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*I confirm that I understand my coursework needs to be submitted online via Google Classroom under the relevant module page before the deadline in order for my assignment to be accepted and marked. I am fully aware that late submissions will be treated as non-submission and a marks of zero will be awarded.*

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## Abstract

Technology and innovations are growing, and new advancements are being made. Home automation is one of the emerging concepts in today's world. With this increase in automation, different smart devices are being used and among them smart room temperature controller, smart lights and uses of google assistant are one of those. Smart room temperature controller is capable of adjusting the current room temperature in the desired range set by the user. It can automatically adjust the heating and cooling based on the temperature. Smart lights automatically turn off if it is daytime and turn on if it is nighttime. Google assistant is one of the features which is implemented in the system which helps to control the devices via google assistant from the mobile phone.

As thermal comfort and proper thermal condition for a human being cannot be neglected, the automatic room temperature controller system aims to manage the thermal comfort in the desired temperature set by the user. By the use of a DHT11 sensor, room temperature is measured and NodeMCU is used as the main microcontroller. The user set the desired room temperature and by measuring the temperature from the sensor the system manages the temperature of the room by turning on the heater (LED) if the temperature is below the set temperature and turning on the fan if the temperature is above the set temperature. And smart lights are there to properly manage the use of energy and by accessing the current time from NTP server the smart lights turn on automatically if it is nighttime and turn off if it is daytime. This makes the users save the energy and should not worry about accessing the lights physically. Google assistant is there for controlling the devices easily with the mobile phone and especially this aims to help the disabled people who cannot physically access the devices.

This report focuses on the introduction of the system and technology, literature review, background, methodology used and followed by development and testing of the system. By analyzing and studying the current market and visualizing the current scenario of home automation and problems associated with people about the thermal comfort, controlling the lights and difficulty of disabled people for controlling the devices. This report identified the problems domain, and the aims and objectives of the project is defined and mentioned here targeting the end users. And by mentioning the problem domain and the aims and objectives, comprehensive definitions and overview of the project is mentioned. Then a detailed literature review is done

where the problem domain is compared with the different journals and reports where it verifies that the mentioned problem domain is valid. Analysis of the solution and implementation of the solution is also done in that section which provides the knowledge of how the problems can be defended and what kind of system can be designed to reduce such problems. A proper background analysis is done mentioning the theoretical knowledge about the hardware, software and other components that are needed in the system. Evolutionary prototype is the selected methodology for this project and based on that methodology the entire project is based on. Further development and testing of the system is also mentioned in the development section below. Also, the legal, social and professional issues are mentioned along with some recommendation and future work.

## Table of Contents

1. Chapter 1: Introduction .....	1
1.1 Project declaration.....	4
1.1.1 Aims and objectives.....	4
1.1.2 Comprehensive Definition of the Project .....	5
1.2 An overview of the project.....	6
1.2.1 Problem domain.....	7
1.3 Overview of sensors .....	9
1.4 Overview of Adafruit and IFTTT.....	10
1.5 Overview of google assistant .....	12
1.6 Elaboration of current scenario .....	14
1.6.1 State of IOT .....	14
1.6.2 Status of home automation .....	16
1.6.3 Status of thermal comfort/condition in home .....	18
1.6.4 Status of smart lights .....	22
1.6.5 Status of google assistant.....	24
1.6.6 Effect of thermal discomfort in human health.....	26
1.7 Analyzing the problem domain .....	27
1.8 Project as a solution.....	29
2. Chapter 2: Literature review .....	30
2.1 Analyzing the problems .....	30
2.2 Analyzing the solutions .....	33
2.3 Implementation of the solutions .....	36
2.4 Identification of the main Aims and Objectives.....	40

3. Chapter 3: Background and Theoretical Foundation .....	42
3.1 MQTT protocol .....	42
3.2 Hardware and Software.....	46
3.2.1 NodeMCU .....	46
3.2.2 DHT11 Temperature and Humidity sensor .....	50
3.2.3 Breadboard.....	51
3.2.4 Relay module .....	52
3.2.5 LCD display.....	54
3.2.6 5v DC fan.....	55
3.2.7 LED light .....	55
3.2.8 Arduino IDE .....	56
3.2.9 Fritzing.....	58
3.2.10 Adafruit, IFTTT, Google assistant .....	58
3.2.11 End Users.....	59
4. Chapter 4: Details on Applied Methodology and Project Development .....	60
4.1 Considered methodologies .....	60
4.1.1 Agile development methodology.....	60
4.1.2 Waterfall development method .....	62
4.1.3 Prototyping model .....	63
4.2 Selected methodology .....	65
4.2.1 Evolutionary prototype model .....	65
4.2.2 Validation of Methodology .....	68
4.3 Project development with evolutionary prototype methodology .....	69
4.3.1 Task 1: Circuit designing.....	69

4.3.2 Task 2: DHT11 sensor for serial monitor.....	71
4.3.2.1 Programming the DHT11 sensor for serial monitor .....	71
4.3.2.2 Testing the DHT11 sensor for serial monitor .....	72
4.3.3 Task 3: DHT11 sensor for LCD display.....	73
4.3.3.1 Programming the DHT11 sensor for LCD display .....	73
4.3.3.2 Testing the DHT11 sensor for LCD display .....	74
4.3.4 Task 4: Room temperature controller .....	75
4.3.4.1 Room temperature controller programming .....	75
4.3.4.2 Testing for room temperature controller.....	76
4.3.5 Task 5: LED light test.....	78
4.3.5.1 Programming for the LED light test. ....	78
4.3.5.2 Testing the LED light.....	78
4.3.6 Task 6: Smart lights.....	79
4.3.6.1 Programming the smart lights.....	79
4.3.6.2 Testing the smart light .....	83
4.3.7 Task 7: Google assistant .....	85
4.3.7.1 Programming for the google assistant.....	85
4.3.7.2 Testing the google assistant .....	87
4.3.8 Task 8: Room temperature controller with google assistant .....	91
4.3.8.1 Programming for the room temperature controller with google assistant .....	91
4.3.8.2 Testing for the room temperature controller with google assistant .....	95
4.3.9 Task 9: Smart light with google assistant.....	102
4.3.9.1 Programming for the smart light with google assistant .....	102
4.3.9.2 Testing for the smart light with google assistant .....	107

4.3.10 Task 10: Final test.....	112
4.3.10.1 Program of the final test.....	112
4.3.10.2 Testing the final two systems.....	112
4.4 Securing the IOT devices .....	114
4.4.1 Physical security .....	114
4.4.2 Device security .....	114
5. Chapter 5: Conclusion.....	116
5.1. Legal, Social and Professional issues.....	118
5.1.1. Legal issues.....	118
5.1.2. Social issues.....	118
5.1.3 Professional issues.....	119
5.2. Recommendation.....	119
5.3 Future work .....	120
6. Chapter 6: References .....	122
7. Chapter 7: Appendix .....	131
7.1 Appendix 1: Survey.....	131
7.1.1 Survey form .....	131
7.1.2 Sample of survey form .....	137
7.1.3 Survey result .....	146
7.2 Appendix 2: Sample codes .....	147
7.2.1 Code for DHT11 for serial monitor.....	147
7.2.2 Code for DHT11 for LCD display.....	148
7.2.3 Code for room temperature controller .....	149
7.2.4 Code for LED light .....	150

7.2.5 Code for smart lights .....	151
7.2.6 Code for google assistant.....	154
7.2.7 Final code for room temperature controller with google assistant .....	156
7.2.8 Final code for smart lights with google assistant .....	161
7.3 Appendix 3: System design.....	166
7.3.1 Work breakdown structure .....	166
7.3.2 Gantt chart .....	167
7.3.3 Flowchart of the system architecture.....	168
7.3.4 Use case diagram .....	169
7.3.5 Circuit diagram .....	170
7.3.6 Hardware architecture.....	171

