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***Dissertation on***

**“Connected Living Spaces”**

*Submitted in partial fulfilment of the requirements for the award of degree of*

**Bachelor of Technology**

**in**

**Computer Science & Engineering**

***Submitted by:***

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*Under the guidance of*

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**January – May 2020**

**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

FACULTY OF ENGINEERING

**PES UNIVERSITY**

(Established under Karnataka Act No. 16 of 2013)

100ft Ring Road, Bengaluru – 560 085, Karnataka, India

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**FACULTY OF ENGINEERING**

**CERTIFICATE**

*This is to certify that the dissertation entitled*

**‘Connected Living Spaces’**

*is a Bonafede work carried out by*

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In partial fulfilment for the completion of eighth semester project work in the Program of Study Bachelor of Technology in Computer Science and Engineering under rules and regulations of PES University, Bengaluru during the period Jan. 2020 – May. 2020. It is certified that all corrections / suggestions indicated for internal assessment have been incorporated in the report. The dissertation has been approved as it satisfies the 8th semester academic requirements in respect of project work.

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**DECLARATION**

We hereby declare that the project entitled “Connected Living Spaces” has been carried out by us under the guidance of Prof. Prasad B Honnavalli and Prof. Charanraj BR and submitted in partial fulfillment of the course requirements for the award of degree of **Bachelor of Technology** in **Computer Science and Engineering** of **PES University, Bengaluru** during the academic semester January – May 2020. The matter embodied in this report has not been submitted to any other university or institution for the award of any degree.

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Abstract

With this project, we aimed to establish an ecosystem where various devices and appliances in a house communicate with each other. This enables the existing infrastructure like fans and bulbs to be communication ready with upcoming technologies. The project was aimed to build systems than made homes safe, reliable and self-sustained. New processes were set up that increase the efficiency of the day to day tasks. One key goal along with the rest was to reduce the total carbon footprint of the house on the environment. The key functionalities included were to build secure mechanisms and logic for automated door access control, Air Quality Management & Temperature control, and facial recognition. Along with this, a system comprising of various sensors was built which could monitor water level in tanks, control valves and gas leakage which makes a house safe to live in.

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# Chapter 1 Introduction

The Internet of Things is one of the fastest growing domains of the 21th century. The core principle of IoT is to enable devices communicate with each other, use the data collected by each other and build an ecosystem that is autonomous and self-sustained. With the ever-increasing number of devices which are able to communicate with each other, an architecture had to be built and developed to bridge the gap between the existing infrastructure and the upcoming smart infrastructure.

With the Internet of Things, a network of devices (like thermostats, air conditioners, door locks, televisions etc.) can be built. Each and every device collects data points which can be harvested to make a house a better place to live in. As the energy demand is at a steady increase, a lot of emphasis needs to be made on increasing efficiency and reducing the carbon footprint. With IoT, devices can be monitored remotely and its usage can be moderated as and when required.

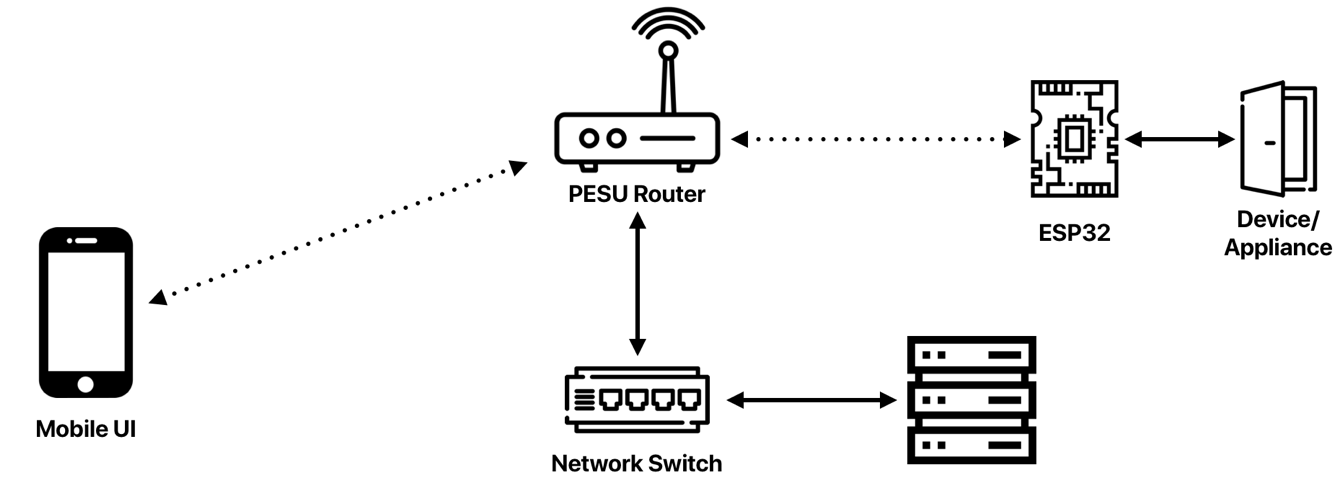
The project was initially aimed at building and developing an automated door lock system that can be deployed across the classrooms at PES University. Alone the process of development, a set of new modules were developed along with it like temperature monitoring and control, facial recognition, water level management and user mood detection. The places of implementation was widened from classrooms, to labs, warehouses and lobbies.

The five major modules are,

1. Access Control
2. Temperature Monitoring and Control
3. Lighting and Appliance Management
4. Leakage Detection and Alerts
5. Face and Mood Detection

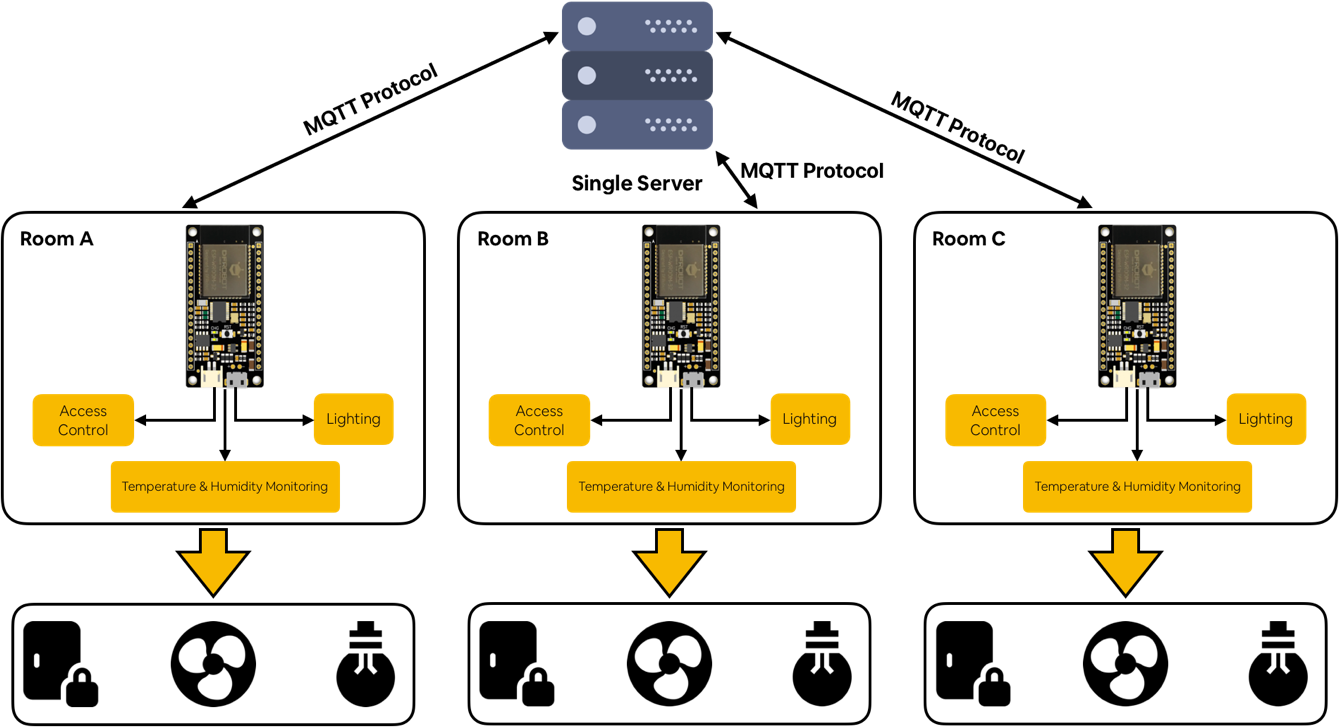
All of the modules are hosted locally on a server located at the PESU Center of Internet of Things. The system comes with a dashboard which the users can access with the help of an IP Address. On loading the dashboard, the users can control the devices, be it locking/unlocking the doors, turning on/off the fans, turning on/off the lights or setting everything on ‘Auto’ mode, in which case the user can let the system decide on as to what appliance has to run. Each user has a level of authorisation which has a limit and specific device they can control. A pyramid authorisation model was developed where the Department Chairs and Heads of Centers are at the top and have complete authorisation to control everything. At the bottom, were the students, who have the lowest level of authorisation. Students can access the devices specific only to the classroom they have been assigned to.

*Blueprint of the setup:*



Node-Red was used as the backend framework, it runs on the central server. Node-Red is a flow based system, where devices can be wired up together for them to communicate with each other locally. Node-Red comes with a GUI where the status of every device can be checked in real time as well as toggle their states with a click of a button.

