	0
Bulb (On)	1	0	1	0	18	0
Bulb (Off)	0	1	0	1	0	18

Figure 9.4: Confusion matrix for room 2 appliances

	Fan (On)	Fan (Off)	Light (On)	Light (Off)	Bulb (On)	Bulb (Off)
Fan (On)	18	2	0	1	1	0
Fan (Off)	0	18	1	0	2	1
Light (On)	0	1	18	0	1	0
Light (Off)	1	0	1	18	0	0
Bulb (On)	1	0	1	0	20	1
Bulb (Off)	0	2	0	1	0	18

Figure 9.5: Confusion matrix for room 3 appliances

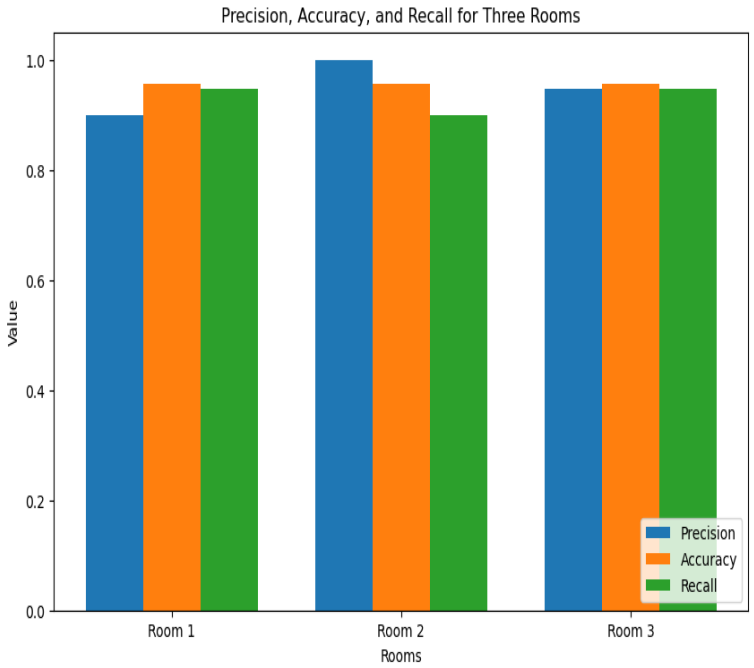


Figure 9.6: System Performance Measure Bar Plot

Chapter 10

Discussion

The implementation of this IoT-based monitoring and control system holds immense value for home automation. By combining hardware, software, and voice control, we have created a comprehensive solution that enhances convenience and accessibility for users. The successful integration of the voice module in Urdu has been well-received, as it allows for hands-free operation and a more intuitive user experience. User feedback has highlighted the system's effectiveness and ease of use, validating its practicality and suitability for Urdu-speaking individuals.

The future prospects of this project are promising. The selection in the National Incubation Center provides an opportunity to refine and launch the product in the market. As the system can be scaled to other local languages in Pakistan, it holds the potential for widespread adoption and acceptance. Continued improvements and updates, based on user feedback and emerging technologies, will further enhance the system's functionality and ensure its competitiveness in the home automation industry. In addition to the positive outcomes and future prospects, there are important considerations for the IoT-based monitoring and control system. Ensuring security and privacy through robust measures such as encryption protocols, authentication mechanisms, and regular audits is vital. Interoperability with existing smart home devices and standards should be prioritized to enhance functionality and appeal to users with existing setups. Continuous monitoring, maintenance, and software updates are crucial for optimal performance and a seamless

user experience. Staying updated with advancements in IoT, voice recognition, and home automation, and exploring emerging technologies like artificial intelligence and machine learning will unlock new possibilities. By addressing these considerations and focusing on user needs, the system can revolutionize home automation and establish itself as a significant player in the market.

Chapter 11

Conclusion and Future Work

11.1 Conclusion

In conclusion, this project has successfully implemented an IoT-based monitoring and control system for home automation. We began by setting up the hardware for a prototype model, ensuring effective communication between the IoT devices and the control system. Subsequently, we developed a mobile application using Flutter, providing a user-friendly interface for remote access and control. The integration of a voice module allowed users to control home appliances using voice commands in Urdu, catering specifically to the Urdu-speaking population.

The positive outcome of this project has opened doors for future opportunities. Being selected for the National Incubation Center is a significant milestone, paving the way for the conversion of this project into a sustainable business venture. The potential scalability of the system to other local languages spoken in Pakistan, such as Pashto and Punjabi, further expands the target audience and market potential.

11.2 Future Work

Moving forward, there are several areas of future work to enhance and expand this project. Firstly, incorporating additional features such as energy monitoring and optimization can provide users with valuable insights into their energy consumption patterns and promote sustainability. Moreover, integrating machine learning algorithms can enable the system to learn user preferences and automate routine tasks intelligently.

Expanding the language support beyond Urdu to other regional languages spoken in Pakistan, such as Pashto and Punjabi, will broaden the user base and increase market penetration. Conducting user research and usability studies in different regions will aid in adapting the system to meet the specific needs and preferences of diverse user groups.

Additionally, exploring integration possibilities with other smart home devices and platforms will enable seamless interoperability and enhance the overall home automation experience. Collaborating with manufacturers and service providers can facilitate partnerships and distribution channels, leading to wider adoption and market reach.

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