## Table of figures

Figure 1 Example of an IOT system (Gillis, 2020) .....	3
Figure 2 Adafruit dashboard .....	11
Figure 3 Applets of IFTTT .....	12
Figure 4 Growth of IOT (Froese, 2018).....	14
Figure 5 Total active devices in IOT (Lueth, 2018) .....	15
Figure 6 Growth of global home automation market (Terrelle, 2019) .....	16
Figure 7 Global market of home automation (Rajput, 2019).....	17
Figure 8 Room temp variation (Nafisa Bhikhoo, 2017) .....	19
Figure 9 Temperature inside a concrete house (Q. Roslan, 2016).....	20
Figure 10 External and internal temperature (Sayang Syazanna Raf', 2018).....	20
Figure 11 Smart lighting market (Ankita Bhutani, 2018).....	23
Figure 12 Installed smart lights (news, 2020).....	23
Figure 13 Voice platform in 2020 (Richter, 2020) .....	25
Figure 14 MQTT architecture (Dave, 2018).....	43
Figure 15 Example of a feed (Adafruit, 2019).....	45
Figure 17 NodeMCU pins (Components, 2020).....	48
Figure 16 NodeMCU (Components, 2020) .....	48
Figure 18 DHT11 sensor (admin, 2018) .....	51
Figure 19 Breadboard (Cannaday, 2016).....	52
Figure 20 Relay module (Osoyoo, 2017).....	53
Figure 21 LCD display (MisterBotBreak, 2018) .....	54
Figure 22 LED (rowan07, 2018).....	55
Figure 23 Arduino IDE (Aqeel, 2018) .....	56
Figure 24 Agile Methodology (Contributor, 2018) .....	61
Figure 25 Waterfall development method (UKessays, 2019).....	63
Figure 26 Prototyping Model (Team, 2018) .....	64
Figure 27 Evolutionary Prototype model (Shaharin, 2016).....	66
Figure 28 Circuit diagram of smart room temperature controller.....	69
Figure 29 Circuit diagram of smart light .....	70

Figure 30 Temperature sensor code for serial monitor .....	71
Figure 31 Result of temperature and humidity in serial monitor.....	72
Figure 32 Temperature sensor code for LCD display.....	73
Figure 33 Temperature in LCD.....	74
Figure 34 Code for room temperature controller.....	76
Figure 35 Heater (LED) on .....	77
Figure 36 Fan on .....	77
Figure 37 Code for LED light testing .....	78
Figure 38 LED light on .....	79
Figure 39 Code for smart light.....	82
Figure 40 Light on in nighttime .....	83
Figure 41 Light off in daytime.....	84
Figure 42 Code for google assistant.....	86
Figure 43 Light off by google assistant .....	87
Figure 44 Light on by google assistant .....	88
Figure 46 Command for light off .....	88
Figure 45 Command for light on .....	88
Figure 47 Adafruit dashboard showing light is on.....	89
Figure 48 Adafruit dashboard showing light is off .....	89
Figure 49 IFTTT applets .....	90
Figure 50 Code for room temperature controller with google assistant .....	95
Figure 51 Heater (LED) on while low temp .....	96
Figure 52 Fan on while high temp .....	97
Figure 53 Fan on via google assistant.....	97
Figure 54 Heater (LED) on via google assistant.....	98
Figure 55 Command for heater (LED) on.....	98
Figure 56 Command for fan on.....	98
Figure 57 Command for all off .....	99
Figure 58 Adafruit dashboard showing fan on .....	100
Figure 59 Adafruit dashboard showing heater on.....	100

Figure 60 Adafruit dashboard showing all off.....	101
Figure 61 IFTTT applets .....	101
Figure 62 Code for smart light with google assistant .....	106
Figure 63 Light off in daytime.....	107
Figure 64 Lights on in nighttime .....	108
Figure 65 Light on via google assistant .....	108
Figure 66 Light off via google assistant .....	109
Figure 67 Command for lights off .....	109
Figure 68 Command for lights on.....	109
Figure 69 Adafruit dashboard showing light is on.....	110
Figure 70 Adafruit dashboard showing light is off .....	110
Figure 71 IFTTT applets .....	111
Figure 72 Survey form .....	136
Figure 73 Survey responses .....	146
Figure 74 Final code for DHT11 for serial monitor .....	147
Figure 75 Code for DHT11 for LCD display.....	148
Figure 76 Code for room temperature controller.....	150
Figure 77 Code for LED lights .....	150
Figure 78 Code for smart lights .....	153
Figure 79 Code for google assistant.....	155
Figure 80 Final code for room temperature controller with google assistant .....	160
Figure 81 Final code for smart lights with google assistant .....	165
Figure 82 Work breakdown structure .....	166
Figure 83 Gantt chart .....	167
Figure 84 Flow chart of the system architecture.....	168
Figure 85 Use case diagram.....	169
Figure 86 Circuit diagram of room temperature controller .....	170
Figure 87 Circuit diagram of smart light .....	170
Figure 88 Hardware architecture of room temperature controller .....	171
Figure 89 Hardware architecture of smart light.....	172

Figure 90 LCD display of room temperature controller .....	173
Figure 91 LCD display of smart light .....	173

## Table of tables

Table 1 Test for the DHT11 sensor for serial monitor.....	72
Table 2 Test of the DHT11 sensor for the LCD display.....	74
Table 3 Test for the room temperature controller .....	76
Table 4 Test for the LED lights .....	78
Table 5 Test for the smart light.....	83
Table 6 Test for the google assistant.....	87
Table 7 Test for the room temperature controller with google assistant .....	95
Table 8 Test for the smart light with google assistant .....	107
Table 9 Final test of the system .....	113

## 1. Chapter 1: Introduction

Home automation can be simply defined as the electronic devices that are automatically controlled, which can perform the task itself and also can be controlled via the internet. From the term itself it says home automation which means that there is the automatic control of electronic devices in our home or in our workplaces. The concept of home automation has been around from a very long period of time. From the period of 1940s to 1960s in the evolution of digital computers, Jim Sutherland created the ECHO IV in 1966 which was the first home automation system. It can control the temperature, turn the appliances on or off and allow for input and later retrieve the shopping lists and recipes (Systems, 2019). Since then, home automation has been in practice. Home automation involves the internet, different sensors that monitor and control the devices based on the motions, temperature and lights. Based on those sensors, IOT platform and internet the user can set any parameters and make those devices perform as they like. Here the devices are connected through each other and perform the task side by side. For example, when the security camera sees or detects any motion it triggers the smart siren to make an alert by turning it on. Home automation allows us to monitor, control, automate devices and interact with the voice control / voice assistant which are the google assistant, amazon Alexa and apple Siri where it is easy to control the devices via these voice assistants. Home automation is rapidly growing in today's world because it makes our life more convenient and easier. It gives us access to control our devices remotely, it is not very complicated to use which makes it more usable and comfortable, it is also energy efficient as it operates itself by turning off the devices that are not in use and everyone are able to make a good use of home automation (Aliza Vigderman, 2021) .

IOT is one of the growing topics in today's world. IOT is being used widely across the whole world. IOT refers to the physical devices that are interconnected with each other to perform certain tasks and which are connected to the internet for sharing and collecting the data. But not only with the internet the devices are connected to different sensors and monitors which collect data, process those data into some result and present them with the final outcome. IOT makes devices smarter by letting it connect through the internet and communicate with people and other devices. It has the ability to collect and exchange data from the user or environment without the

involvement of a human source. Implementation of IOT in homes are extremely useful and are in need nowadays (Ranger, 2020).

IOT itself is a huge topic, it includes many important things which as a whole makes the IOT platform perform well. IOT has been growing rapidly since the past few years and it has become one of the most important and useful technologies ever developed. By connecting the devices near us with each other and via the internet, it has established a connection between the internet and our daily life devices. By the use of IOT data collection, data visualization, data processing has been easier without human interaction (BURGESS, 2018). IOT of things are there for us to make our life easier and more convenient, there are many benefits of IOT which are:

- Communication and connectivity of the devices are easier, the devices are connected through each other as they work simultaneously. They can connect via the internet and different sensors through which the data is collected and processed and then another device performs the needed task according to the collected data from the sensor of the internet. IOT makes it easier to stay connected and work simultaneously.
- For the monitoring purpose the sensors can be used which can monitor or sense the temperature, motion, pollution, fire, water and many more. By collecting the data via those sensors, it can interact with different devices and perform accordingly to the user's desire. IOT allows us to maximize performance, look past the sensor data and understand how the data is collected and transmitted, such as timestamps and error logs (Quek, 2017).
- IOT provides more efficient working and saves time, the implementation of the sensors and internet in the devices which leads the devices to work on their own where there is no need for human interaction. The use of voice assistants, use of sensors to automatically turn on and off the lights and operating the electronic devices makes the work more convenient and saves time.
- Remote controlling of the devices is easier via the internet, data can be visualized remotely and can be accessed without any problem which makes it easier for the user to interact with the devices without the physical presence.

- IOT for industries is important, hospitals can make a huge use of IOT as they can monitor the patients remotely and can send alerts if the patients are in need of something or are in some kind of problem. different industries can make the use of IOT for monitoring and for the security purposes (Reed, 2019).
- IOT provides better quality of life increasing the comfort, convenience, and better management, which improves the quality of life.

