Home Automation Using IoT

1. Introduction

1.1 Brief overview of the work:

In recent years, wireless systems like Remote Control have become more popular in home networking. Home Automation is automation of home, housework or household activity. In other words, it refers to use of IT/computer to control home appliances. It integrates electrical devices in a house with each other. For example, It can include centralized control of lighting, appliances, security lock of gates & doors to provide improved convenience, comfort, energy, efficiency and safety.
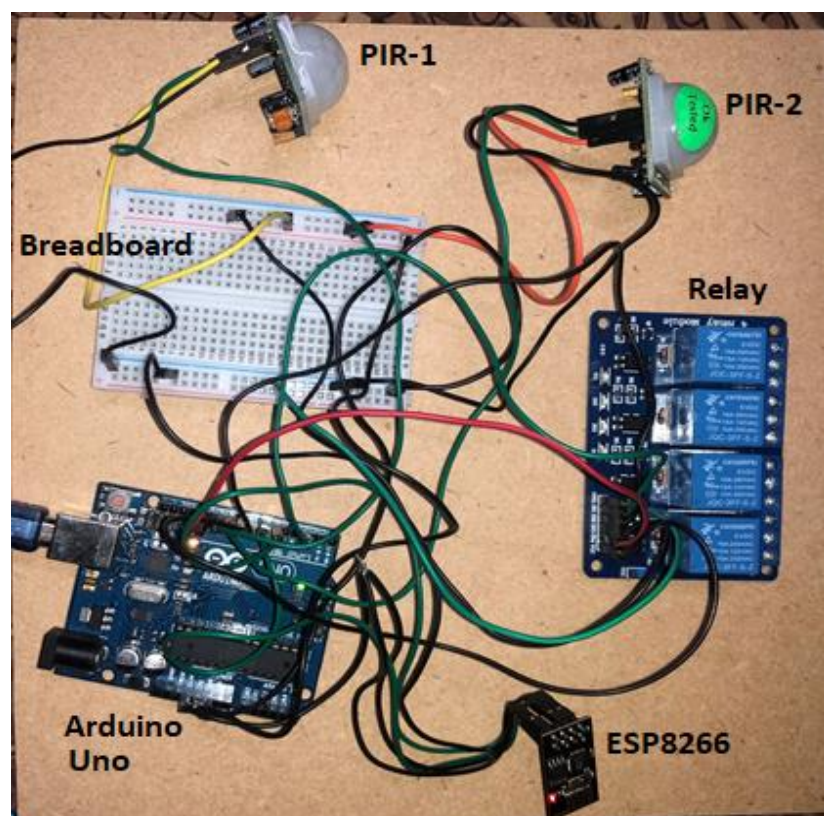

Figure 1.1.1: Circuit

In this project, user will be able to control the electrical appliances in the particular room, based on his appearance. Also the hardware is connected to an Android App which is developed on our own using MIT App inventor. By using this app, we will be able to monitor and control the home appliances. Socket Programming has been used to achieve client-server communication. PIR sensor in this project is used to switch ON automatically the appliances whenever a person enters the room and switch OFF the appliances whenever the person leaves the room. The Arduino Uno connected with ESP8266 WiFi module is used to implement the micro web server for the home gateway. A conventional light switch will be integrated with the Arduino using relay driver module to demonstrate the switching capability. A Relay is used for connecting each device to the Arduino, which helps in converting high Voltage supply to low voltage. This hardware architecture is very flexible and allows other home appliances and devices to be seamlessly integrated with minimal changes.

1.2 Project Objective:

The objective of this project is to implement a low cost , reliable and scalable home automation system that can be used to remotely switch on or off any household appliance, using a microcontroller to achieve hardware simplicity ,internet service for live status of appliances and control from mobile-phone to toggle the switch state. Save time and utilize energy is also an important objective.

1.3 Project Scope:

The project work is complete on its own in remotely & automatically switching on or off any household appliances and sends a status message(ON or OFF) indicating the new present state of the appliance, by the physical presence as well as by using the Smartphone.

1.4 Project Modules:

- ➢ Interfacing in Arduino
- ➢ Motion detection using PIR Sensor
- ➢ Device Management
- ➢ Data Management
- ➢ Authentication Module
- ➢ Device Management through Android Application

1.5 Project Requirements:

1.5.1 Hardware Requirements:

- ➢ Arduino Uno with Atmega 328P microcontroller
- ➢ PIR Sensors
- ➢ ESP8266 Wi-Fi Module
- ➢ 5 V Relay Driver Module X 4
- ➢ Prototyping board (Bread board)
- ➢ Connecting wires
- ➢ Smartphone or tablet (Wifi enabled)

1.5.2 Software Requirements:

- ➢ Arduino IDE
- ➢ Android application

2. Literature Review

Home automation systems face four main challenges, these are high cost of ownership, inflexibility, poor manageability, and difficulty in achieving security. The main objectives of this research is to design and implement a home automation system using IoT that is capable of controlling and automating most of the home appliances through an easy manageable user interface.

With the increase in consumption of energy and population, there is a grave need to conserve energy in every way possible. The inability to access and control the appliances from remote locations is one of the major reasons for energy loss. A web or an android application is used by the users to give instructions to these systems.

Home automation is a challenging one not only to the developer but also to the consumer. Developer has to choose the component as per the customer requirement. Due to all the customer demands are not equal hence they have to compromise with the existing products. Through detailed study of various existing systems such as,

➢ "Home Automation Using Internet of Thing" proposed by Shopan Dey, Ayon Roy and Sandip Das, it is found that they have used Raspberry pi module to connect ESP8266-01 module to the internet. Through this module they are controlling various devices through web page and also through android application.

➢ K. Venkatesan and Dr. U. Ramachandraiah in their paper have implemented Zigbee module in Arduino mega through which they are controlling devices. They have used various sensors for various purpose. With the help of logic gates, a Raspberry pi, 555 timer and flip-flop also the devices are controlled from web app.[1]

➢ "Programmable Infrared Accessory Light Switch" by Warsuzarina Mat Jubadi and Normaziah Zulkifli shows how TV remote is used to control room light and other appliances. Here IR remote and one IR receiver is used and programmed in such a way that it stores the frequency of the existing remote and use them directly to control appliances.

➢ Sirsath N. S, Dhole P. S, Mohire N. P, Naik S. C & Ratnaparkhi N.S paper proposes a Home Automation system that employs the integration of multi-touch mobile

devices, cloud networking, wireless communication, and power-line communication to provide the user with remote control of various lights and appliances within their home. This system uses a consolidation of a mobile phone application, handheld wireless remote, and PC based program to provide a means of user interface to the consumer.[5]

➢ Deepali Javale, Mohd. Mohsin, Shreerang Nandanwar prepared project to assist handicapped/old aged people. It gives basic idea of how to control various home appliances and provide a security using Android phone/tab. The design consists of Android phone with home automation application, Arduino Mega ADK. User can interact with the android phone and send control signal to the Arduino ADK which in turn will control other embedded devices/sensors.

➢ "Raspberry pi home automation with wireless sensors using smart phone" this project presents a low cost and flexible home control and monitoring system using an embedded microprocessor and microcontroller, with IP connectivity for accessing and controlling devices and appliances remotely using Smartphone application. The proposed system does not require dedicated server PC with respect to similar systems and offers a novel communication protocol to monitor and control the home environment with more than just the switching functionality. To demonstrate the feasibility and effectiveness of this system, devices such as light switches, power plug, temperature sensor and current sensor can be integrated with the home control system.