*The following is the proposed architecture of all the modules,*



The architecture has been divided into three level,

* The top/first layer is the central server. It has Node-Red running locally and connected to the local network via Gigabit Ethernet. The ethernet connected to the switch which is in turn connected to the building network. One striking advantage is that, this system can be controlled only when connected to the PESU Network.
* The middle layer consists of the ESP-32 microcontroller board which is local to every room. All the devices in a room, be it light, or a fan or a door lock is connected to this. A 5A relay acts like an interface between the ESP-32 and the devices. This is because the operating voltage of the ESP-32 is 3.3V DC and of the devices can be anywhere around 220V. Thus, if directly connected, may lead to the board being burnt. The ESP-32 is a Wi-Fi and Bluetooth enabled board, thus this connects to the PESU Network and communicated with the server.
* At the bottom we have the devices intended to be controlled. Each device has a separate ID unique to the ESP-32 board it’s been connected to and each ESP-32 has a unique ID with which it can be identified by the server.

The MQTT protocol is the backbone of the entire project. This underlying protocol is the one the sends and receives messages from one device to another. MQTT stands for message queuing, telemetry and transport. The MQTT protocol runs off the TCP/IP and is lossless and bidirectional.

A voice control interface too was built along with this, to add an extra functionality to the user control. The user can use the ‘Google Assistant’ application on their phone and control the devices. All they have to say is “Okay Google, turn on my study lamp” and the system does the needful.

# Chapter 2 Problem Definition

The project was initially aimed at building and developing an automated door lock system that can be deployed across the classrooms at PES University. Alone the process of development, a set of new modules were developed along with it like temperature monitoring and control, facial recognition, water level management and user mood detection. The places of implementation was widened from classrooms, to labs, warehouses and lobbies.

The five key objectives were,

1. Establish an ecosystem where various devices in a house communicate with each other.
2. Enable existing infrastructure to be communication ready with upcoming technologies.
3. Build safe and reliable homes that are self-sustained.
4. Understand the current underlying infrastructure in Internet of Things.
5. Set up processes that increase the efficiency of the day to day tasks.

# Chapter 3 Literature Survey

Of all the papers we referred to for assistance, these are the 7 papers we felt were important and helpful for us. We got to learn and understand on as to how the MQTT protocol works. MQTT protocol is our underlying protocol for on entire project and is its backbone. One more domain we researched into was about how to integrate the sensors and their data so that they can work in unison.

## 3.1 Sensor Based Home Automation and Security System

### 3.1.1 Introduction

In recent years security issues have grown so that the need to remotely control and secure residential and commercial properties given significant importance.

Although there have been many attempts to develop and implement a fully functional and reliable home security system, none of those was really able to penetrate the market. Statistical data reveal that a home without a security system is three times more likely to be broken into compared to those which are equipped with a state-of-the art security system [8]. These facts make it obvious that a good home security system will reduce the chances of intrusion and thus, can protect both life and property. Hence, it is necessary to develop and implement a very dependable home security system that can protect the user and properties.

3.1.2 Characteristics and Implementation

The user must be able to communicate directly with the board through an Internet web browser; the board communicates with the user using the browser and email/SMS messages [3], [6]. This allows for two-way communication and therefore, the user is always in control over the system [2]. Although the concept seems relatively straightforward, there are many issues that need to be resolved in order to have a high quality system. The following sections will describe the major approaches in hardware and software that were chosen so that a proper system could be implemented. Figure 2 presents the system design diagram.

3.1.3 Features

**Sudheer**

3.1.4 Evaluation

**Sudheer**

3.2 MQTT – Messaging Queue Telemetry Transport

3.2.1 Introduction

In the past few years, Wireless Sensor Networks (WSNs) have been gaining increasing attention, both from commercial and technical point of views, because of their potential of enabling of novel and attractive solutions in areas such as industrial automation, asset management, environmental monitoring, transportation business, etc. [5]. This paper describes the pub/sub protocol *MQTT* [9].MQTT is an extension of the open publish/subscribe protocol Message Queuing Telemetry Transport [7]. Designed by IBM, it is originally intended for unreliable networks with restricted resources such as low bandwidth and high-latency. It consists of one broker server and two kinds of clients called as Publisher (Publish client) and Subscriber (Subscribe client). Broker server acts as an intermediary for messages sent between Publish client and Subscribe client for the interesting topic. When the Publish client issues a topic and sends a message to the Broker server, the Subscribe client selects the topics which it finds interesting.

3.2.2 Components

**Sudheer**

3.3 Microcontroller based Home Security System with Remote Monitoring

**Sudheer**

3.2.1 Introduction

3.4 IoT Real time Data Acquisition using MQTT Protocol

3.4.1 Introduction

The Internet of Things (IoT) provides ease to monitor and to gain sensor data through the Internet [1]. The need of high-quality data is increasing to the extent that data

monitoring and acquisition system in real time is required, such as smart city or tele diagnostic in medical areas [2]. Therefore, an appropriate communication protocol is required to resolve these problems. Lately, researchers have developed a lot of communication protocols for IoT, of which each has advantages and disadvantages. This study proposes the utilization of MQTT as a communication protocol, which is one of data communication protocols for IoT. This study used temperature and humidity sensors because the physical parameters are often needed as parameters of environment condition [3]. Data acquisition was done in real-time and stored in MySQL database. This study is also completed by interface web-based and mobile for online monitoring. This result of this study is the enhancement of data quality and reliability using MQTT protocol.

3.5 Room Temperature control and fire alarm/suppression using MQTT

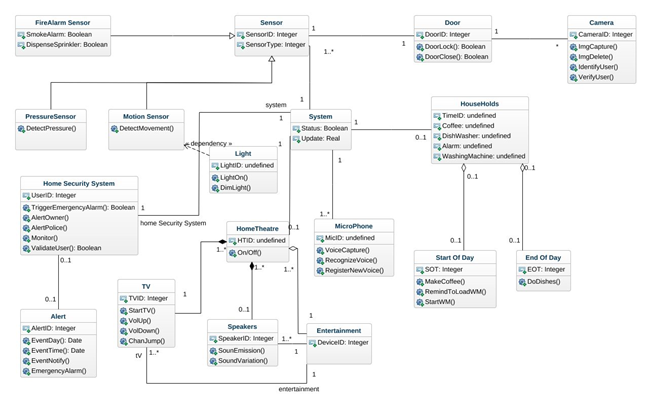
3.5.1 Introduction

We produce a MQTT(Message Queue Telemetry Transportation) pro on Amazon Web Service(AWS). The MQTT pro has been utilized as a phase to give the Internet of Things (IoT) organizations which screen and control room temperatures, and sense, caution, and smother fire. Arduino was used as the IoT end device partner sensors and actuators to the phase through Wi-Fi channel. We made sharp home circumstance and created IoT works satisfying the circumstance need. We in like manner completed the insightful some system in hardware likewise, programming, and checked the structure operation. We create the impression that MQTT and AWS are incredible particular contender for little IoT business applications. To be sure, even three or four years back we didn't dream that the IoT would come into our life so early. From GE to Belkin to Home Depot, enormous measures of things and whole organic frameworks need to empower you to control your home by methods for a lone iOS or Android application. Nowadays the IoT is transforming into a novel perspective that is rapidly grabbing business run in the present day remote communicate correspondences with the compromise of a couple of progressions and exchanges courses of action. MQTT is a disperse/subscribe message exchange tradition made by IBM [2]. The MQTT system involves MQTT delegate and client. The MQTT delegate is a message exchange arrange that enables the message creator client to disperse messages with a message identifier Topic. Exactly when the message customer client subscribes to the Topic, the MQTT middle person passes regarding the matter messages. Starting late, MQTT has been gotten as the message move limiting tradition in one M2M IoT worldwide standards.

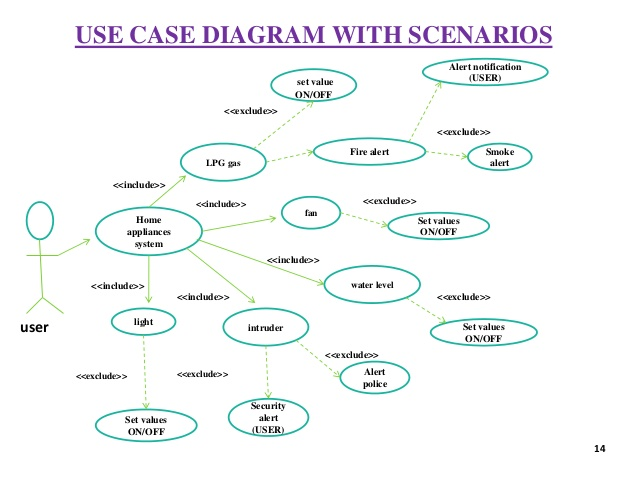
**Sudheer**

# Chapter 4 Project Requirement Specification

## 4.1 Class Diagram



## 4.2 Use Case Diagram



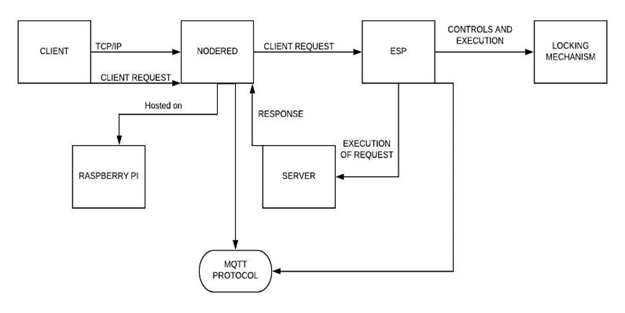
## 4.3 Modules

### 4.3.1 Access Control System

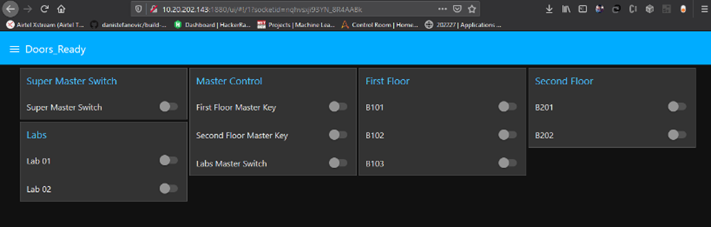
This module deals with the automatic access control imparted to the doors/entrances/exits of the facilities. The users are provided with a Web User Interface (compatible with both PC and mobiles) to control their locks. The User interface provides a GUI of all the locks pertaining to their living spaces in the form of switches. Users can also monitor and view the number of locks and unlocks of a particular lock and can also monitor and view the times it was last locked/unlocked. The counters and time are reset every week.