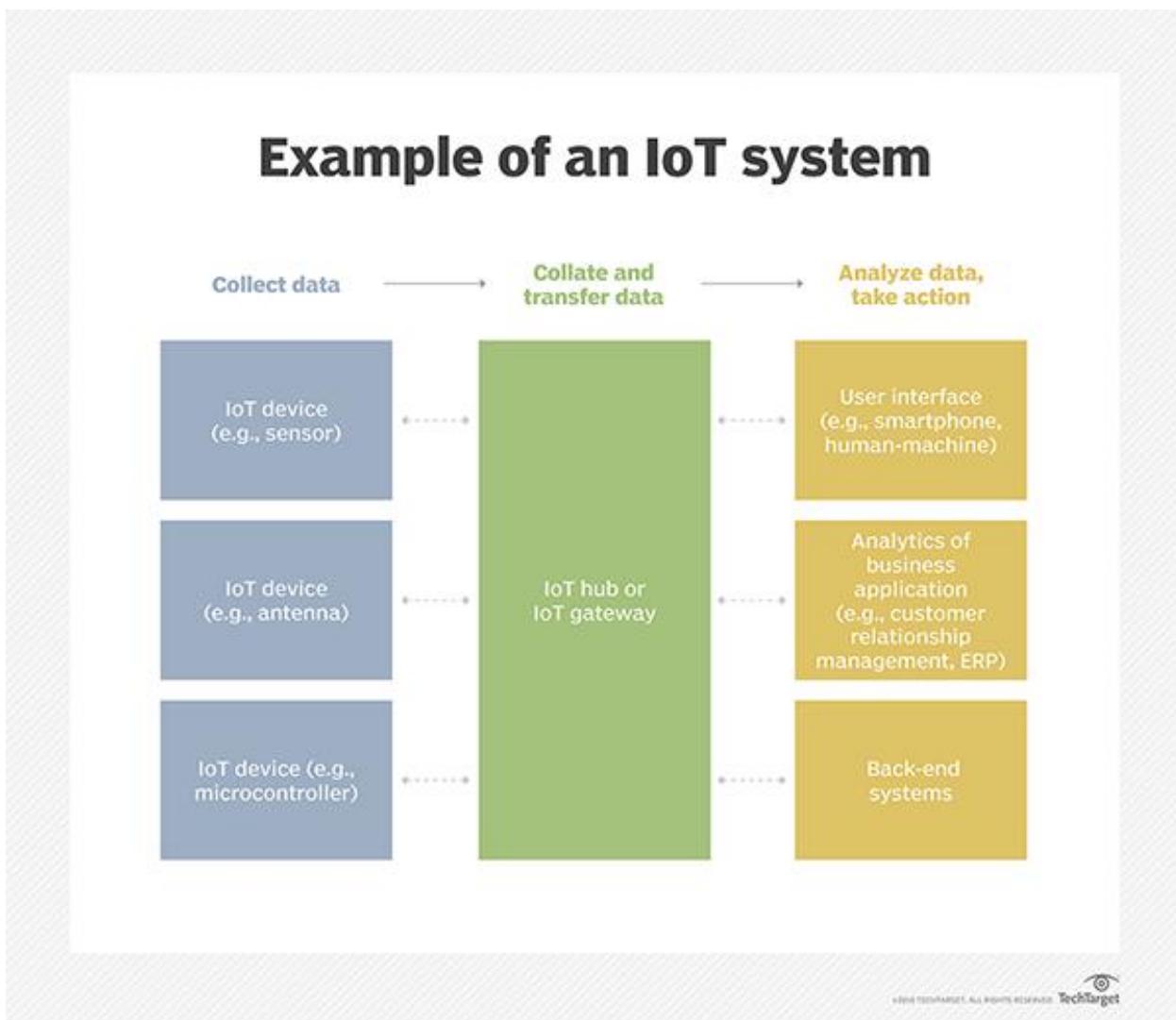


Figure 1 Example of an IOT system (Gillis, 2020)

As from the above figure it gives us the vision of how the IOT system works. First collection of the data is done which can be from the sensors, internet, microcontrollers and the collected data is transferred where necessary according to the user and then form the data action is performed. The whole process is done without the user interaction but for instance the user interacts with the devices to set them up according to the need and the devices work on their own (Gillis, 2020).

As IOT is one of the important technologies, it can be used everywhere and in return IOT can be very helpful and the IOT industry is very strong for the future as well.

## 1.1 Project declaration

### 1.1.1 Aims and objectives

#### Aims

The main aim and delivery of the project is to develop a prototype system which automatically controls the room temperature using sensors and microcontrollers and automatically controls the lights using internet time and also the devices can be controlled via google assistant.

#### Objectives

The objectives of the project are as follows:

- To research and collect papers on the specific topic before starting the project.
- To do a complete overview of IOT and home automation for better delivery of the final system.
- To use the IOT devices like sensors and microcontrollers according to the need of the project and circuit diagram.
- To use the voice assistant which is the google assistant for controlling the devices.
- To determine the area of uses and benefits of the project.
- To write the proper programming and use the hardware and software effectively.
- To analyze the data captured in the sensors and according to the data generated analyzing the data and converting it into some useful output according to the user.

### 1.1.2 Comprehensive Definition of the Project

This project of smart room temperature controller and smart light is developed with the purpose of making the home a better, comfortable and more well-organized place to live in. This prototype system is the part of home automation and for the smart room temperature controller, microcontrollers and sensors are used. For the microcontroller NodeMCU (ESP8266) is used and DHT11 sensor is used. First the users set the desired temperature of their choice and when the sensor receives the temperature data, that data is processed through NodeMCU and if the temperature is below the set temperature the heater (LED) would turn on and if the temperature is above the set temperature, then the fan would turn on with the purpose of maintaining the room temperature as desired for the user.

For the smart lights, the time is captured from the internet and there is the use of another NodeMCU (ESP8266), and when it is daytime, the lights would automatically turn off and when it is nighttime the lights would automatically turn on. And for those devices there is also the implementation of the google assistant where the heater (LED), fan and lights can be controlled via google assistant.

## 1.2 An overview of the project

This project involves two systems where both systems are the part of the home automation whose intention is to make the home better, smart, comfortable and effective where the people can use it for their own purpose and their needs. The first system is the smart room temperature controller. This system controls the temperature of the room automatically as per the desired set temperature of the user. This system uses the DHT11 sensor for sensing and measuring the temperature of the room, it uses NodeMCU as its main component where all the coding and processing of the system is performed, also it uses LCD display for displaying some information. Explaining the mechanism of this system, first the sensor receives the temperature data with the help of the DHT11 sensor and sends it to the NodeMCU where all the coding part and processing part is performed. The user sets the desired temperature via the actual coding in the NodeMCU. After providing the temperature data to the NodeMCU, if the temperature of the room is below the set temperature, then the heater (LED) would turn on automatically and if the room temperature is above the set temperature, then the fan would turn on automatically which maintains the desired room temperature for the user. The connected LCD display displays the current room temperature, the set temperature by the user and the information about the system where it is in automatic mode or google assistant mode.

The second system is the smart lights which uses the internet time to automatically operate, if it is daytime the lights would automatically turn off and if it is nighttime the lights would automatically turn on. It uses another set of NodeMCU which does the processing and where the actual coding is done, also it uses the LCD display where it shows the current time and date.

For the final part, those devices that are mentioned above can also be controlled via google assistant. Google assistant is a very important and useful thing where people can easily control the devices by their own voice rather than controlling them physically. For the google assistant Adafruit and IFTTT are used where it is easy to connect those devices via google assistant. In the Adafruit dashboards for the first and second system are created, and feeds are also created. And in the IFTTT the command for the google assistant is set and the Adafruit is linked to IFTTT. Then both of the system, Adafruit and IFTTT are also linked and from the mobile phone the heater

(LED), fan and lights can be controlled. So, both the system can perform automatically and with the google assistant as well.

### 1.2.1 Problem domain

IOT makes our life easier, better and efficient, it provides the solutions to the existing problems. With the use of IOT we can solve many of our problems and with the help of IOT improvements can be made. In our home there could be some problems and there would be the need for some improvement and to deal with it the two-prototype systems are designed which could mitigate and improve those existing problems. So, let's discuss the problems that we can face in our home and how IOT and home automation would help to tackle those problems.