➢ Rajeev Piyare paper presents a low cost and flexible home control and monitoring system using an embedded micro-web server, with IP connectivity for accessing and controlling devices and appliances remotely using Android based Smart phone app. The proposed system does not require a dedicated server PC with respect to similar systems and offers a novel communication protocol to monitor and control the home environment with more than just the switching functionality. To demonstrate the feasibility and effectiveness of this system, devices such as light switches, power plug, temperature sensor and current sensor have been integrated with the proposed home control system.[3]

> ➤ In paper Ahmed El Shafee, Karim Alaa Hamed presents a design and prototype implementation of home automation system that uses Wi-Fi technology as a network infrastructure connecting its parts. Their system consists of two main components; the first part is the server (web server), which presents system core that manages, controls, and monitors users' home. Users and system administrator can locally (LAN) or remotely (internets) manage and control system code. Second part is hardware interface module, which provides appropriate interface to sensors and actuator of home automation system. Unlike most of available home automation system in the market the proposed system is scalable that one server can manage many hardware interface modules as long as it exists on Wi-Fi network coverage. System supports a wide range of home automation devices like power management components, and security components. The proposed system is better from the scalability and flexibility point of view than the commercially available home automation systems.[6]

So this system can make use of a host of various communication methods such as Wi-Fi, GSM, Bluetooth, ZigBee etc. Different controlling devices and configurations can be found in existing systems. Such systems have been found already in many places for a wide variety of applications. So now we will see different types of communication methods used for Home Automation System.

> ➤ Bluetooth based home automation system using cell phones:
> In Bluetooth based home automation system the home appliances are connected to the Arduino BT board at input output ports using relay. The program of Arduino BT board is based on high level interactive C language of microcontrollers; the connection is made via Bluetooth. The password protection is provided so only authorized user is allowed to access the appliances. The Bluetooth connection is established between Arduino BT board and phone for wireless communication.

> ➤ Zigbee based home automation system using cell phones:
> To monitor and control the home appliances the system is designed and implemented using Zigbee. The device performance is record and store by network coordinators. For this the Wi-Fi network is used, which uses the four switch port standard wireless

ADSL modern router. The network SSID and security Wi-Fi parameter are preconfigured. The message for security purpose first process by the virtual home algorithm and when it is declared safe it is re-encrypted and forward to the real network device of the home. [7] Over Zigbee network, Zigbee controller sent messages to the end. The safety and security of all messages that are received by the virtual home algorithm. To reduce the expense of the system and the intrusiveness of respective installation of the system Zigbee communication is helpful.

➢ GSM based home automation system using cell phones:

Because of the mobile phone and GSM technology, the GSM based home automation is lure to research. The SMS based home automation, GPRS based home automation and dual tone multi frequency (DTMF) based home automation, these options we considered mainly for communication in GSM. The system use transducer which convert machine function into electrical signals which goes into microcontroller. The sensors of system convert the physical qualities like sound, temperature and humidity into some other quantity like voltage. The microcontroller analysis all signal and convert them into command to understand by GSM module. Select appropriate communication method among SMS, GPRS and DTFC based on the command which received GSM module.

➢ Wi-Fi based home automation system using cell phones:

Wi-Fi based home automation system mainly consist three modules, the server, the hardware interface module, and the software package. Wi-Fi technology is used by server, and hardware Interface module to communicate with each other. The same technology uses to login to the server web based application. The server is connected to the internet, so remote users can access server web based application through the internet using compatible web browser. Software of the latest home automation system is split to server application software, and Microcontroller (Arduino) firmware. The Arduino software, built using C language, using IDE comes with the microcontroller itself. Arduino software is culpable for gathering events from connected sensors, then applies action to actuators and pre-programmed in the server. Another job is to report the and record the history in the server DB.[2]

➢ Home automation using RF module:

In this type of project the important goal is to build a home automation system using a RF controlled remote. In order to accomplish this, a RF remote is combined to the microcontroller on transmitter side that sends ON/OFF signals to the receiver where devices are connected. By operating the stated remote switch on the transmitter, the loads can be turned ON/OFF globally using wireless technology.

➢ Home automation using Android & ADK:

The devices of home are associate to the ADK and the Connection is established between the Android device and ADK. The devices of house are link to the input/output ports of the board (EMBEDDED SYSTEM) and their current situation will have passed to the ADK. The microcontroller board (Arduino ADK) is based on the ATmega2560. It has a USB host connection to associate with Android based phones, and that is based on the MAX3421e IC. The two important features of Android Open Accessory Protocol 2.0(AOAP) are as follows: It has audio output that is from the Android device to the component and it also support for the component serves as one or more Human Interface Devices (HID) to the Android device. This paper depends upon Android and Arduino platform in which both are FOSS(Free Open Source Software)[4]. Including motion sensors for safety systems will detect an unauthorized action and it will automatically notice the user through cell phone or the security system.

➢ Raspberry pie home automation with wireless sensors using smart phone:

Home Automation System has been developed with Raspberry Pi by reading the algorithm and subject of E-mail. Raspberry Pi guarantees to be an efficient platform for implementation powerful, and economic smart home automation. For example, DTMF (dual tone multi-frequency) using home automation, the call tariff is a big demerit, which is not the problem in their proposed method. In Home Automation using web server, the design of web server and the memory space required is dismiss by this method, because it just uses the already established web server service given by G-mail. LEDs were used to identify the switching action. This System is efficient and flexible interactive.[3] Using PIR motion sensor we can send the data signal to the Raspberry Pi, we just run a script which can reads the sensor by a GPIO pin and

transmit the data to overall system through the IoTF platform. This can then be look by the IoTF console.

➢ Wireless Home Automation system using IoT

This system uses mobiles or computers to control basic home control and function automatically through internet from anywhere around the world globally, an automated home is sometimes called a smart home. It is meant to save the electric power and human energy. The proposed system is a distributed home automation system, consists of server i.e. Wi-Fi module, sensors. Server controls and monitors the various sensors, and can be easily configured to handle more hardware interface module (sensors). The Arduino board, with built in Wi-Fi module acts as web server. Automation System can be accessed from the web browser of any local PC using server IP, or remotely from any PC or mobile handheld device connected to the internet with appropriate web browser through server real IP (internet IP). Wi-Fi technology is selected to be the network infrastructure that connects server and the sensors. Wi-Fi is chosen to improve system security (by using secure Wi-Fi connection), and to increase system mobility and scalability.

Comparison of different communication method:

Available technology	IEEE standard	Network Topology	Maximum Power Consumption (in mW)	Data Rate	Maximum Range(in meter)	Cost
Bluetooth	802.15.1	One to many	10	1 to 3 Mbps	10	Medium
Zigbee	802.14.5	Star, Cluster, Mesh	3	20 to 250 Kbps	100	High
ESP8266	802.11	Star, Mesh	100	1 to 11 Mbps	150	Low

Table : Comparison of different communication method

From table, it is observed that Esp8266-01 works on 802.11 b/g/n protocol whereas Zigbee uses 802.14.5 protocol. Zigbee consumes least power as 3mW whereas Wi-Fi and Bluetooth

consumes nearly 100mW. But if we compare speed of Esp8266 has maximum speed up to 11mbps but Zigbee has only 250kbps. Clearly esp8266 defeat Zigbee and Bluetooth not only in cost but also in speed . Fig.1 is giving a brief idea about the interconnection of microcontroller , peripheral devices as well as sensors.