The Web GUI was built using node-red - a JavaScript compatible flow-based software for creating web flows and processes. In this the ESP32 board communicates with the locks and controls the various locks, it communicates with the Node-Red server running on the raspberry pi via an MQTT connection running on the raspberry pi. It then stores important data like the number of locks, unlocks, time the particular lock was locked or unlocked on a local ubuntu server and is sent as a response back to the web graphical user interface. MQTT is a protocol used for communication between the various servers, boards and devices.

*The following is the flow chart for the access control module,*



*The following is the user interface for the access control module,*



### 4.3.2 Temperature Monitoring and Control

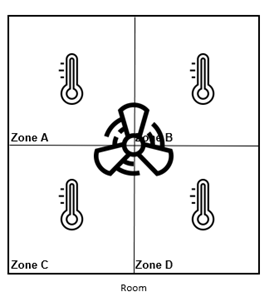
This module is about viewing the temperature of each and every zone in the facility and providing means to monitor and control it. Alone the process of development, we developed automatic cooling and heating systems to facilitate the users. Whenever the temperature drops below a certain threshold the heater gets activated and the air conditioner gets activated whenever the current temperature exceeds the upper threshold limit.

Four sensors are located in the four corners of a room and the mean of those gives us the temperature of the room, the temperatures of the four zones and the central temperature is being displayed dynamically on the screen. The data regarding the temperatures, the number of times both the heater and the air conditioner has been used are logged in the database. A failsafe mechanism has been also developed in case any of the sensors fail.

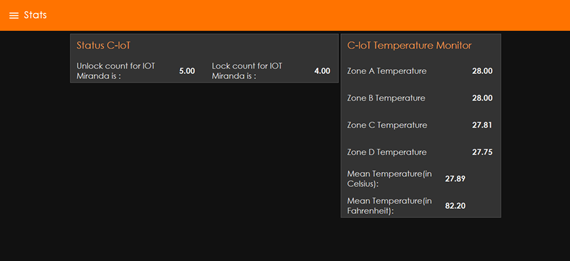
#### 4.3.2.1 Mechanism

The room is shaped to fit that of a square’s dimensions and then the room is divided to four zones- Zone A, B, C and D. Then we monitor the temperatures across the zones and calculate the mean temperature and display it on the UI. When the temperature goes above the upper threshold, the cooling system is activated and when it goes below the lower threshold the heating system is activated.

There might arise a scenario where a sensor might go rogue and send in faulty data. Be it because of wear and tear, age or damage, a system is able to identify outlier data and eliminate the use of that sensor.

*The following is the pictorial representation of how the room will be divided,*

*The following is the user interface for the temperature module,*



### 4.3.3 Facial Recognition

Set-up a system where the access control can be controlled using a user’s face. This can be used as an alternative to the use of password to unlock doors.

The face recognition module consists of four folders and three python scripts

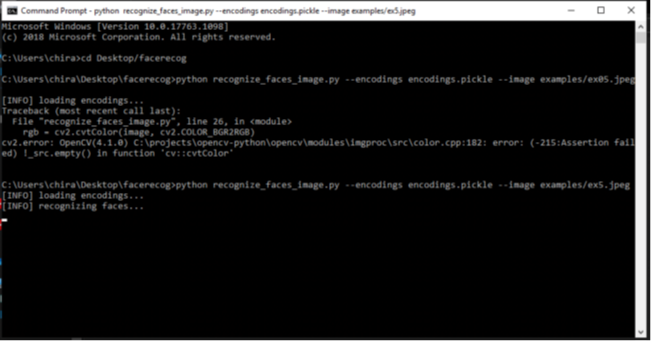
* Facial\_recog
* datasets
* example
* outputs
* Encode\_faces.py
* Recognize\_face\_video.py
* Recognize\_face\_image.py
* Encodings.pickle

4.3.2.1 Datasets

Suppose there are four authorised users then datasets contain four subfolders with their names as the folder names and each folder has the respective user’s pictures. All the images are in standard quality for faster training purposes

4.3.2.2 Encoding

We iterate through every image, we extract the name from the path, convert the OpenCV image to dlib ordering and store the ordering in a variable ‘RGB’.  Then we detect the x and y coordinates of the defining points of the face in the images and store it in boxes. Then we compute the facial encodings using ‘RGB’ and ‘boxes’ and store in encodings .Then we loop through the encodings and add the encoding and name to known names and encoding .Then we create a dictionary containing name and encodings and add the known names and encoding and write it to the encodings.pickle file .



4.3.2.3 Detection Procedure

1.We can either detect it in real time using a video stream or by an image file.

2. Since the implementation is to be in real-time, we stick to the video stream method.

3. We start the video stream first, then convert the OpenCV image to dlib ordering and store the ordering in a variable ‘RGB’, detect the x and y coordinates of the defining points of the face in the images and store it in ‘boxes’, we compute the facial encodings using ‘RGB’ and ‘boxes’ and store in encodings.

4. We then loop over the encoding, compare it with the encodings from the pickle file.

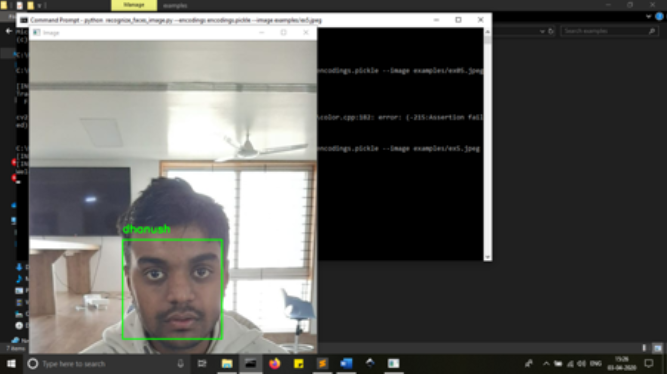
5. If a match is found, we find the indexes of all the matched faces, calculate the total number of times each face was matched and we select the name with the maximum number of votes and append it to names.

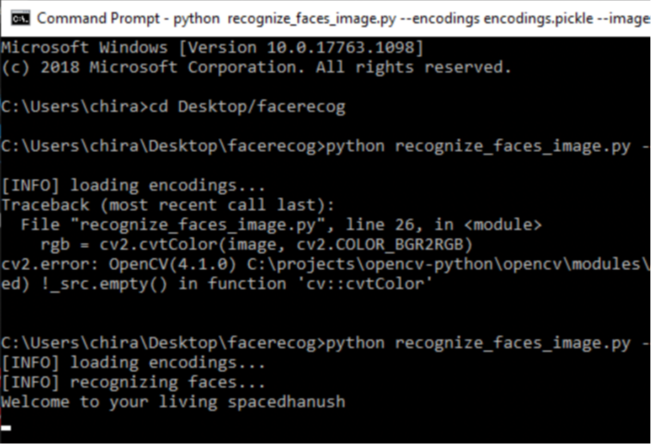
6. Then we loop over the recognized faces, we rescale the face co-ordinates, construct a rectangle around it and label it with the name of the user from the list ’names’.

7. Then after the user presses q we exit the process.

8. Suppose there is no match, then the name is displayed as ‘Unknown’.

*The following is the output after face recognition,*





### 4.3.4 Mood Detection

The user listens to their choice of music on “Spotify” Music App. The system built monitors the songs being listened to and analyses the mood of the user. Based on the mood, further recommendations are made.

4.3.4.1 Authentication

In this the user has to provide their client identification number and client secret from his Spotify developer dashboard.

They also have to give his username for the same.

 We are creating a token from the username, scope, client\_id and client\_secret provided. The “authenticate\_spotify” function does the authentication and it creates a Spotify instance for future tasks and development

Code:

token=util.prompt\_for\_user\_token(username,scope ,client\_id=client\_id,client\_secret=client\_secre t,redirect\_uri=redirect\_uri)

 if token:

        def authenticate\_spotify():

                             print("..Connecting to spotify")

                            sp=spotipy.Spotify(auth=token)

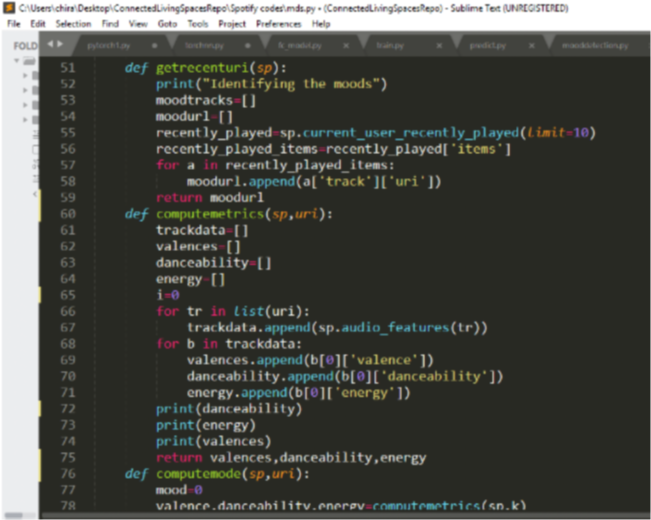
                            return sp

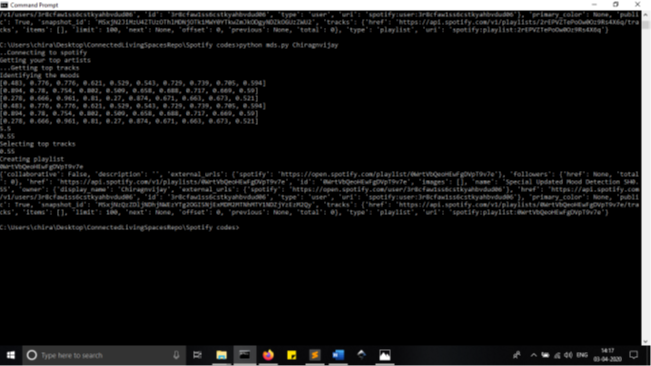
4.3.4.2 Detection

In this we gather data regarding the last 10 songs the user has listened to. We then gather the audio features of every song and we predict the mood value based on the values of the audio features.