- In today's world people are very busy in their life, they don't have much time to think about their home, they want everything to be controlled by their mobile phone.
- People often forget to turn off their lights while going to work early in the morning which causes wastage of energy as well as money.
- The temperature varies outside and inside the home and the weather might be hot or cold and when returning home from work, people want their room temperature to be suitable for their choice automatically but without IOT it is not possible.
- Thermal comfort is a crucial component which should be properly maintained inside our home, due to thermal discomfort problems in human health can also arise.
- Indoor and outdoor temperatures vary and there should be a proper mechanism to detect the indoor temperature and maintain the temperature where the people can live in with their range of thermal comfort.
- People want their devices to be controlled by their voice rather than controlling physically, so IOT is there for these kinds of problems.
- Mainly disable people face problems like they cannot turn on or off the lights manually, they face problems controlling the heater or fan and any devices manually inside their home.

To support the above problem scenario some research papers have shown that people want everything in their mobile phone they don't want to do more things, they want an easy life and

with the help of IOT it has been easy to do so. According to the United Nations Environment Programme (UNEP), residential and industrial buildings use 60% of the world's electrical energy, a trend that is growing over time. Around 50 percent of this volume is attributable to HVAC systems, and the excessive use of appliances and equipment is attributable to a large waste of energy resources. So, there is a huge use of electricity and it is also due to carelessness of humans. And to some limit IOT can play a vital role to tackle these problems (Claudio Marche, 2019). IOT is there for those problems as mentioned, that people often forget to turn off the lights and electronic appliances and due to the implementation of auto turn on and off of the devices it is easy to manage and save the cost of the electricity. Nowadays people mostly stay indoors like in office, schools and homes and thermal comfort is very important for them. It has been stated that fitness, happiness, creative capacity, and working efficiency are of great importance to thermal comfort. So, people are looking forward towards automation and IOT is important as we can make our own home automation and make our room perfect for thermal comfort (Miao Zang, 2019).

Elderly and disable people are growing and very important as they need more care than other people. The proportion of the population aged 65 and over in the United States has risen from 12.4 percent in 2000 to 13.3 percent in 2011 and is projected to expand to 21 percent of the population by 2040. It is said that 17% of the world population have blindness and visual impact, 1% of the world population need a wheelchair on a daily basis. This shows that people need more facilities in home. Implementing smart home systems with remote display controls and health care capabilities would reduce the cost of home personal assistance. So IOT is important among elderly and disable people where they are not supposed to do much for better living experience (Bilal Ghazal, 2015).

### 1.3 Overview of sensors

Sensors are the devices which are often used to detect and measure a certain change in the environment or in the surroundings which take the data as an input and send to the computer processor to generate a useful output based on the sensor data. The application area of the sensor is very simple as it takes the input of the data from the surrounding and sends to a processor for further processing of the data into an informative output. Sensors are always used with another electronic component so that it can send the data there. Sensors are used almost everywhere; they are mainly used with IOT components (TEJA, 2021).

There are different types of sensors available, different appliances require different types of sensors. Some of the sensors are:

- Temperature sensor
- Pressure sensor
- Light sensor
- Ultrasonic sensor
- Smoke, gas sensor
- Motion sensor
- Rain sensor
- Water flow sensor
- Flame sensor

There is also the classification of sensors, which are the active and passive sensors. Active sensors need an external excitation signal or a power signal to operate and passive sensors do not need any external power and it can deliver output response directly. Another is analog and digital sensors; analog sensors generate analog output which measures the quantity, and the digital sensor works and measures the digital data and generated output is in digital form (TEJA, 2021). Sensors are widely being used and there is the potential growth of the sensors in the future as well. According to the MIT researcher's photovoltaic technology is a technology which can enhance the use of the sensors even more, as the sensors uses the external power it feels like it needs some upgrade as it feels impractical. The photovoltaic technology helps sensors to use thin-film

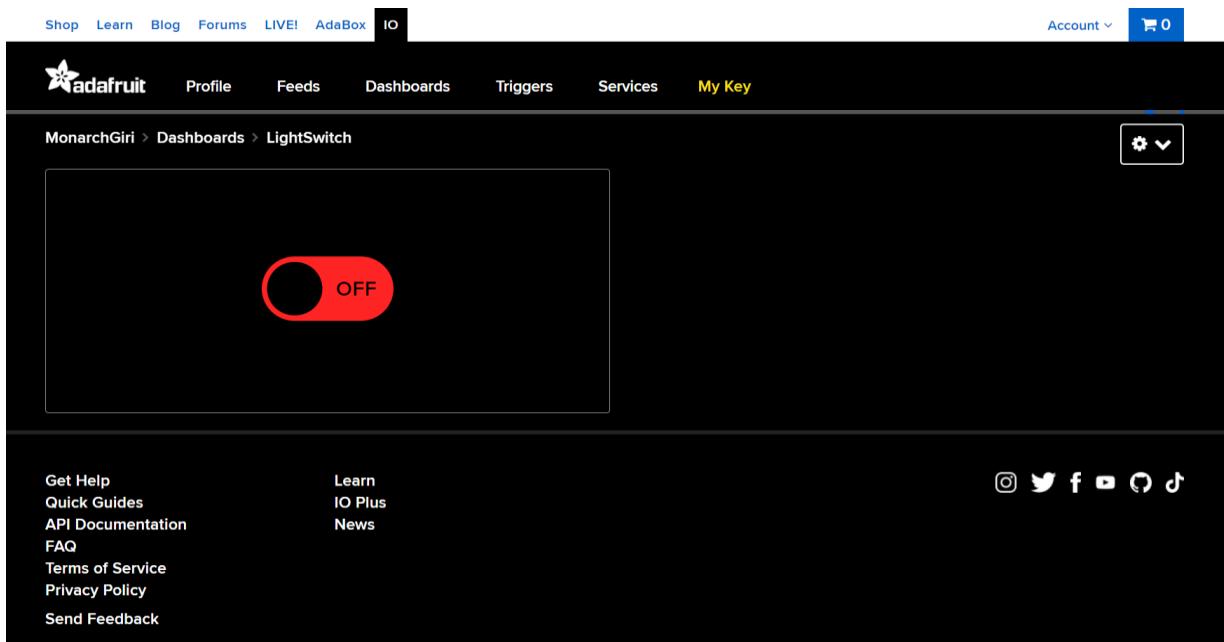
perovskite cells, which are very flexible and suitable for almost any surface and it can make the sensors completely automatic, and it does not use much energy (Sajip, 2019).

For this project it uses the temperature and the humidity sensor which is the DHT11 sensor which collected the temperature and humidity data from the surrounding. As this is the most important element in this project which measures the temperature and with that data the further work is possible.

#### 1.4 Overview of Adafruit and IFTTT

Adafruit IO is a cloud service which provides us the service to connect our devices to the internet, it is a platform for storing data, viewing data, and controlling devices. It uses different protocols like MQTT, REST. Adafruit IO is a great platform for IOT where every device can be connected to the internet. It helps us in different way like, it can display the real time data, helps to maintain connected to the internet, it helps to connect the projects to other internet enabled devices. It handles multiple data. Dashboards available there can help to visualize the current data and help to interact with those data, it displays the chart, graph, log and many more. In the dashboards, it displays the data from different sensors and can also interact with the connected devices. Adafruit IO makes the project easier to connect to the internet and store the data so we can access anytime we want (adafruit, 2018).

Here in this project Adafruit is used so that it can store the feeds of the devices and can be used time and again. Adafruit IO has helped to connect the device over the internet in this project. There are dashboards and the dashboard stores feed inside and triggers through IFTTT. IFTTT is further discussed below. The below figure shows how the dashboard looks in Adafruit IO.