So, here we introduce Arduino Uno with ESP8266-01 module. This is not only cost-effective but also prove to be the easiest one when it comes in term of programming and also implementation.

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3. System Analysis and Design

3.1 Comparison of existing application with our Project

As per our survey, there exist many systems that can control home appliances using website and application. Each system has its unique features. Currently certain companies are officially registered and are working to provide better home automation system features. Following models describes the work being performed by others.

1) Muhammad Izhar Ramli designed a prototype electrical device control system using Web. They also set the server with auto restart if the server condition is currently down. In this project they have developed home automation system only through the web. While in our project, we have provided automatic as well as manual way to control the electrical appliance.

2) Hasan has developed a telephone and PIC remote-controlled device for controlling the devices pin check algorithm has been introduced where it was with cable network but not wireless communication.

3) Satyam Nalawade had created web-based home automation using Raspberry Pi. His project is quite similar to our project. But, in our project we have used Arduino microcontroller rather than Raspberry pi. Which eventually, lower the cost of our project. Also, our project implements motion detection through sensor along with the Android Application, to control the appliance.

3.2 Project Feasibility Study:

This project can be implemented using affordable electronic and software technology making it economically, technically and operationally feasible.

3.2.1 Economic Feasibility:

This project is based on few electronic components like Arduino microprocessor, PIR Sensors, Relay switches etc. which are affordable, making it economically feasible to implement.

3.2.2 Technical Feasibility:

This project is based on wireless technology and embedded system which are reasonably in phase with currently used technology. Therefore, it is very much favored by the technology.

3.2.3 Operational Feasibility:

This software will have very easy to use, user friendly interface so it will be pretty much operable by anyone having little experience of using Android Application. It could be helpful for physically disabled person too, controlling home appliances with the click of a button. So, it is operationally feasible.

3.3 Project Timeline Chart:
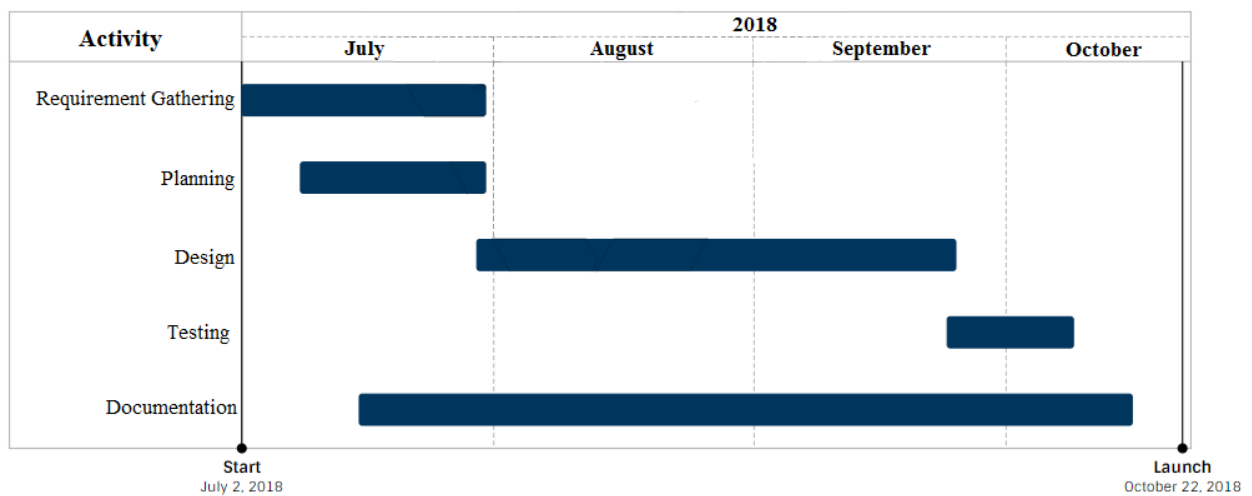
3.4 Detailed Modules Description:

3.4.1 Interfacing with Arduino:

In this module, we will setup our Arduino Uno microcontroller with the PC for programming. Also, we will setup the ESP8266 Wi-Fi Module with the Arduino, so that we can send our sensor data to the cloud.

3.4.2 Motion detection using PIR Sensor:

In this module, we will connect our PIR Sensor with the Arduino Uno microcontroller. Data acquisition from the Sensor will be included in this module.

3.4.3 Device Management:

In this module, we will configure our Relay Drivers to the Arduino microcontroller. Which will be helpful to controlling the high voltage. Also, we will connect the electrical appliance with the Relay.

3.4.4 Data Management:

In this module, we will send our sensor data for the cloud computing. We will use open source API 'ThingSpeak' to achieve our purpose. Also, we will detect the physical presence by means of PIR sensor & operate the electrical appliance in this module.

3.4.5 Authentication Module:

In this module, we will design the Android Application for controlling the device through Smartphone. For using our Android Application, user needs to be authenticated. Admin bind the MAC Address of Authenticated User with Application so by that we can provide the greater level of security.