In getrecenturi function we are appending the URI’s of all last 10 listened songs to a list.

In compute metrics function we are calculating valence, danceability and energy values of the songs in the URI list and appending it to 3 different lists.



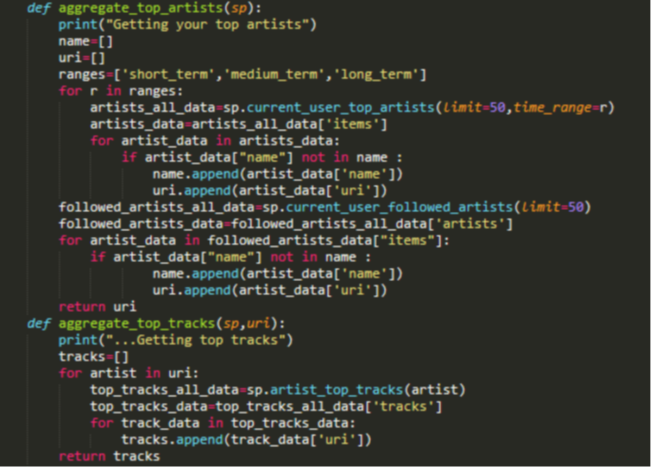


4.3.4.2 Processing

Aggregate\_top\_artists function prepares a list of the URI’s of the artists the user frequently listens too or follows. aggregate\_top\_tracks consists of a list of the songs belonging to the artists from aggregate\_top\_artists.

In this the output from the compute mode function is passed as a parameter to the select tracks function.

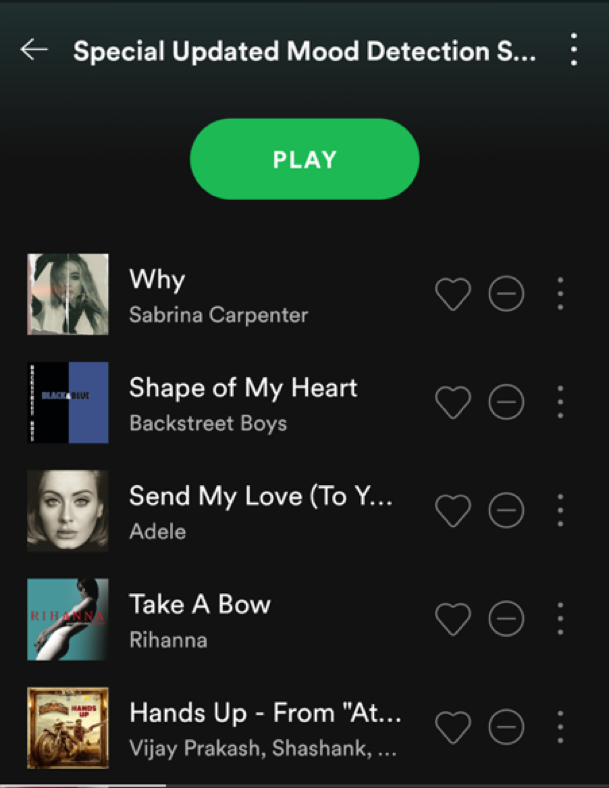
In this a list of tracks by the artists the users follow is prepared and then the audio features of those songs are compared with the computed mood values and only the ones which match are appended to a list called selected\_tracks.



4.3.4.3 Delivery

We then create a playlist and then add 30 songs from the selected\_tracks into the playlist. The user can then access it from the library option from their spotify accounts.

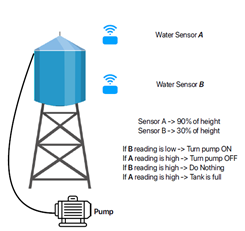
*The following is the output on the spotify app,*



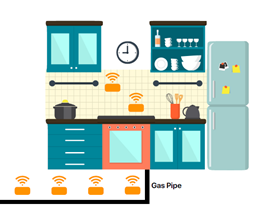
### 4.3.5 Water Leakage Detection

A water leakage and monitoring system is developed to monitor the water level and to prevent water leaks. We have two water sensor w1 and w2 located at 30% of the height of the tank and at 90% of the height tank respectively. We monitor the readings and when the value of w1 is less than the threshold then the pump is turned on automatically and when the value of w2 is more than the threshold the pump is turned off. The water level and the number of times the pump has been turned on/off has been recorded and shown

the dashboard and backed up in a persistent database.

*The blueprint of this module,*

### 4.3.6 Gas Leakage Detection

A gas leakage detection and mitigation system has been developed which uses MQ2 and MQ5 sensors for detecting the gas leaks.MQ2 sensors detect smoke and combustible gas while MQ5 detects LPG and natural gas. There are a number of sensors in potential places e.g.) kitchen. The system identifies the origin of the leak and then closes the valves. It also communicates with the cooling system to turn on the nearby fans and also communicates with the access control system to contain the leak. The number of leaks is displayed on the dashboard and backed up in a persistent database.

## 4.4 Constraints

1. The project works well with Windows and Linux based Operating systems and is platform independent. Works both with computers and mobile devices
2. The server system requires python 3.5+ preinstalled and various packages such as dlib, face\_recognition, Spotify, argparse.
3. The server also needs to have NodeJS and node red installed
4. Uninterrupted power supply is required.

## 4.5 User Classification

1. The project helps a wide set of users, it is mainly designed for the educational and the corporate sector. The classification of the users is a hierarchical structure.
2. A pyramid authorisation model was developed where the Department Chairs and Heads of Centers are at the top and have complete authorisation to control everything. At the bottom, were the students, who have the lowest level of authorisation. Students can access the devices specific only to the classroom they have been assigned to.

*The blueprint of the different levels of authorisation,*



# Chapter 5 System Requirement Specification

## 5.1 Functional Requirements

5.1.1 Access Control

The Access Control Module has been designed to control the entry/exit of personnel to and from a facility. It involves identifies the individual who is seeking to enter, also with their level of authorization. The time of access too needs to be accounted for, which is in turn stored in the database. In accordance with the classroom scenario, the system can function in either of the two modes, a) open at a designated time, stay open during the course of the day and close at a designated time or b) open to only specific students/faculty who have been authorized that room. The module connects through Wi-Fi to a centralized server.

5.1.2 Temperature Control

This module has been designed to monitor and track the temperature conditions of a facility. At the same time, based on the collected temperature data, the system can decide it turn on/off the air conditioning system. The user has the ability to manually overwrite the same and set the temperature if required. The room will be divided into zones and each zone will have temperature recording apparatus which will write data to the central database. There might arise situations where the apparatus might malfunction and send in wrong data to the database which might in turn lead to the wrong operation of the air conditioning system.  A subsystem has been developed to find the faulty sensors and eliminate their influence on the decision making.

5.1.3 Facial Recognition

The face recognition module was developed to reduce the complexity to the Access Control Module. The face/facial details of the authorized users can be registered on the database/face recognition repository. This can be used instead of the Access Control User-Interface or along with it for added security to the sensitive facilities. The face recognition code base has been hosted on a separate server, as it requires a lot of compute and this server will be networked with the main IoT control server.

5.1.4 Mood Detection

The mood detection module works in accordance with Spotify, the music mobile application. Based on the music the user listens to, a mood number can be obtained which enables the system to understand and set the house conditions which helps the user to ease out. It includes setting the air condition temperature or the light brightness and color.

5.1.5 Lighting Control

The light fixtures in a facility can be monitored and controlled using this module. Again, for this, there are multiple apparatus setup across the facility that monitors the conditions and logs the data to the database. This is useful and vital for situations when a user might forget to turn off a light when not using it. There exists a lighting index which is like a benchmark, below which the lights turn off or on to provide the optimal environment to work at.

## 5.2 Non-Functional Requirements

* The user interface should work either on desktop web browser and the mobile web browser. The UI should optimize itself to the particular screen its being viewed on without any user intervention.
* Dark Mode and Light Mode themes has been made available for the user preference.
* The user has been given the preference to choose the color scheme for the user interface. A hex color code can be given based on the user preference.
* The user has been given the ability to choose the font face/style and the font size.