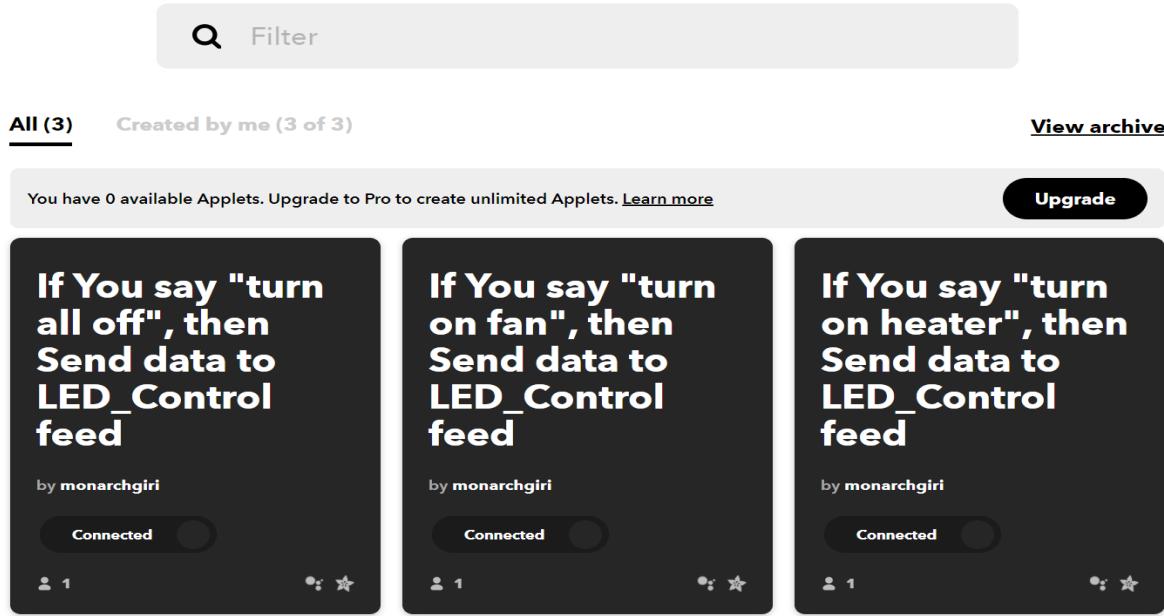


*Figure 2 Adafruit dashboard*

IFTTT (If This Then That) is a service that allows users to program responses to different types of incidents around the world. IFTTT is a free service that allows us to connect hundreds of our favorite applications and gadgets, such as Twitter, Dropbox, Evernote, Nest, Fitbit, Amazon Alexa, and Google Assistant. It provides many services from which we can choose and complete our work. IFTTT works with triggers like if this happens then do that. It allows us to make different applets and make a connection. In this project IFTTT connects the feeds from adafruit with google assistant, so likewise we can make applets which trigger one action and if this happens then do that. It helps to develop connections between different apps and devices. IFTTT helps to establish the connection between devices and the internet and through the applets in the IFTTT it triggers some action to perform certain things (Martin, 2020).

IFTTT has established a connection between Adafruit and google assistant in this project to control the devices over the internet. The applets have allowed access to the feeds from the Adafruit and perform the action as said to the google assistant. The applets have worked like a bridge between Adafruit and google assistant. The below figure is about the applets and those applets trigger some action when said something to google assistant.

# My Applets



The screenshot shows the IFTTT 'My Applets' page. At the top, there is a search bar with a magnifying glass icon and the word 'Filter'. Below the search bar, there are three tabs: 'All (3)', 'Created by me (3 of 3)', and 'View archive'. A message at the top states 'You have 0 available Applets. Upgrade to Pro to create unlimited Applets.' with a 'Learn more' link and an 'Upgrade' button.

Three applets are listed:

- If You say "turn all off", then Send data to LED\_Control feed** - Created by monarchgiri, Connected, 1 user, 0 reviews.
- If You say "turn on fan", then Send data to LED\_Control feed** - Created by monarchgiri, Connected, 1 user, 0 reviews.
- If You say "turn on heater", then Send data to LED\_Control feed** - Created by monarchgiri, Connected, 1 user, 0 reviews.

Figure 3 Applets of IFTTT

## 1.5 Overview of google assistant

Google assistant is a google voice assistant and artificial intelligence where it accepts our command and queries through our voice. It is available in mobile phones and google home devices. It is a two-way communication system where it provides us a result when asking any queries. It can find us the results from the internet, it can access our information from our calendars, contacts, events and perform phone calls, read weathers, set alarms and many more according to our command. It can control the devices and smart home appliances when connected to google assistant. Talking to a google assistant feels like talking to a real person and it also recognizes our voice. We don't need to physically activate the device we can simply say "hey google or OK google" to activate and place our queries. For smart homes google assistant plays an important role as we can control any of our devices in our rooms like lights, AC, fan, tv, and many other electronic appliances. Not only in the home, google assistant can be accessed in our cars if it supports android auto (Tillman, 2021).

Since Google Assistant knows us and understands our background, it will react in a knowledgeable or intelligent manner. This is significant because it allows voice modulation much

more strength and takes it away from only responding to particular phrases or orders. It's made to be more than just a reactionary system. As google assistant is available for everyone, we are able to connect to our devices and control them with our voice which is a very easy and productive way to control our devices and connect to the internet (Parrish, 2021).

This project also uses the google assistant to control the devices, and the google assistant, IFTTT and Adafruit are all equally important for controlling those devices as they are connected between each other. Once the command is passed to the google assistant it communicates to IFTTT to trigger an action and further it passes to Adafruit which manages the feeds and dashboard. So, every component is equally important to perform any given query smoothly.

## 1.6 Elaboration of current scenario

### 1.6.1 State of IOT

The technology sector is undoubtedly a huge growing sector worldwide. Among that IOT has also been growing in rapid pace. From the below figure it is seen that IOT is growing, and it makes a huge value nowadays. Software, connection of IOT and its devices are growing very rapidly where the bar graph clearly shows it. From the graph below in 2018, the global IOT industry, consisting of applications, services, networking, and devices, reached \$130bn. Global Data, according to the data and analytics firm, is expected to hit \$318 billion by 2023, at a 20 percent compound annual growth rate (CAGR) (Froese, 2018).

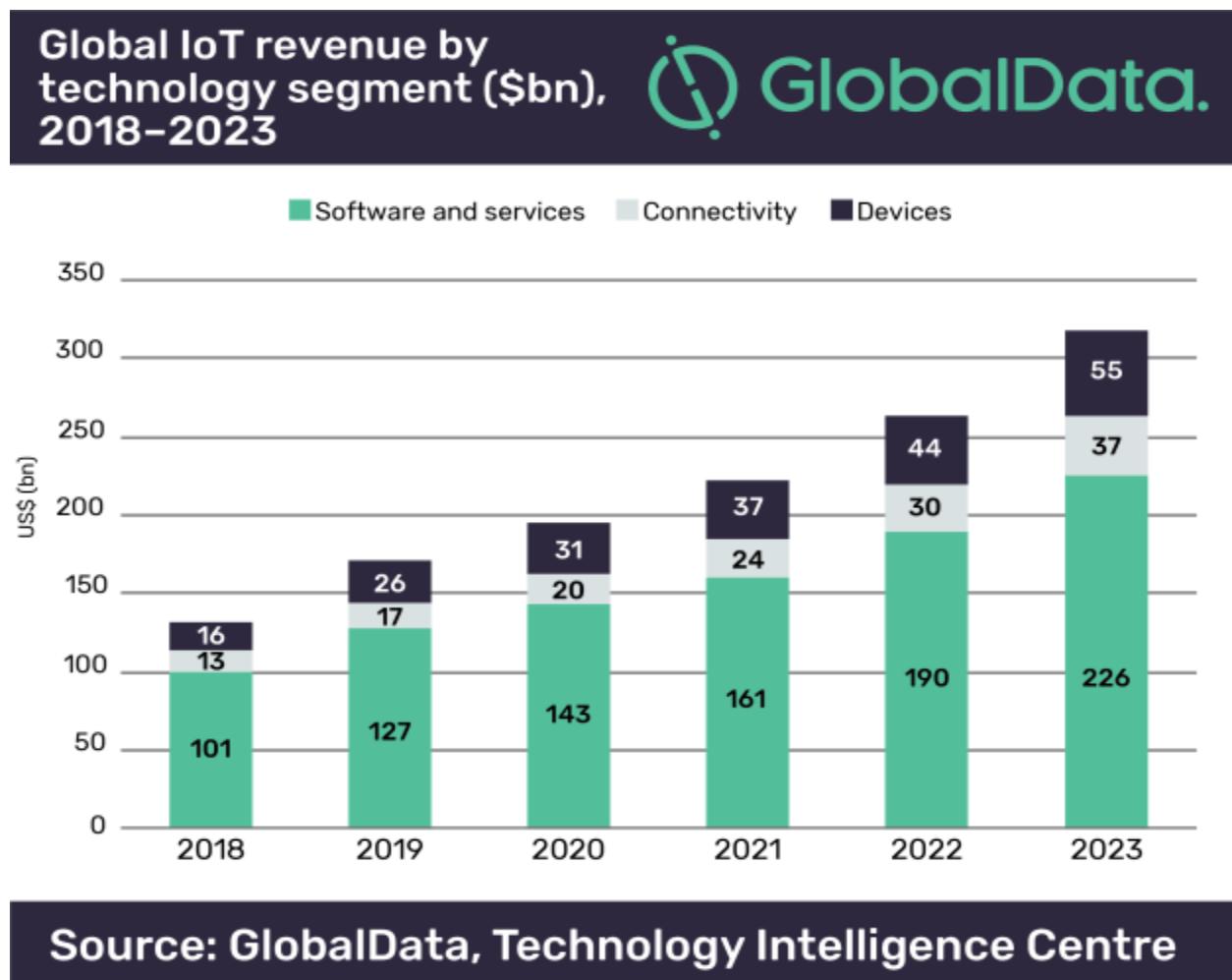


Figure 4 Growth of IOT (Froese, 2018)