3.4.6 Device management through Android Application:

In this module, we will setup a connection between our Android Application & Arduino Uno. As soon as the user will change the state of the appliance with the help of Android Application, the database will be change accordingly. So, according to the database value, Arduino will change the state of electrical appliance. Also, we will retrieve the number of persons in room form ThingSpeak API through Android Application.
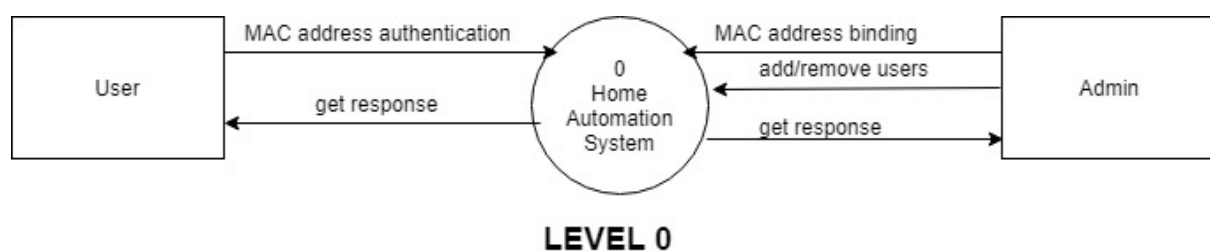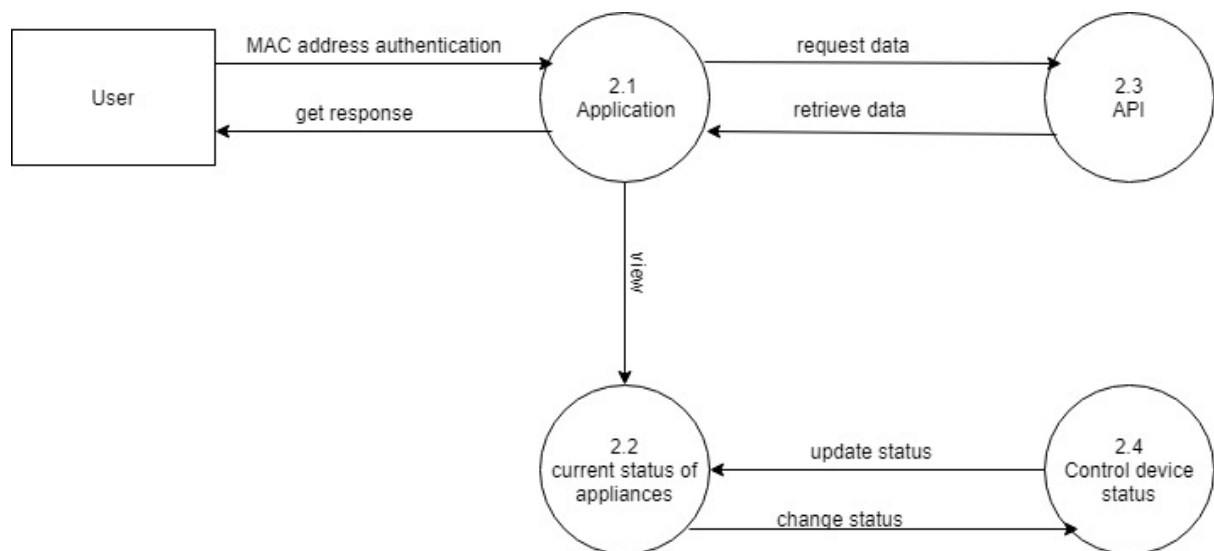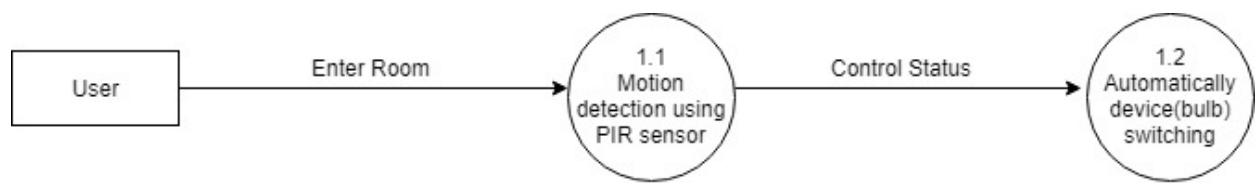
3.5 Project SRS:

3.5.1 Use Case Diagram:
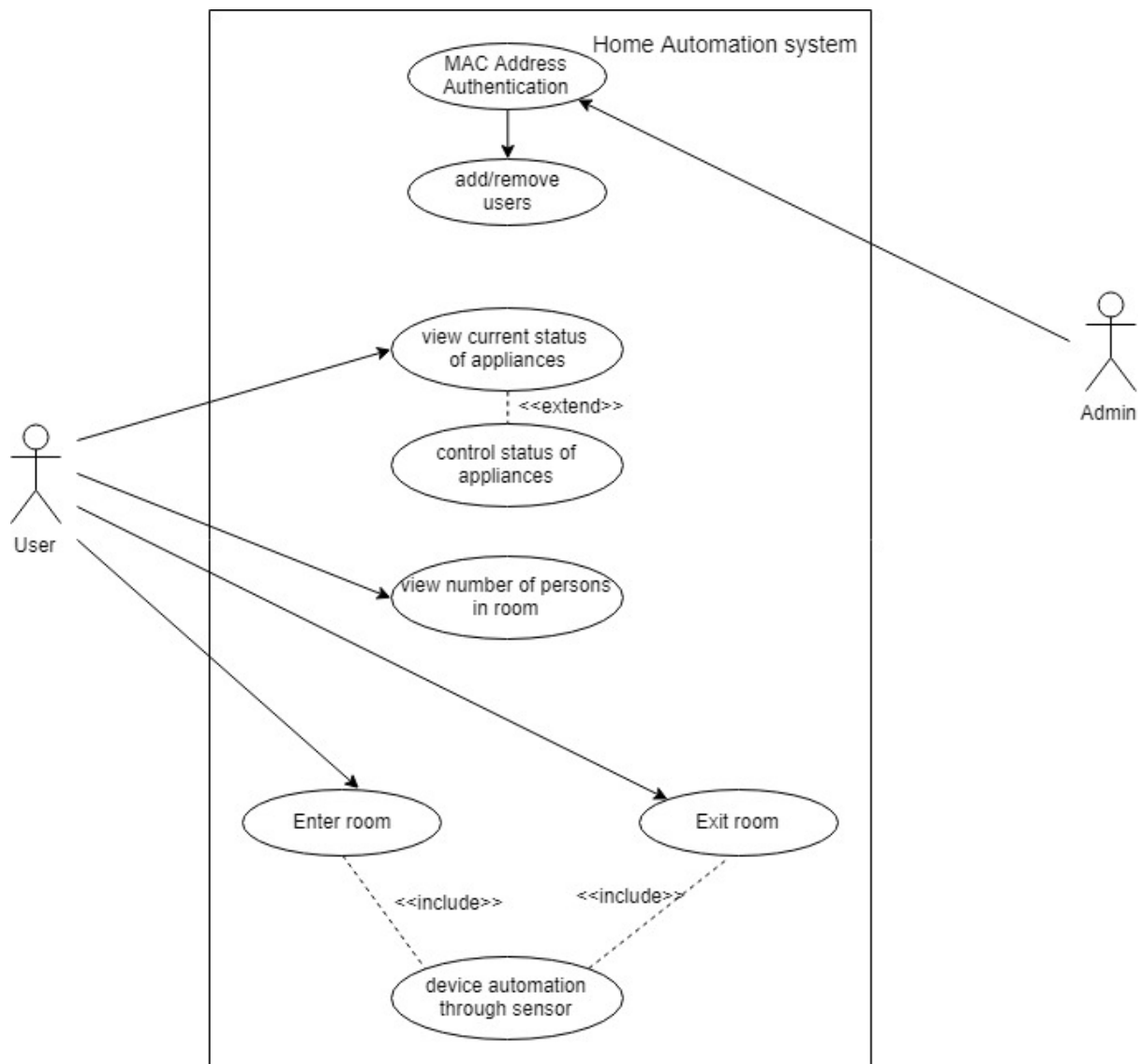
Use Case Diagram

3.5.2 Data Flow Diagram:

LEVEL 0

LEVEL 1

Level 2 (Device Management Automatically)
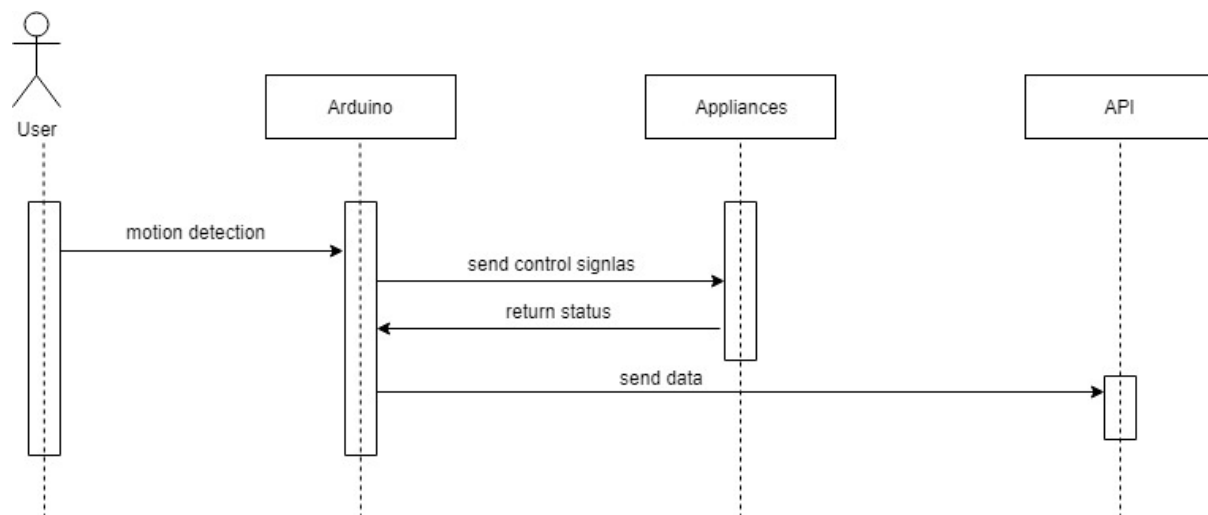