5.2.1 Dependencies

* Node-Red
* Server with good ram and processor running Ubuntu
* Access to Intranet

5.2.2 Assumptions

* Uninterrupted power supply is present as the entire module depends on it
* Intranet is up and running continuously

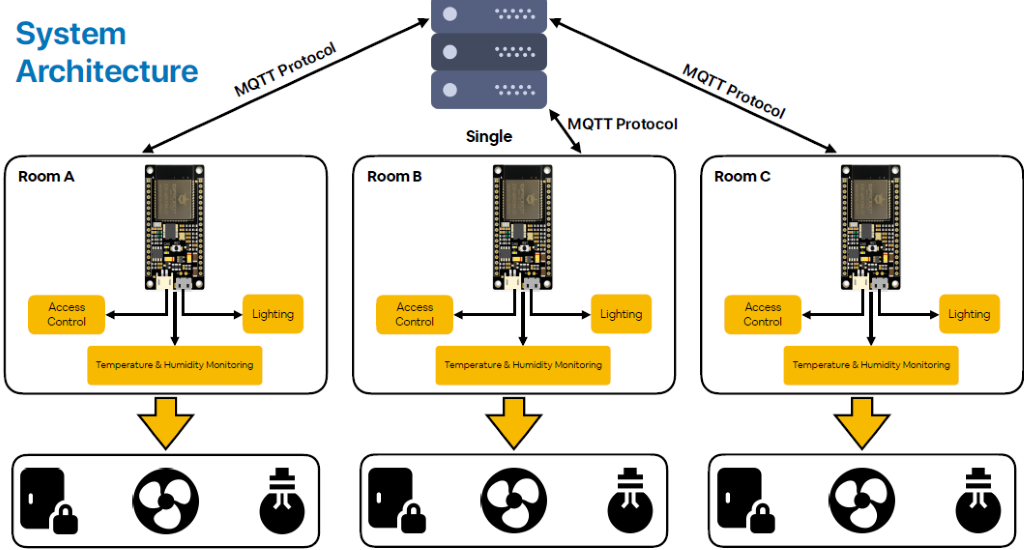
5.3 Hardware Requirements

Each of the micro sub modules runs on an ESP-32 microcontroller board. The ESP-32 has Bluetooth and Wi-fi in built. The Wi-fi ability of the ESP 32 has been harnessed to connect to the routers which in turn means, can communicate with the centralized server. In the case of Access Control, an electromagnet has been fixed on the door which fixates onto a metal strip which is on the door frame when powered on. A 12V/5V SMPS power supply powers the entire module. TH SMPS has been used because of the refined and steady output which leads to longer life of the hardware. A 5A relay has been used to interface the 12V electromagnet and the 3.3V ESP-32. If the relay is not used, the 12V will fry the ESP-32. For the temperature sensing and control module, a DS18B20 module is used. A Dell PC with an i7 processor, 16GB RAM and 4GB graphics card has been used as the server.

# Chapter 6 System Design

The chosen system is a hybrid system consisting of computers, microcontrollers and various hardware devices. It consists of a central PC acting as a server which is connected to the Wi-Fi routers. All the microcontroller boards are connected to the system through the local Wi-Fi and the hardware devices such as lights and fans are connected to various ports on the ESP32 microcontroller board. Various sensors and servos and regulators are also connected to the microcontroller boards.

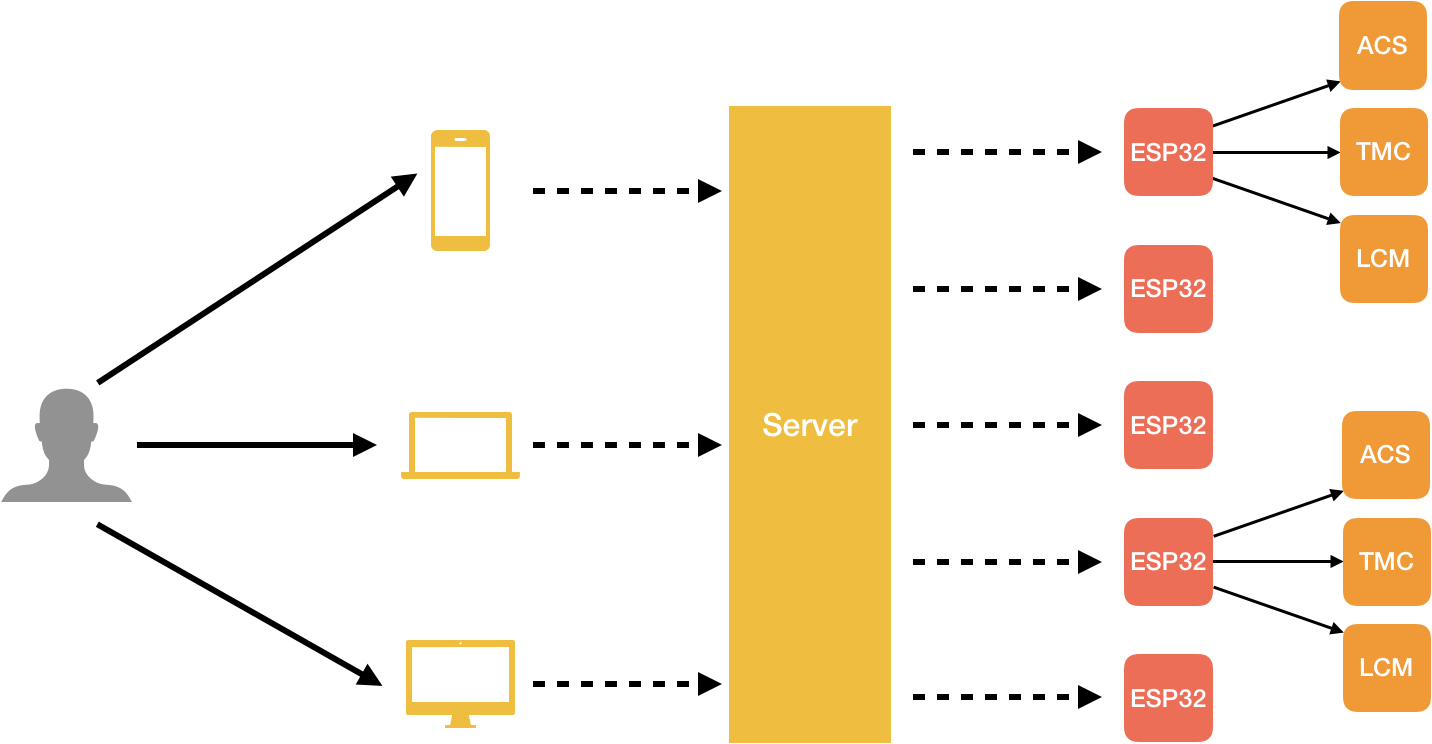
## 6.1 System Architecture



The various modules and devices communicate through the MQTT protocol over Wi-Fi. MQTT is a messaging protocol designed for communication in the Internet of Things domain. The primary programming languages being used are C++ and Python. Spotify integration is facilitated and Alexa support is provided.

6.2 Why This System

The system was carefully chosen keeping all the constraints in mind. The system is platform independent. The GUI designed is accessible once the user connects to the Wi-Fi. The user can access it from their laptops, computers, mobile phones, tablets, it is truly platform independent. We chose the ESP32 as the primary microcontroller because it has its own memory, processor and an inbuilt Wi-Fi module. It contains many digital ports through which we can connect the various devices. Its supportability with the MQTT Protocol is another reason the ESP was chosen as the primary microcontroller board. The PC which acts as a server also is a DELL PC with 16GB RAM and 4GB Graphics. We used it as we need to run facial recognition, mood detection and the access control server parallelly. All the data regarding the various modules is stored in a persistent database on the PC. MQTT protocol was chosen for making the devices communicate with each other and thus make existent infrastructure smart infrastructure.



The previous diagram shows the pictorial representation  of the architecture. The user can access the UI either from a mobile device, tablet or a desktop. The solid lines represent the wired connection and the dashed lines represent the wireless connection. ACS stands for Access Control System, TMC stands for temperature monitoring and control and LCM stands from the lighting control management.

# Chapter 7 Detailed Design

## 7.1 Access Control Module

The components used in this module are a central server, esp32 board, magnetic lock. The electromagnetic lock is attached to the door and it is connected to the esp32 board which is connected to a power supply. The ESP32 connects to the server which is being hosted on an Ubuntu DELL PC through its inbuilt Wi-Fi module.

Configurations of the PC are,

* Operating System - Ubuntu 18.04
* RAM - 16GB
* Graphics - 4GB
* ROM - 1TB.

The above-mentioned system was chosen as the central server because it has large memory, high processing power and fast processing rate. An Ubuntu PC was chosen as it is open sourced and most of the software that is developed works best with Linux based systems.

ESP32 is a low-cost portable microcontroller with inbuilt Wi-Fi and Bluetooth modules. It is an upgraded version of the widely known ESP8266 boards. It is used as the primary computing device which controls the working of the magnetic locks. ESP32 is chosen as it is compatible with the MQTT Protocol and has its own Wi-Fi module and has a well-furnished software development library. It has 36 digital ports to which the locks, the buzzers and the LEDs are connected.

Electromagnetic locks are used and they are attached laterally to the door and near the hinge. The lock basically is of 2 parts one is the strong electromagnetic part and the other is the iron slab which gets attached to the magnet when turned on hence locking the door. The terminals from these are then connected to the digital pin of the ESP32 board. These locks were chosen as they are very strong, reliable, can be controlled by electricity and tough to tamper with.

The ESP32 first connects to the server using the Wi-Fi module and then communicates with the server through the MQTT Protocol. MQTT stands for Message Queuing Telemetry Transport Protocol which facilitates the communication between devices. The ESP connects to the broker client installed on the server and communicates with the server and the other connected devices. MQTT was chosen as it is compatible with microcontrollers and has well defined libraries to develop and modify the connections and the communication infrastructure. MQTT also doesn’t need internet it just requires an active Wi-Fi connection. Packets are rarely lost and it doesn’t require large bandwidths.

The GUI is developed using Node Red. Node Red is an opensource flow-based development tool developed by IBM for visual programming. It uses JavaScript as its backend language and the whole user interface is designed using node red. Node red is used as it has a variety of nodes from text nodes to function nodes and also provides support for MQTT integration and Alexa support.

## 7.2 Temperature Management Module

This module consists of the central server, temperature sensors, fans and regulators.

At first the DHT22 temperature sensors were used but then they were removed as they are prone to damage and are provide erroneous readings. The DS18B20 sensors were then used as they are widely used in the industry, are of good quality and provide accurate readings. It is in shape of a wire with a steel extension so they are less prone to damage and can be hung or placed at convenient places effortlessly. Their most unique property is any number of sensors can be connected and can be connected to a single wire which can be connected to the ESP32 board. Hence any number of sensors can be connected through a single wire. It is referred to as the one wire protocol. It requires minimum calibration time and are accurate all the time.