IOT home automation is a topic which is familiar with everybody. The worldwide smart home mechanization market is expected to cross 21 billion US dollars by 2020. The expected cumulative annual rate of growth should be 26.3 percent between 2013 and 2020. According to Statista report, more than 45 million smart home devices will be connected in U.S. homes by the end of the 2018 year, giving an average income per house of approximately \$490. (Bhatt, 2019)

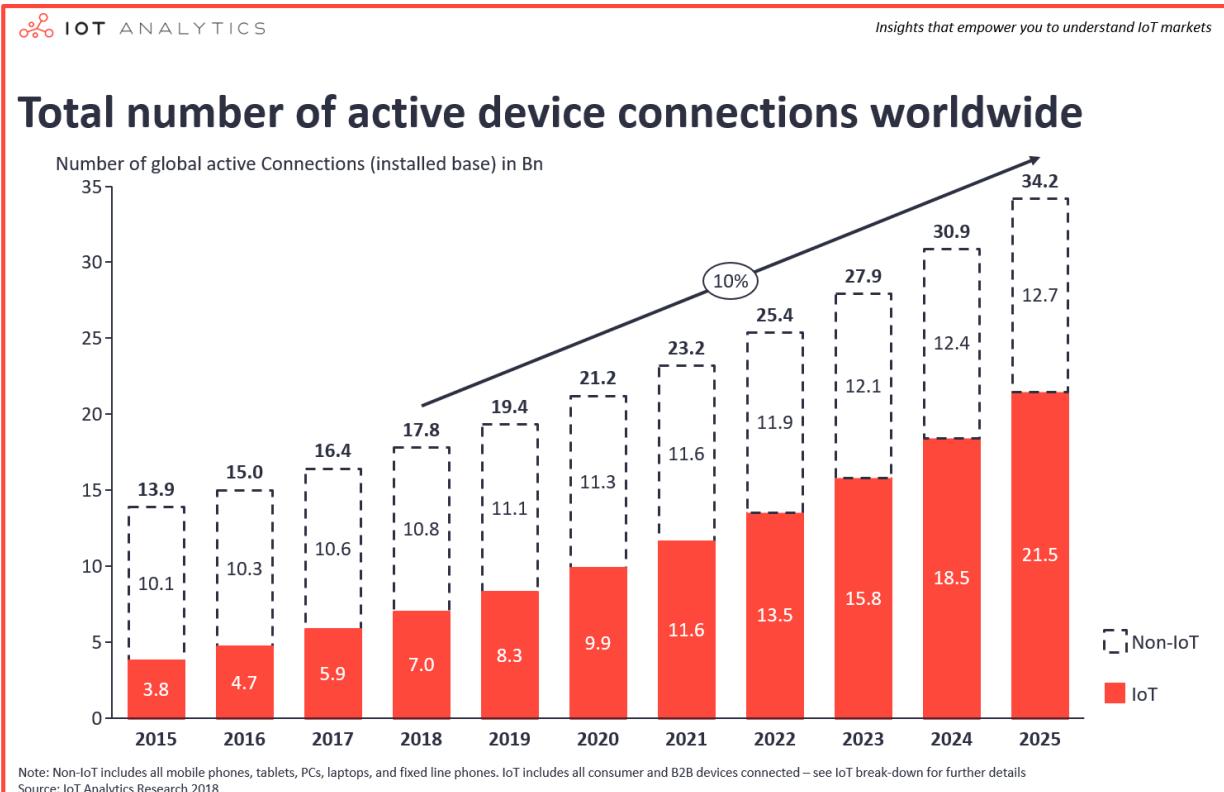


Figure 5 Total active devices in IOT (Lueth, 2018)

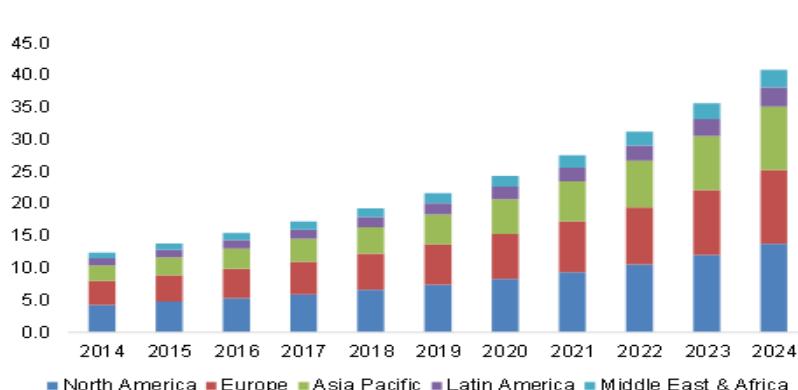
The total number of devices connected worldwide is more than 17 billion whereas the number of devices is more than 7 billion excluding the mobile phones, laptops, tv or tablets. It is expected that the number of device connection by 2025 would be around 22 billion, so we can imagine that IOT has been growing at a very high pace and it would be doing great in the future (Lueth, 2018)

### 1.6.2 Status of home automation

The Internet of Things (IOT) has helped clever creativity to become a clear part of our everyday lives in recent years. Smart home technologies will monitor anything from refrigerators to appliances to home protection. Home devices are an important component of the Internet of Things as they can be monitored and managed remotely from the Internet. Smart homes today are more concerned with convenience and live more sustainably. Remote flexible monitoring, computerized lights, robotized indoor regulator adjustment, booking computers, and remote video observation are all current trends in home mechanization. And for home automations sensors also plays very important role as sensors are the home system's eyes and ears. Sensors can be used every possible place so that it can be used for collecting data to make a useful output, sensors like temperature sensor, fire sensor, smoke sensor, ultrasonic sensors, light sensor, motion sensor and many more (Sharda R. Katre, 2017).

Future homes would be capable of providing nearly all necessary facilities, such as connectivity, medical, electricity, utility, entertainment, and defense. If we progress into the next decade, we can see an increase in the number of devices that link to one another. The perfect future is one in which data is shared between computers and humans without the need for individual byte input. Future would be more advanced and new technology will be introduced by the time being and we can expect that the future would be more advanced than what we have today (Sharda R. Katre, 2017).

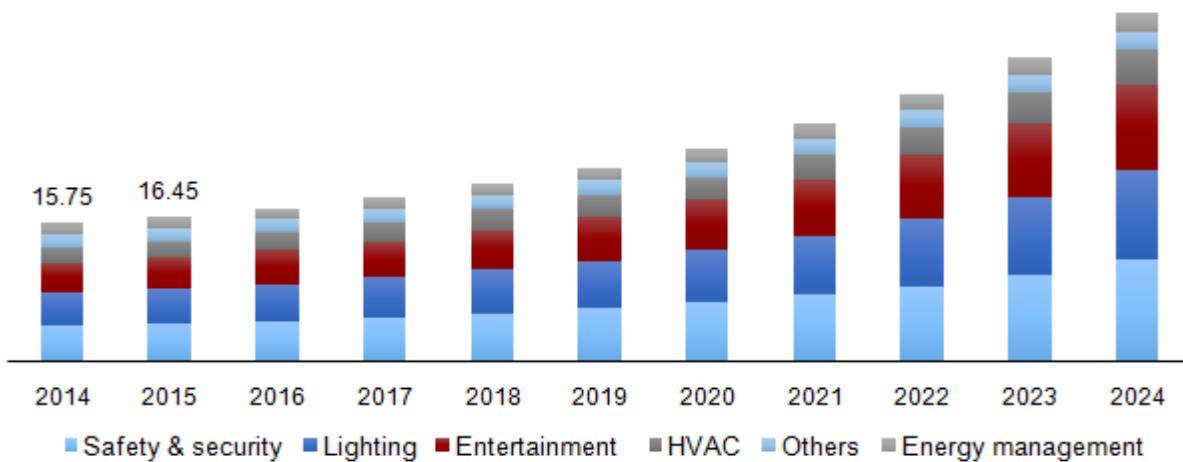
**Global Home Automation Market, by Region, 2014-2024 (in BN USD)**



Attribute	Details
Base Year	2016
Historic Analysis	2014 & 2015
Forecast	2017 to 2024
Complete Free Customization*	Equivalent to 50 analyst hours

Figure 6 Growth of global home automation market (Terrelle, 2019)

The above graph is based on the region of the global home automation market and it shows a major growth in home automation market. It was based on 2016 and the forecast is from 2017 to 2024 and it is expected to be 40 to 45 billion USD. So, we can imagine that home automation is being widely used and the connected devices as well as the valuation of home automation is increasing.