LEVEL 2(Device Management Manually)
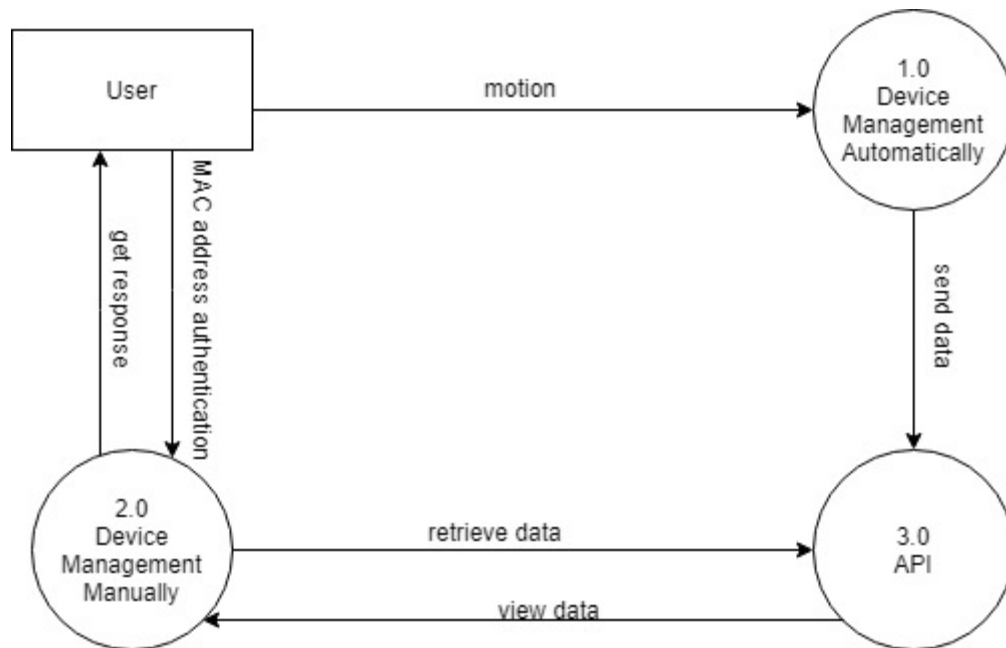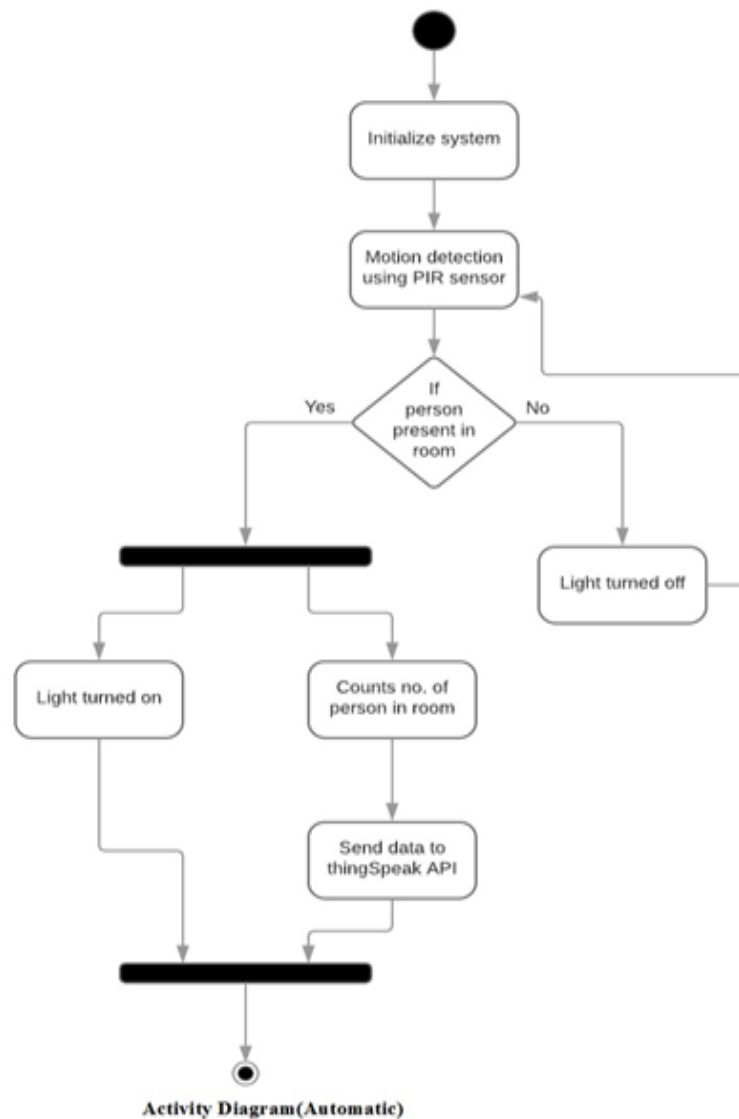
3.5.3 ER Diagram:
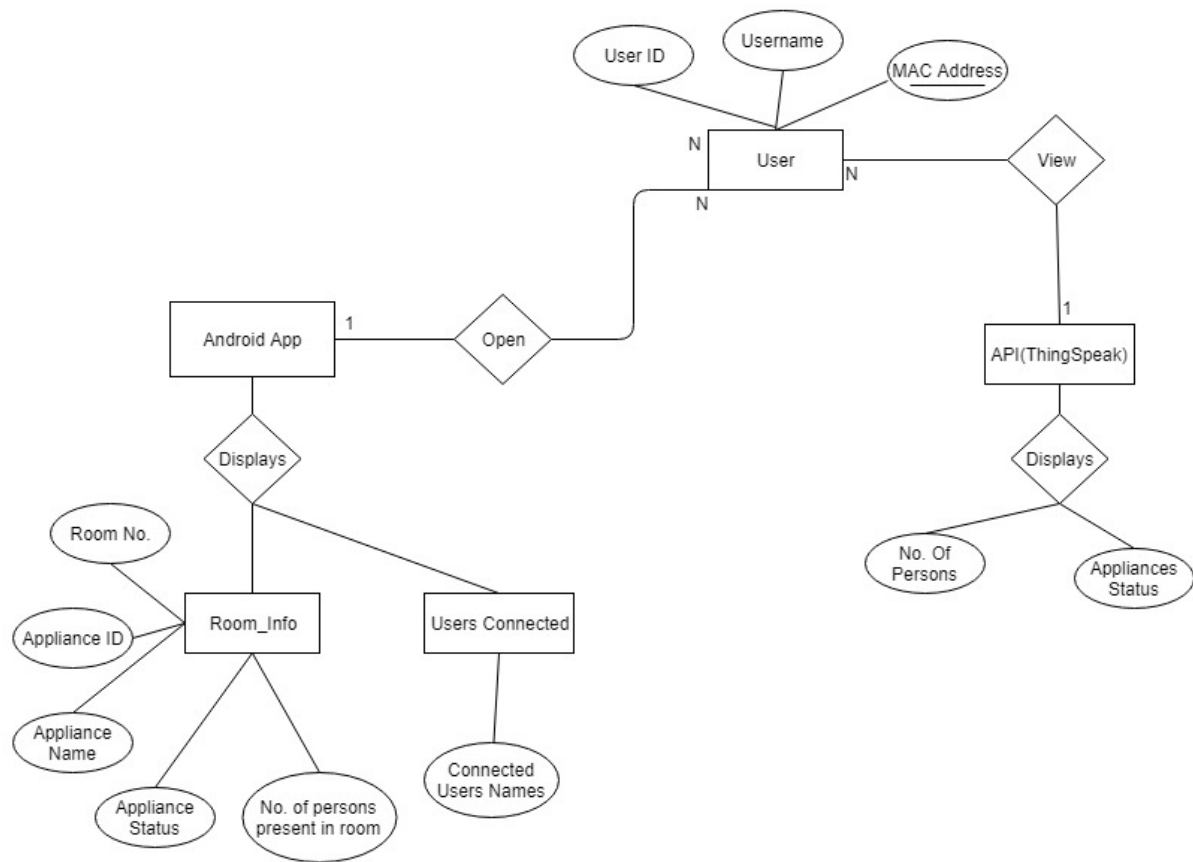
3.5.4 Sequence Diagram:
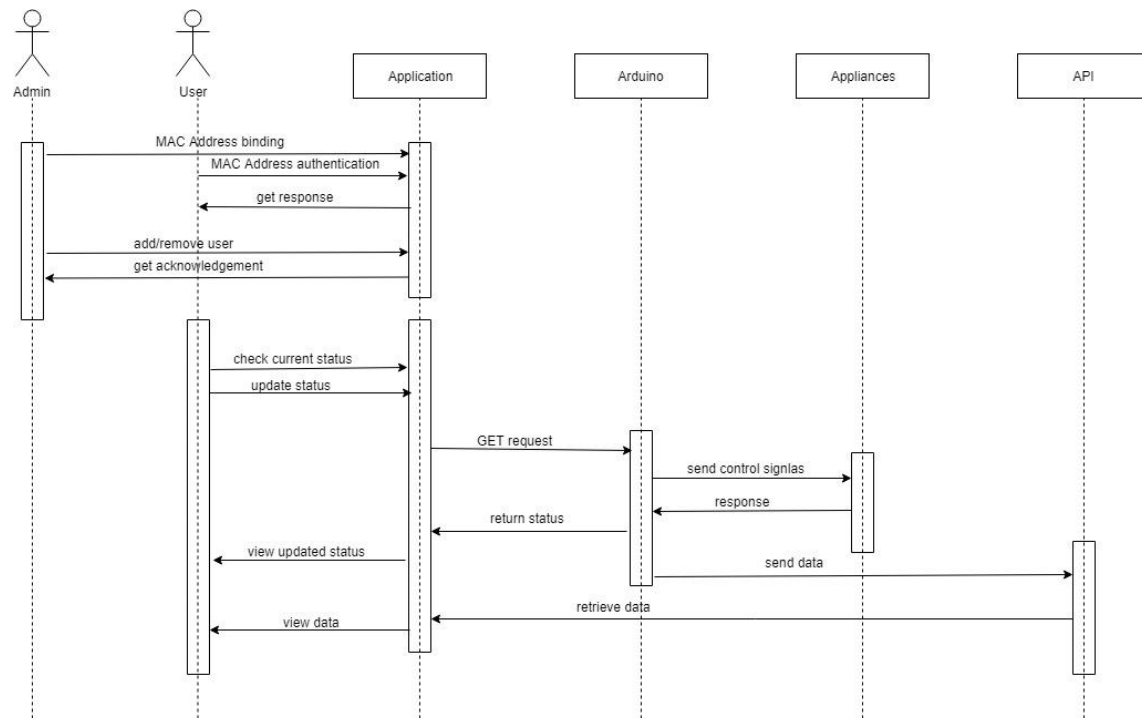
Sequence Diagram(for Manually)