Then wires from the switches of the actual AC fans are extended and connected to the L298N motor driver which is a low cost effective driver which acts as a regulator and controls the speed of the fans.L298N is a dual H-Bridge motor driver which controls the speed and directions of the motor at the same time. It is efficient, works on low power and durable. Based on the temperature readings the ESP sets the speed and then turns on the fans in that particular area.

## 7.3 Facial Recognition System

At first the esp32 cam module was used for facial recognition but then proved to be not so reliable and had a significant error rate. Then the raspberry pi cams were used for the process but the computation of that level wasn’t possible on the pi. The pi couldn’t support the heavy computation. So, then a simple webcam was used for the process and with help of some functions from face\_recognition package which is an opensource python package for facial recognition the system was developed, implemented and tested.

The computation is done on the central server as the server was perfectly capable of handling load and computation of that degree. Firstly, the facial features of the authorized people are encoded and recorded, then the facial features of the test subject are compared to find a match and then decisions are taken accordingly. First the recognition was done using an image file but now for practical implementation there was a transition from image-based detection to video stream based facial detection.

## 7.4 Mood Detection

In this module there’s spotify integration with Python3 as the primary development language. Spotify was chosen as it is one of the most widely known and popular music streaming applications, it can be accessed via mobile phones, laptops and PCs. Spotify also allows for developers to use data for their web applications and applications provided the necessary authentication details.

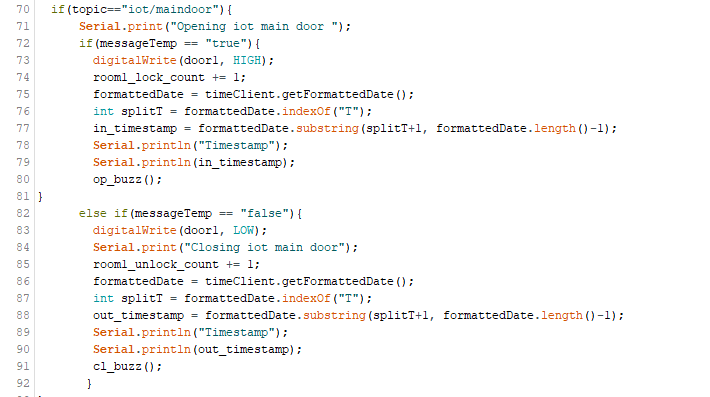
Python was chosen as spotify has a well known and active python library to access and manipulate user data. Their library is referred to as Spotify and its well documented and widely used in the development of the mood detection system.

## 7.5 Water Management System

This module consists of water sensors and a pump. The pump is the kind of pump used in houses and institutions for water pumping. It is connected to the esp32 board. Water sensors are kept at 2 points in the tank to monitor the level of water and pump water accordingly. Water sensors were used to keep track of the level of water and monitor it throughout. The ESP is programmed in such a way that the water is pumped when the water level is below 30 percent and it stops pumping once it is 90 percent. C++ is the development language used with the Arduino IDE for writing the code to program the water leakage monitoring ESP. Data is collected regarding the level of water and it can be used by the user to see on how much water he is using.

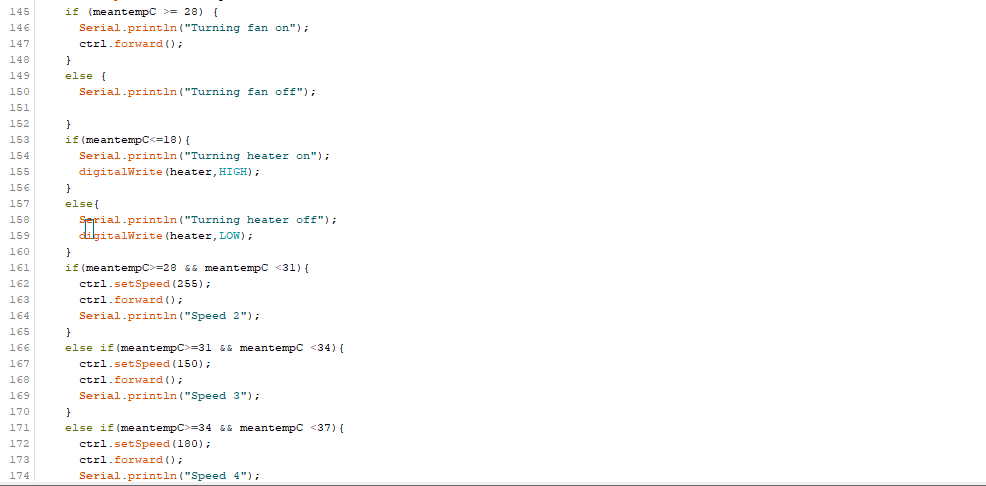
# Chapter 8 Implementation and Pseudo Code

## 8.1 Access Control Module



The above piece of code helps us control the state of the doors. First it checks for the topic name and then checks whether the request was for opening or closing the door. Line number 73 and 83 are for opening and closing the door respectively and the lines74-77 and 85-88 fetch the data such as number of locks and unlocks and the time it was locked and unlocked. We trigger the buzzer 1 time indicated by line 80 1 time when the door opens and 2 times indicated by line 91 when we close the door.

## 8.2 Temperature Monitoring and Control Module



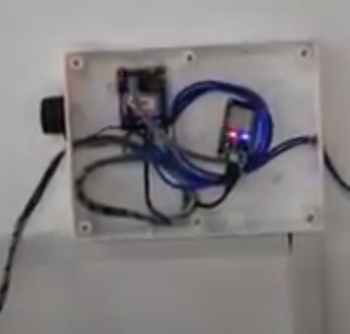
Once we calculate the mean temperature we check if it is greater than 28 degrees and then we have intervals of width 3 degrees from 28 to 43 and we increase the speed of the fan as the temperature rises. E.g.) In line 162 we are setting the speed and then in line 163 we are switching the regulator which controls the fan on with the speed set above. This is done for every temperature interval.

## /var/folders/rn/nfnld9d50fzf6l9frnf17s600000gn/T/com.microsoft.Word/WebArchiveCopyPasteTempFiles/ZkEQVBmsun0AAAAASUVORK5CYII=8.3 Water Level Management Module

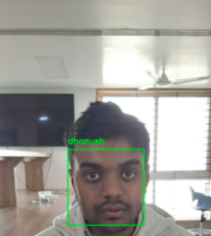
In this we are checking whether the water level is less than 4095 if yes, we are turning on the pump, once it exceeds 4095 we are turning the pump off. Here the sensor gives a 4 digit numeric value as the output as the water level.

# Chapter 9 Testing

The testing was conducted module wise and across various phases of development. As the project involved working with both hardware and software, different methods of testing were employed.



A hardware test bench was created to check if all the used hardware was compliant. The testbench had the required voltage input and had a multimeter connected at the output for checking the PWM signal coming out.

A 24hour endurance test was conducted where the access control system was deployed to the door of the IoT Lab. A few minor errors like Wi-Fi failure and network failure was experienced and sorted out along the way.

For testing the face recognition module, a group of 5 people was consisted where each member’s face was registered on the system. Again a 5-hour endurance test was performed to check for the accuracy of the recognition under various lighting conditions.

*A sample of the face recognition output is above.*

# Chapter 10 Results and Discussion

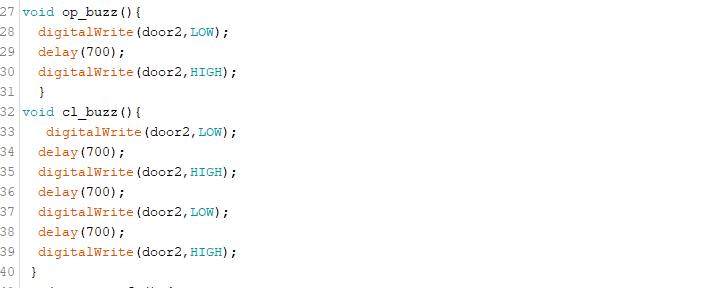
The following were observed at the end of the project development,

* The Access Control Module was installed at G04 Classroom of Computer Science Department. The department office was given control of the system and was used for a duration of 2 weeks under the testing phase.
* The temperature control module has been set up at the PESU C-IoT lab where a mock-up was built with 4 temperature sensors and a fan. The user can choose between automatic or manual modes to control the fan. Under the automatic mode, the fan turns on at temperatures above 28 degrees centigrade.
* The gas detection module can find the presence of carbon di oxide in the atmosphere along with carbon monoxide.
* The water level management system detects the presence of water in the tank and also the level of water present in the tank, a mock-up of the same has been built and tested.
* The mood detection module keeps a track of the songs listened to by the user, comes up with a mood factor number and understands a user’s current mood. Based on the factor, it recommends new songs and builds a playlist to help make the user feel better.