*Figure 7 Global market of home automation (Rajput, 2019)*

The above figure also shows the growth of IOT where safety and security, lightning, entertainment, HVAC, energy management all are constantly increasing with the period of time. It is estimated that home automation and IOT takes a huge place in future as well.

### 1.6.3 Status of thermal comfort/condition in home

Thermal comfort is a term that is very important while we are in the room or outside our room. While we are out there is not much we can do to maintain the thermal comfort but while we are inside our home there are plenty of things that we can do to make ourselves comfortable regarding the temperature. Temperature will vary in different sessions and we should maintain or set the temperature of our home accordingly. An ideal room temperature ranges from 20 to 25 degree Celsius, so if we could maintain this temperature range it would be comfortable for us to live in. According to the Committee on Climate Change in the UK, around 19% of the UK's carbon emissions come from heating the homes and workplaces which includes the unnecessary heating of the homes and workplaces by forgetting to turn it off or human negligence (Marcus, 2020).

As per some data in the UK and around the world in the last 20-30 years the average room temperature has risen, back in 1980 the average room temperature was around 12 degree Celsius and now it has gone up to 17-23 degree Celsius. So, we can say that the climate change has affected the average room temperature as well. People around the world spend around 90% of the time indoors during summer and 97% of the time in winter. Building HVAC systems could adapt in real time to people's changing comfort levels and variations during the day, making them more relaxed. The degree to which a person is satisfied with their surroundings, especially their level of thermal comfort, has a direct impact on their health, well-being, and efficiency. Uncomfortable thermal conditions, on the other hand, lead to low work satisfaction, poor job results, lower self-estimated performance, and trouble focusing. Sick building syndrome (a sense of ill health that develops in the inhabitants of a building, such as eye, nose, and throat irritation) and elevated brain workload to complete cognitive activities may also be caused by high room temperatures. Long-term, a constant heavy mental workload can be harmful to one's physical health. One of the best ways to achieve an ideal working setting is to monitor the thermal environment by changing the room temperature set points (DA LI, 2020).

A study shows, Unintentional accidents are more likely to occur as air temperatures rise, according to 11 of 13 reports. For each 1°C rise in air temperature on days of mild temperatures, the increased risk ranged from 0.4 percent to 5.3 percent. Injury occurrence was reduced on days with very high temperatures. In two out of three reports on industrial injuries, high temperatures

were associated with a rise in work-related accidents. Six studies showed an uptick in trauma hospital admissions during hot weather, while one study found no connection. The evidence for the effects of subgroups including infants, the elderly, and drug users on accidents was minimal and contradictory (Eveline Otte im Kampe, 2015).

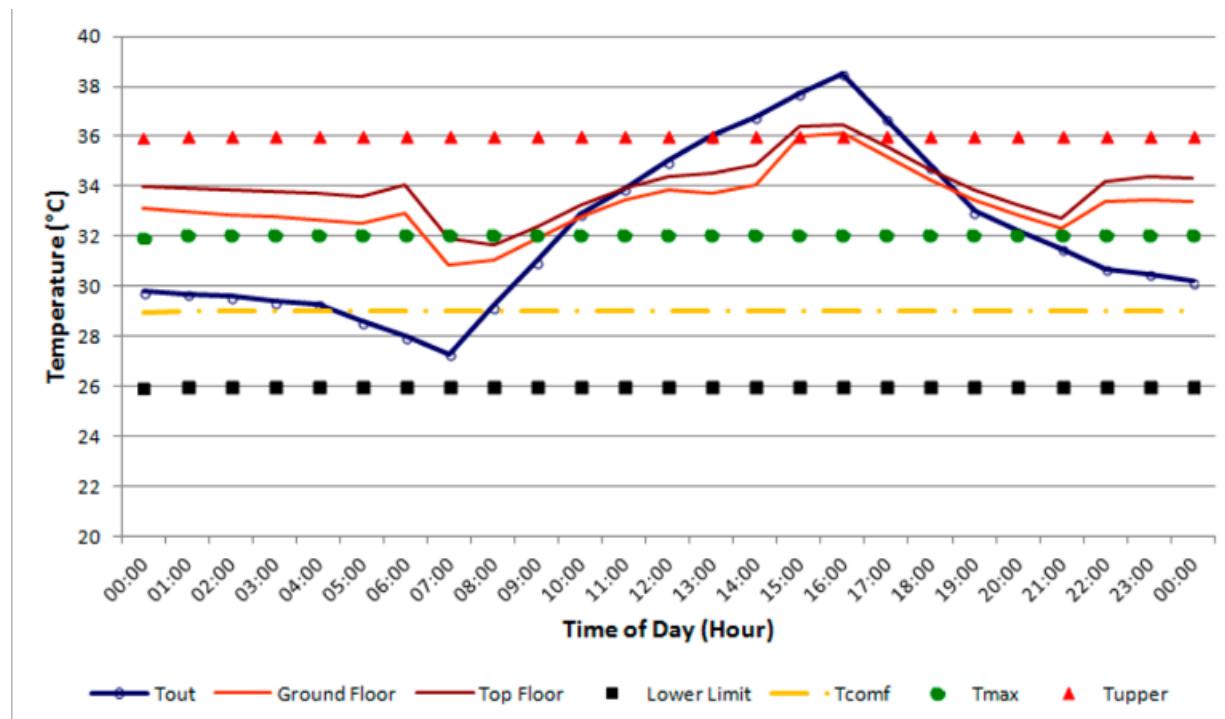
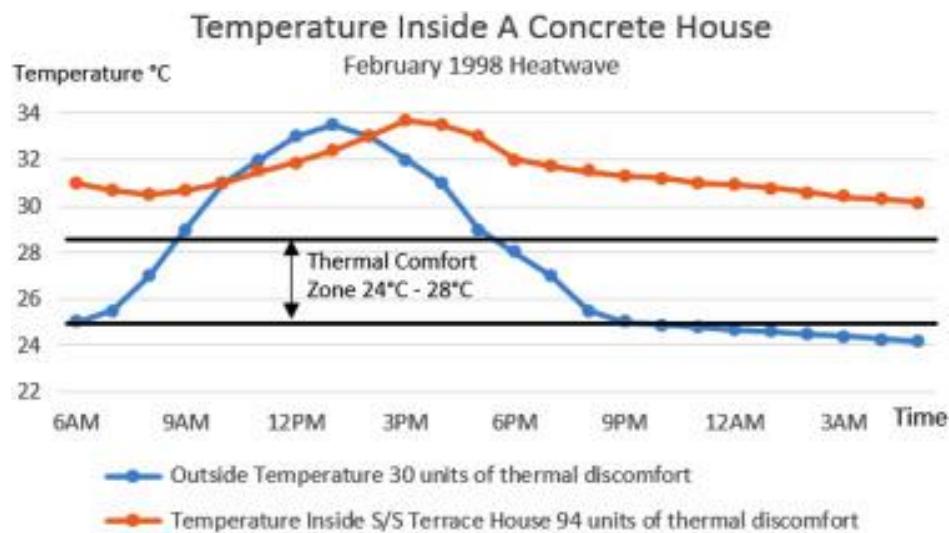