Sequence Diagram(for Automatically)

3.5.5 Activity Diagram:

1) Automatic:

Activity Diagram(Automatic)
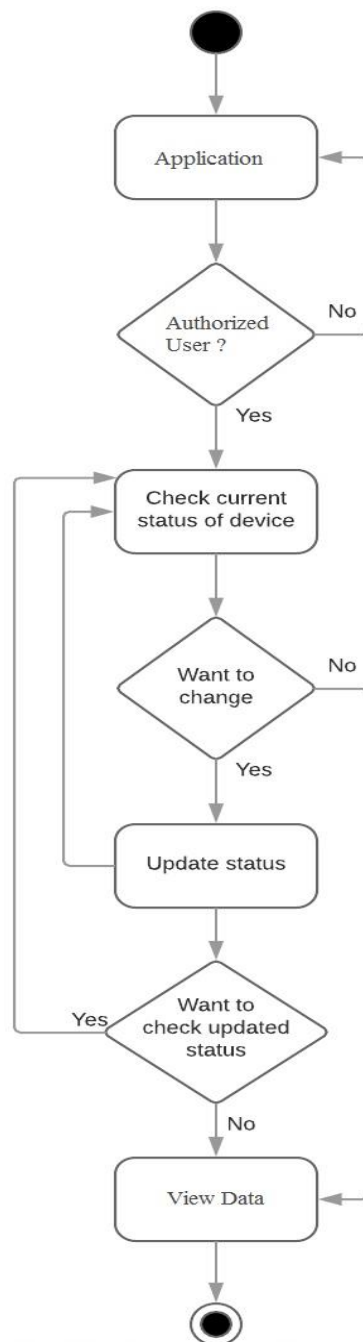
2) Manually:

Activity Diagram(Manually)

3.6 Data Dictionary:

3.6.1 Table Name: device_state

Description: To store the current state of the appliance.