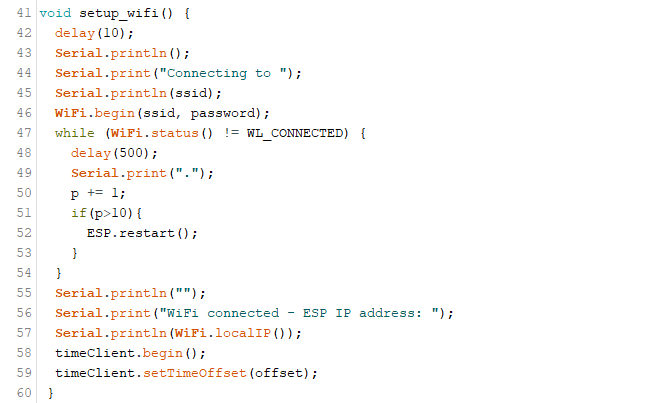
# Chapter 11 Snapshots

11.1 Access Control System

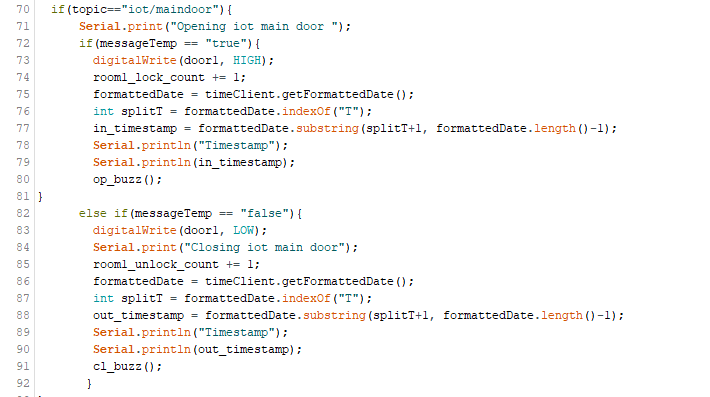
### 11.1.1Buzzer Control



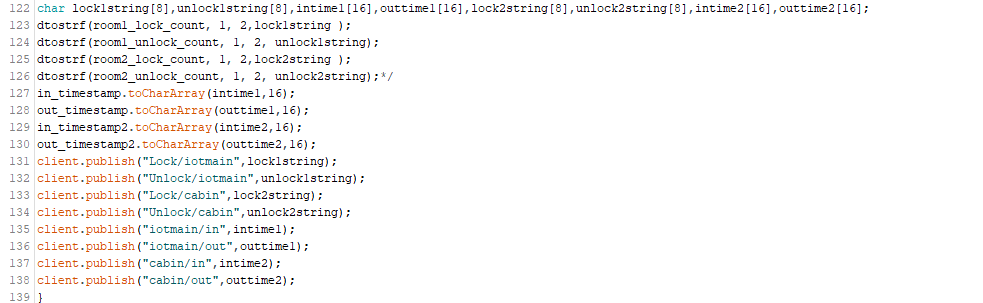
### 11.1.2 Wi-Fi Setup



### 11.1.3 Topic Processing and Access Control



### 11.1.4 Publishing to Topics



### 11.1.5 Reconnection function

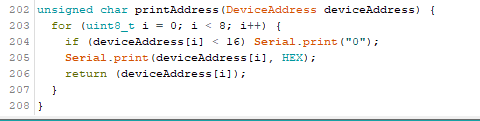


### 11.1.6 Setup and Loop Function

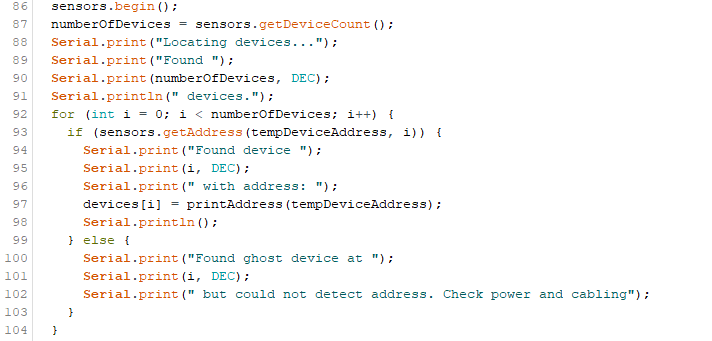


11.2 Temperature Monitoring and Control

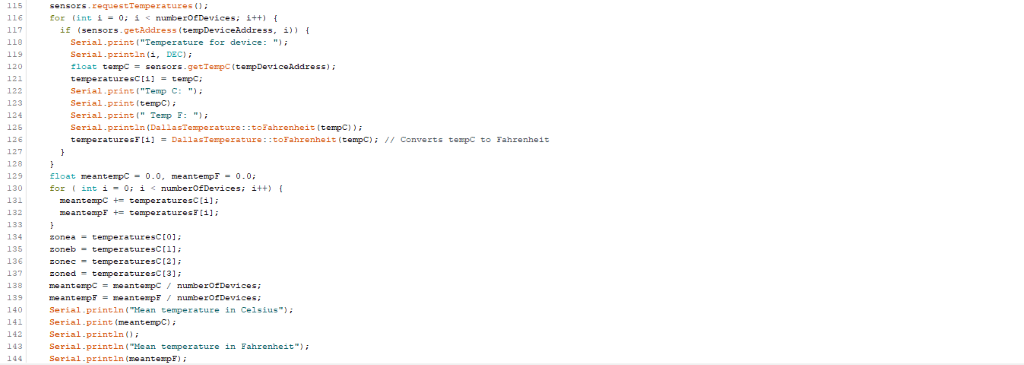
### 11.2.1 Device Address Function



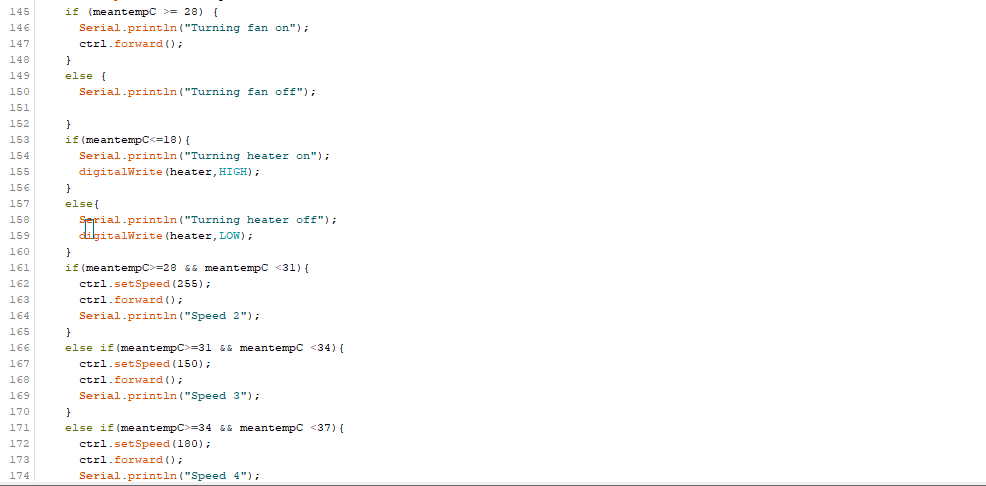
### 11.2.2 Setup Sensors

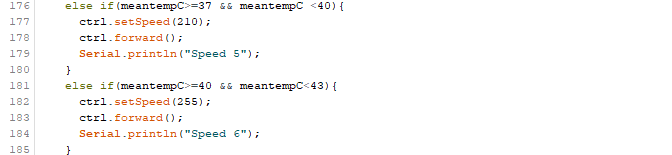


### 11.2.3 Getting Readings

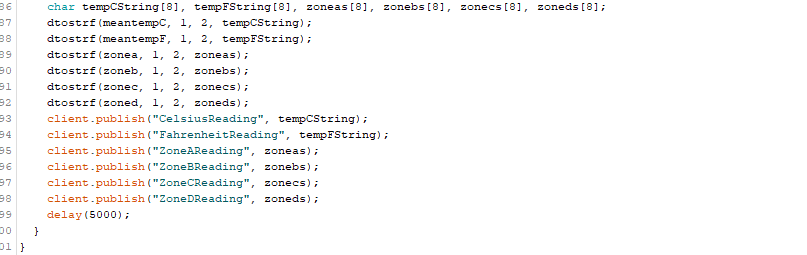


### 11.2.4 Automatic Cooling with Speed Tuning



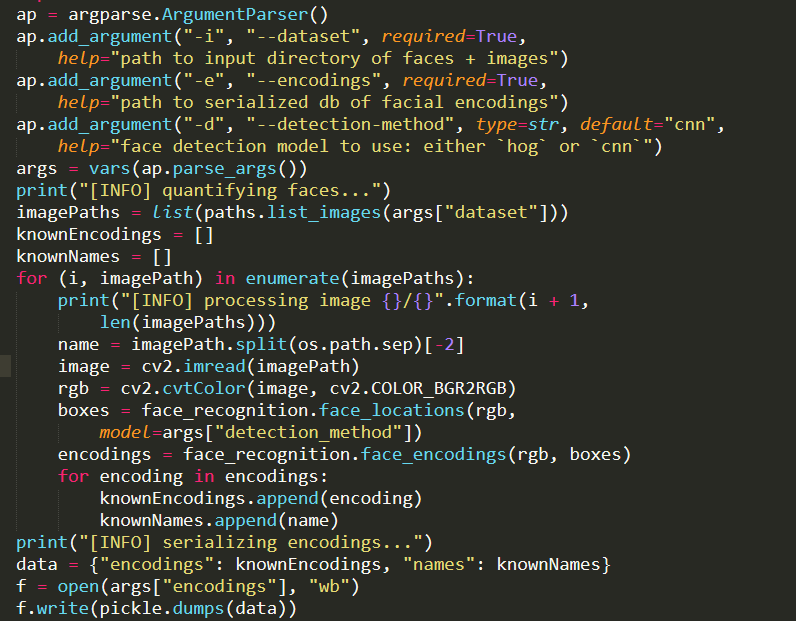


### 11.2.5 Publishing Readings to Topics

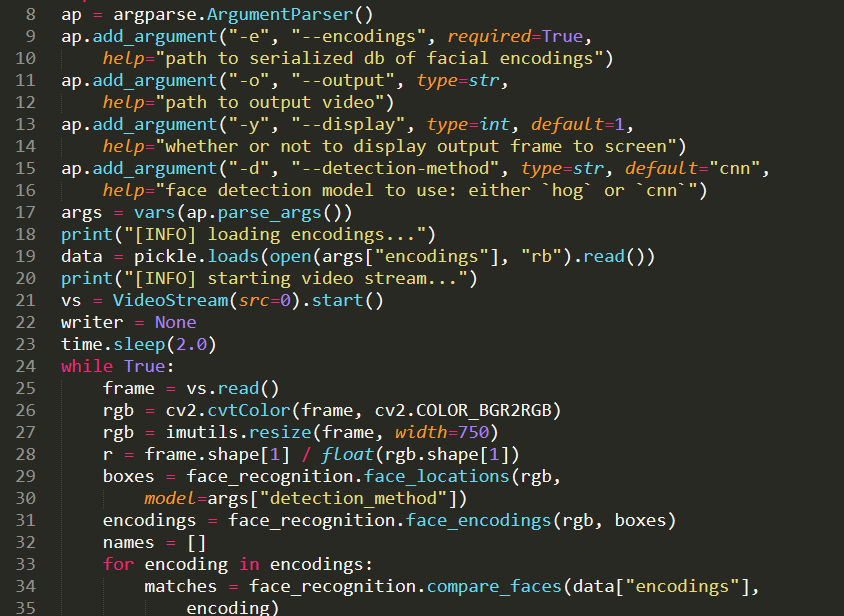


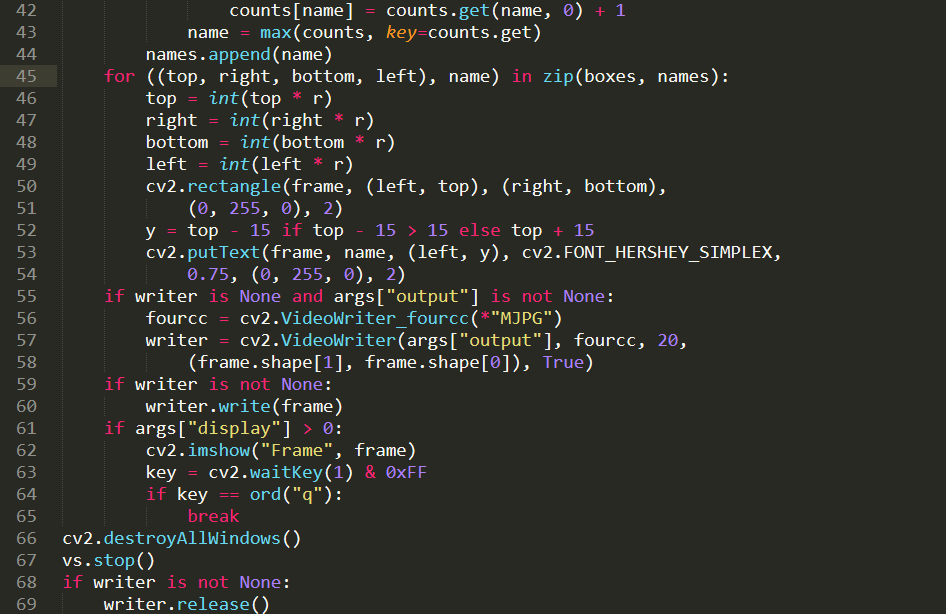
11.3 Facial Recognition

### 11.3.1 Encode Faces



### 11.3.2  Face Detection Video Stream





11.4 Mood Detection System

### 11.4.1 Authentication

token=util.prompt\_for\_user\_token(username,scope ,client\_id=client\_id,client\_secret=client\_secre t,redirect\_uri=redirect\_uri)

 if token:

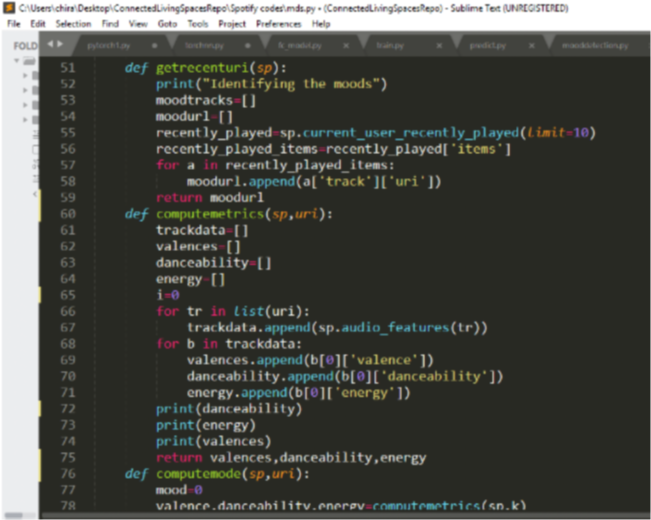
        def authenticate\_spotify():

                             print("..Connecting to spotify")

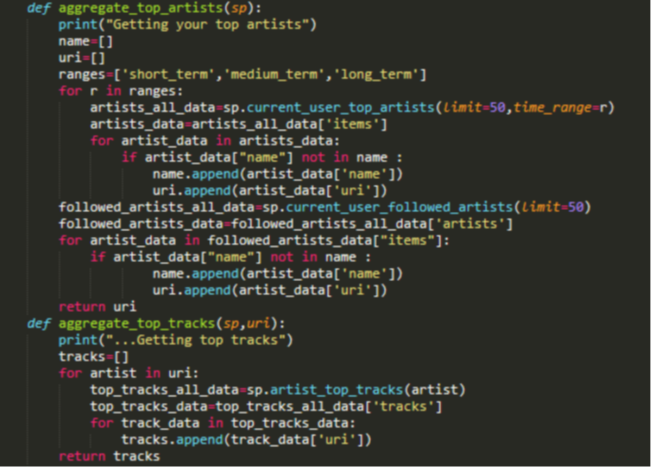
                            sp=spotipy.Spotify(auth=token)

                            return sp

### 11.4.2 Detection



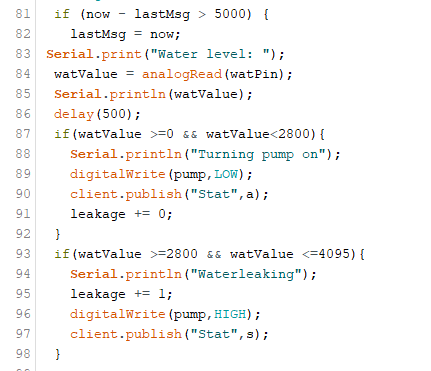
### 11.4.3 Processing and Delivery



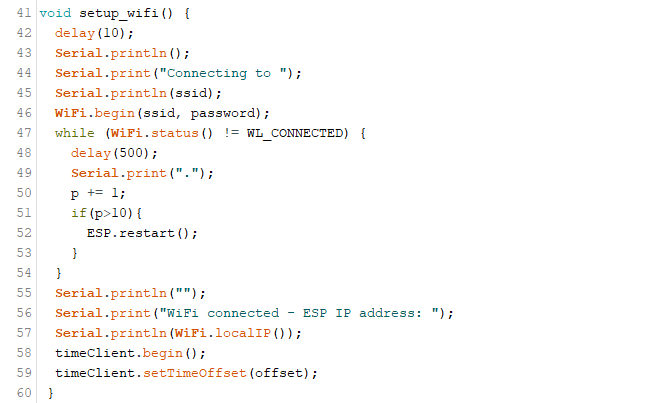


11.5 Water Leakage System

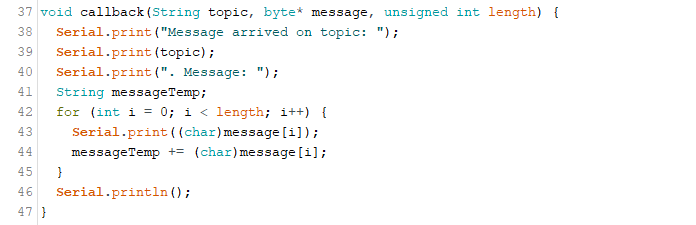
### 11.5.1 Reading Water Level and Controlling Pump



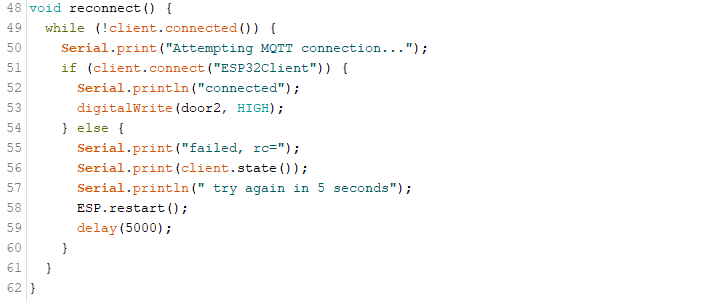