SR. NO.	Attribute	Datatype	Constraints	Description
1.	DEVICE_ID	VARCHAR(10)	PRIMARY KEY	TO STORE THE DEVICE ID
2.	DEVICE_NAME	VARCHAR(10)	NOT NULL	TO STORE NAME OF DEVICE

3.6.2 Table Name: counter_table

Description: To store the record of number of persons in room.

| SR. NO.	Attribute	Datatype	Constraints	Description
1.	COUNTER_ID	VARCHAR(10)	PRIMARY KEY	TO STORE THE COUNTER ID
2.	COUNTER_DATA	INT(4)	NOT NULL	TO STORE RECORD OF NUMBER OF PERSONS

3.6.3 Table Name: connected_device

Description: To store the record of devices connected to application.

| SR. NO.	Attribute	Datatype	Constraints	Description
1.	DEVICE_ID	VARCHAR(10)	PRIMARY KEY	TO STORE THE DEVICE ID
2.	NAME_OF_DEVICE	INT(4)	NOT NULL	TO STORE NAME OF DEVICES CONNECTED

4. Implementation and Testing

## 4.1 User Interface and Screenshot:

4.1.1 Home Screen:
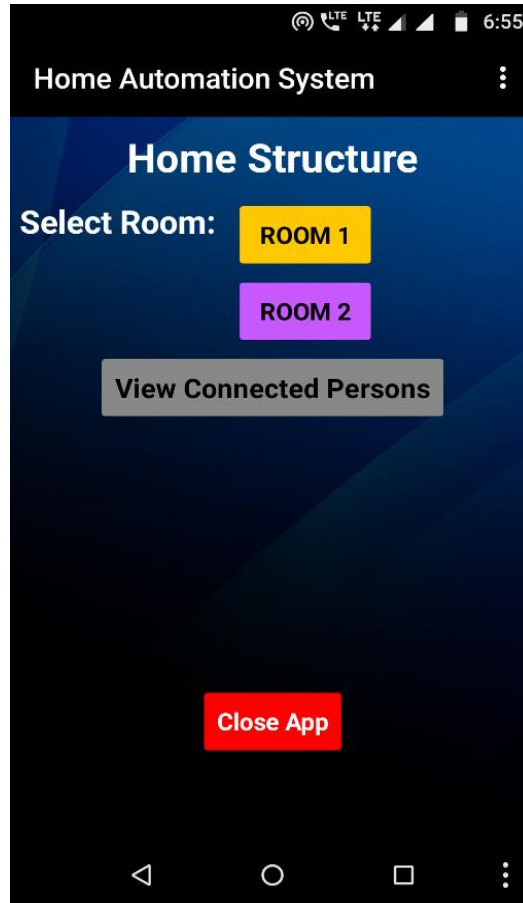
- ➢ Above figure shows the home screen of Home Automation App which contains several buttons.
- ➢ In Select Room field, we can see two buttons of room 1 and room 2.
- ➢ By clicking on room button, user will be directed to screen of that room.
- ➢ Below that View Connected Persons button is given which will direct to screen which displays the list of persons connected to app.

4.1.2 Room 1 Screen:
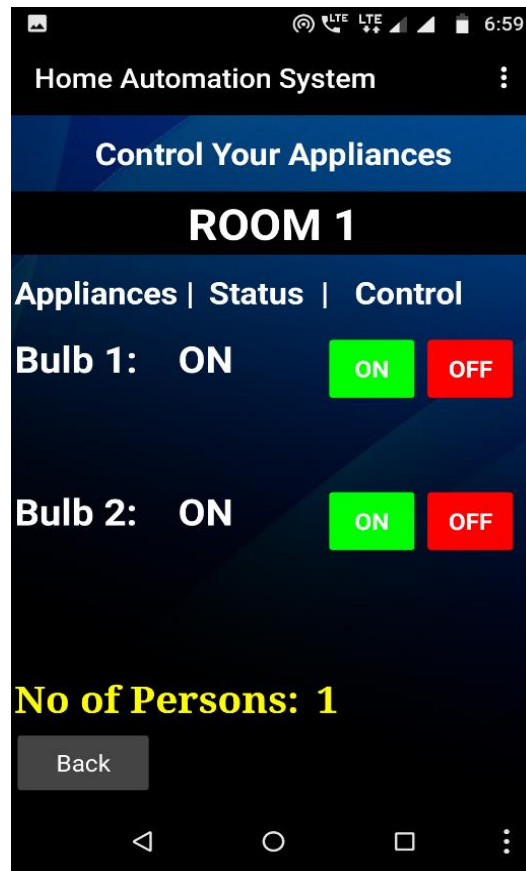
- ➢ Above figure shows screen of Room 1 which will be opened when user clicks on Room 1 button on home screen.
- ➢ This screen contains list of appliances available in room 1 as well as their status, control buttons and number of persons field.
- ➢ Status field updates the current status of the appliance.
- ➢ Two control buttons called "ON" and "OFF" are given for each appliance which helps to switch appliances on or off.
- ➢ No of Persons field displays the number of persons inside room 1 at the present moment and it is updated every 4 seconds.
- ➢ At the present moment, one person is present in the room so it turns on both all the bulbs in the room which is shown by status of both the bulbs and no. of persons shows "1".

4.1.3 Room 2 Screen:
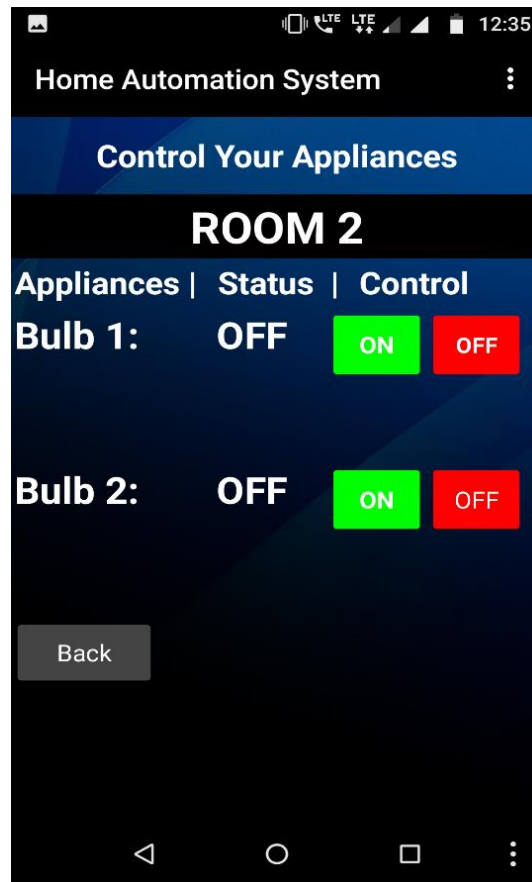
- ➢ This screen displays appliances of room 2 same as screen of room 1.
- ➢ User is navigated to this screen when he clicks on Room 2 button from home screen.

4.3.4 Connected Persons:
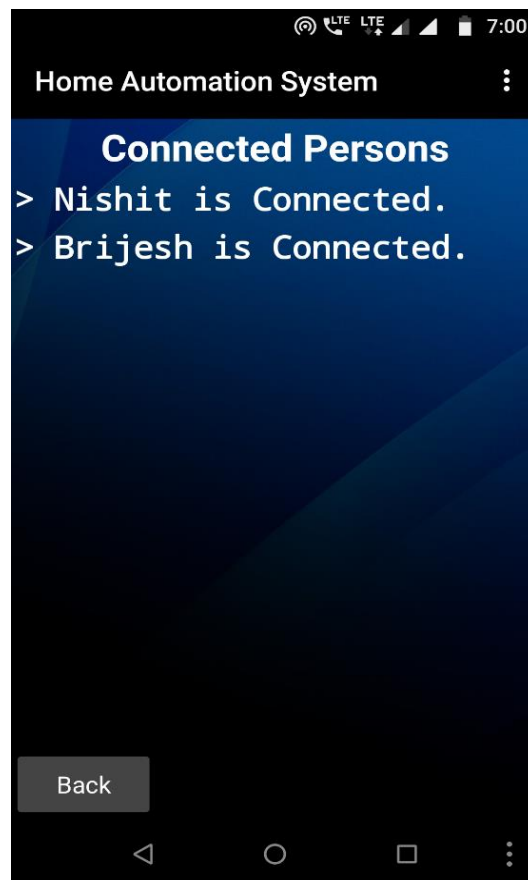
- ➢ Above screen displays the list of persons connected with app.
- ➢ User is navigated to this screen when he clicks on View Connected Persons button from home screen.
- ➢ At the present moment Nishit and Brijesh are connected to app so displays the messages "Nishit is Connected" and "Brijesh is Connected".
- ➢ If any user is not connected then it will display message in form of "Username is Disconnected".

4.3.5 Screen for Unauthorized Devices:
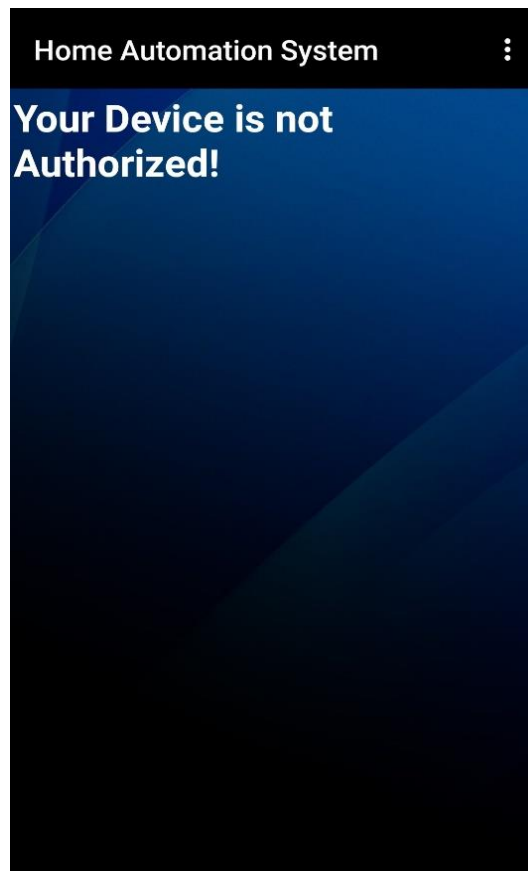
➢ This screen is for security purpose and it displays an error message "Your Device is not Authorized !".

➢ Whenever an unauthorized user tries to open the app at that time he will be directed to this screen and he will not be able to use the app.

➢ So, this way any unauthorized person will not be able to control your home appliances through app.

4.2 Testing using Use Cases:

Test Case Id	Test Scenario	Test Steps	Test Data	Expected Results	Actual Results
TU01	Check user authentication with authorized device	1. Open Application from authorized device.	No Data Required	Application should be opened without any error	As expected
TU02	Check user authentication with unauthorized device	1. Open Application from unauthorized device.	No Data Required	Application should show error "Device is not Authorized"	As expected
TU03	Switch On bulb 1 of room 1	1. Open Application 2. Click on Room 1 button 3. Click on ON button of bulb 1	No Data Required	Bulb 1 of room 1 should be switched on and status in application should be changed to ON	As expected
TU04	Check no. of persons present in room	1. Enter in room 1 2. Open Application 3. Click on Room 1 button	No Data Required	All appliances of room 1 should be switched on and no. of persons should be seen in app	As expected

Test Case Id	Test Scenario	Test Steps	Test Data	Expected Results	Actual Results
TU05	Check list of persons currently connected via application	1. Open Application 2. Click on "View connected persons"	No Data Required	List of persons connected through application should be displayed	As expected
TU06	Check control of appliances through PIR sensors	1. Enter in Room 1	No Data Required	All appliances in room 1 should be switched on	As expected

5. Conclusion and Future Work

5.1 Conclusion:

In this project, we have introduced the event of a Home Automation using Arduino and internet of things technology. The system is suitable for remotely controlling the home appliances. A Home Automation Using IoT System integrates various electrical appliances in a home with each other. In this user will be able to control the electrical appliances based on his appearance. As soon as the person enters into the room, the light will be automatically turned on. Also, we will provide Android Application to the user, so that he can control the light by using his Smartphone. It also stores the sensor parameters in the cloud (ThingsPeak API) in a timely manner. This will help the user to analyze the condition of various parameters in the home anytime anywhere. The automated mode makes life easier for users by complete automation of necessary appliances without any human effort.

The home automation system has been experimentally proven to work satisfactorily by connecting sample appliances to it and the appliances were successfully controlled from a wireless mobile device. We learned many skills such as soldering, wiring the circuit and other tools that we use for this project and was able to work together as a team during this project. The Bluetooth client was successfully tested on a multitude of different mobile phones from different manufacturers, thus proving its portability and wide compatibility. Thus a low-cost home automation system was successfully designed, implemented and tested.

5.2 Future Work:

Using this system as framework, the system can be expanded to include various other options which could include

- The next step would be to extend this system to automate a large scale environment, such as offices, institutes, factories and industries.
- We can implement Image Processing in our system so we can differentiate between persons and other living-things.
- We can enhance this project by controlling intensity of light.
- This kind of a system with respective changes can be implemented in the hospitals for disable people or in industries where human invasion is impossible or dangerous.

- We can include other sensors like temperature, gas, water level, weather sensors, so that we can   perform various automation process more effectively, for example switching on the light when it gets dark.

- We can replace Wifi by GSM modem so that we can achieve device controlling by sending SMS using GSM modem.

References

[1] M.Van Der Werff, X. Gui and W.L. Xu, "A Mobile based Home Automation System, Applications and Systems", 2005, 2nd International Conference on Mobile Technology, Guangzhou, pp.5.

[2] Bader M. O. Al-thobaiti, Iman I. M. Abosolaiman, Mahdi H. M. Alzaharani, Sami H. Almalki, Mohamed S. Soliman, "Design and Implementation of a Reliable Wireless Real-Time Home Automation System Based on Arduino Uno Single-Board Microcontroller", 2014, International Journal of Control, Automation and Systems, Vol. 3(3), pp. 11 - 15.

[3] Baris Yuksekkaya, A. Alper Kayalar, M. Bilgehan Tosun, M. Kaan Ozcan, and Ali Ziya Alkar "A GSM, Internet and Speech Controlled Wireless Interactive Home Automation System", 2006, IEEE Transactions on Consumer Electronics, Vol. 52(3), pp. 837 - 843.

[4] Rozita Teymourzadeh,Salah Addin Ahmed,Kok Wai Chan and Mok Vee Hoong , "Smart GSM Based Home Automation System", 2013, IEEE Conference on Systems, Process & Control, Kuala Lumpur, Malaysia.

[5] A. Alheraish, "Design and Implementation of Home Automation System", 2004, IEEE Transactions on Consumer Electronics, Vol. 50(4), pp. 1087-1092.

[6] Eddie M C Wong, "A Phone Based Remote Controller for Home and Office Automation", 1994, IEEE Transactions on Consumer Electronics, Vol. 40(1), pp. 28-34.

[7] H. Brooke Stauffer "Smart Enabling System for Home automation", 1991, IEEE Transactions on Consumer Electronics, Vol. 37(2), pp. 29-35.