### 11.5.2 Setup Wi-Fi Function



### 11.5.3 Call Back Function



### 11.5.4 Reconnect Function



# Chapter 12 Conclusions

* + - The users are able to control the access to specific rooms,doors using the access control system,facial recognition system and the voice recognition system with minimum delay.
    - They can also access the data regarding the number of locks and the unlocks and arrival of intruders and the time a specific door was locked and unlocked.
    - The users are also able to benefit from the curated playlists created by the mood detection system.
    - The users reap benefits from the water leakage system and the gas leakage system and makes life simpler and easier.
    - The automatic cooling system keeps the temperature normal everytime and monitors the temperature continuously.

# Chapter 13 Further Enhancements

* A RFID interface can be incorporated to register individual students.
* A Biometric system can be setup at sensitive facilities which need an added level of security.
* The Access Control Module can be used to mark the attendance of the students present inside the class by using the data logged from the biometric/RFID system.
* User Registration can be made simpler by linking to “Sign up using Google” or similar services.

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* 1. <https://spotipy.readthedocs.io/en/2.11.1/>
  2. <https://face-recognition.readthedocs.io/en/latest/>
  3. <https://randomnerdtutorials.com/guide-for-mq-2-gas-smoke-sensor-with-arduino/>
  4. <https://www.tutorialspoint.com/arduino/arduino_water_detector_sensor.htm>
  5. <https://github.com/espressif/arduino-esp32>
  6. <https://randomnerdtutorials.com/esp32-multiple-ds18b20-temperature-sensors/>
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