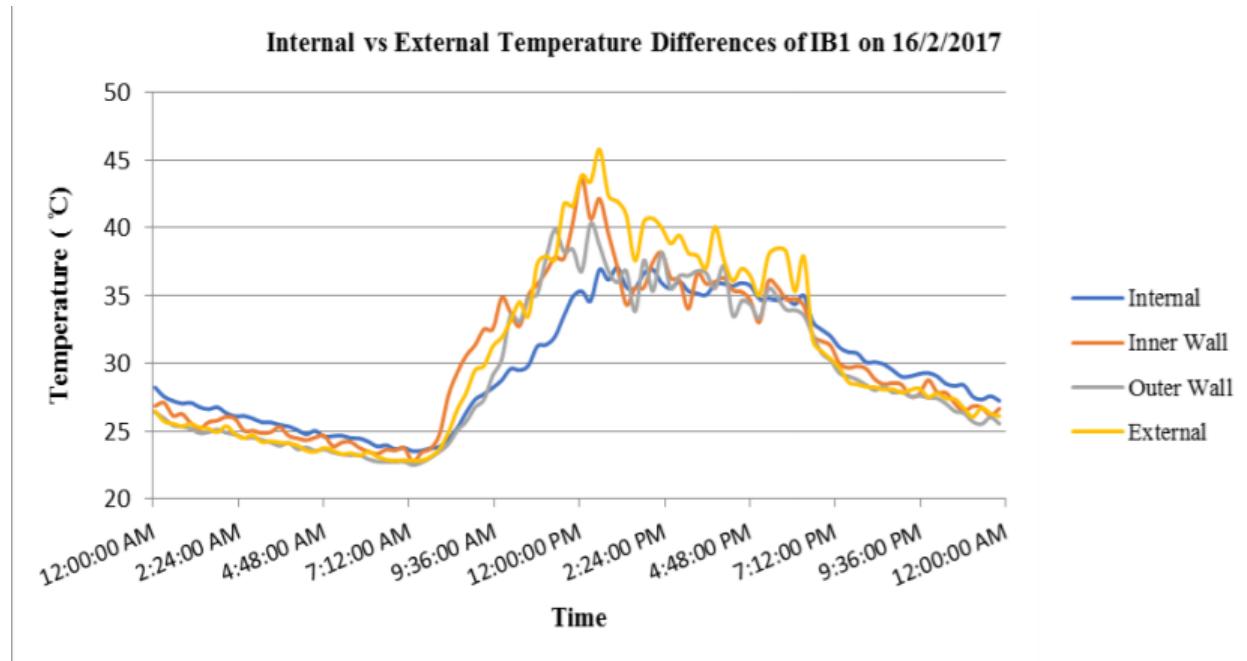
Figure 8 Room temp variation (Nafisa Bhikho, 2017)

The above figure describes the variation of the temperature according to the time in a day. Even compared with the tout, ground floor and top floor there are also the differences. It gradually increases in the daytime and in the night, it again goes back to low temperature. The peak temp shown in this figure has reached up to 38 degree and low as 27. There is much difference in the temperature the entire day. So, we can say that thermal comfort and maintaining it is very necessary in the room.



*Figure 9 Temperature inside a concrete house (Q. Roslan, 2016)*

This figure explains that the thermal comfort zone is usually between 24-28 degree Celsius and the temperature of the room can rise up to more than 35. So thermal comfort should be maintained in the room for better thermal experience and health.



*Figure 10 External and internal temperature (Sayang Syazanna Raf', 2018)*

This figure shows the difference between internal and external temperature. As we can see that there is a much difference in the temperature. To know the exact temperature inside the room we cannot depend upon the weather that shows in our mobile phone, as it only shows the temperature of the outside environment. So, there should be a device to measure the temperature inside our homes so that we can maintain the thermal comfort according to our need. It also shows the temperature variation according to the time. There is different temperature recorded in different time in an entire day. Compared to the external temperature internal temperature is low, so there should be proper measurement of the internal temperature and according to that thermal condition should be maintained.

The majority of households in the United States use thermostats to manage their heating and/or cooling systems. In 2005, over 97% of households in the United States had a heating system and over 75% had air conditioning (Therese Peffer, 2011). People are generally using the thermostats to manage the temperature and people are also using the manual heater and AC for controlling the temperature. Using the thermostat is helpful but until the set temp is not reached it continuously heats the room and until the temperature drops it would continue to heat the room and by setting the thermostat higher than the preferred temperature, the device would overheat the rooms, making them uncomfortable and stuffy, and wasting electricity. And for those who use manual heaters they tend to keep the heater on in the winter while going out which leads to energy loss and high heating of the room which can affect the health of the family (warmup, 2018). For those using thermostat it needs better position as it cannot be placed in direct sunlight and it should not be placed more than 5 feet from the door, it requires regular cleaning and maintenance, so it has problems which can also lead to thermal discomfort. Most of the people are using the heater and cooler as different devices where they should control them manually which can create problems like forgetting to turn it on and off which outside the house and wasting the energy by forgetting the status of the devices (Expert, 2020). So an automatic room temperature controller would be a best option for those people for best thermal comfort.

#### 1.6.4 Status of smart lights

Smart lightning is getting very popular these days. These are the lightning systems where the lights can perform its given task and make adjustments based on the given condition of day and night to turn on or off, or can be controlled via the internet and voice control. The lighting market holds a lot of value. According to McKinsey & Company, the general lighting industry was worth \$83 billion CAD in 2011, accounting for 75% of the global lighting market. Furthermore, according to McKinsey, the industry will expand to \$125 billion CAD by 2020, accounting for 80% of the global lighting market. Lighting in the residential and industrial industries absorbed about 11% of overall US energy demand in 2014 – a staggering 412 billion kWhs! These vast figures indicate a major carbon footprint for jurisdictions with carbon intensive energy supply, such as the United States. With carbon markets on the horizon, lowering demand will become increasingly important. Lights are being used from decades, people need lights almost everywhere leading to a high consumption of electricity and value. To make the lightning industries more valuable smart lights are introduced which changes the light industries (Mars, 2015).

Since 2012, the lighting industry has seen a rise in the number of connected bulbs. Wireless bulbs link to the internet and are powered by software on a customer's mobile device or laptop, rather than being controlled by a light switch or dimmer. According to a new study survey, the global Smart Lighting Market was worth USD 11.23 billion in 2019. By 2026, the demand is projected to expand at a CAGR of 18.5 percent, reaching approximately USD 36.84 billion. Awox SA, Control4 Corp, Cooper Lighting Solutions, Crestron Electronics Inc, Eve Systems GmbH, General Electric Company, are some of the leading industry players (Factors, 2021).

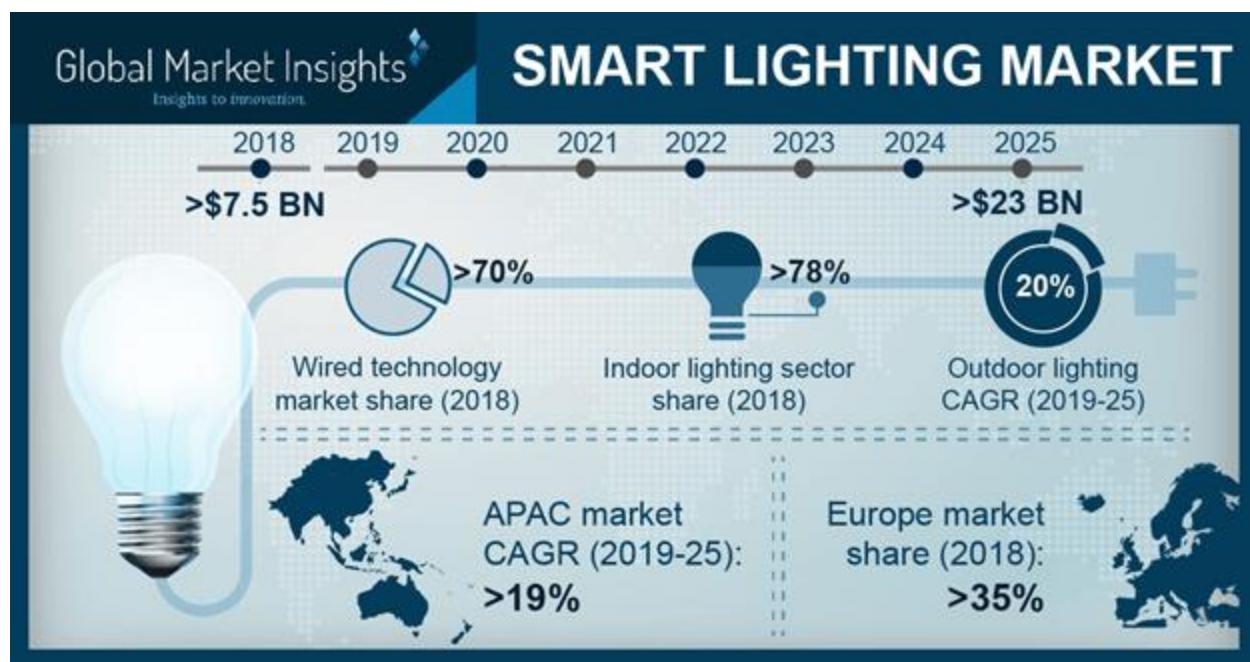
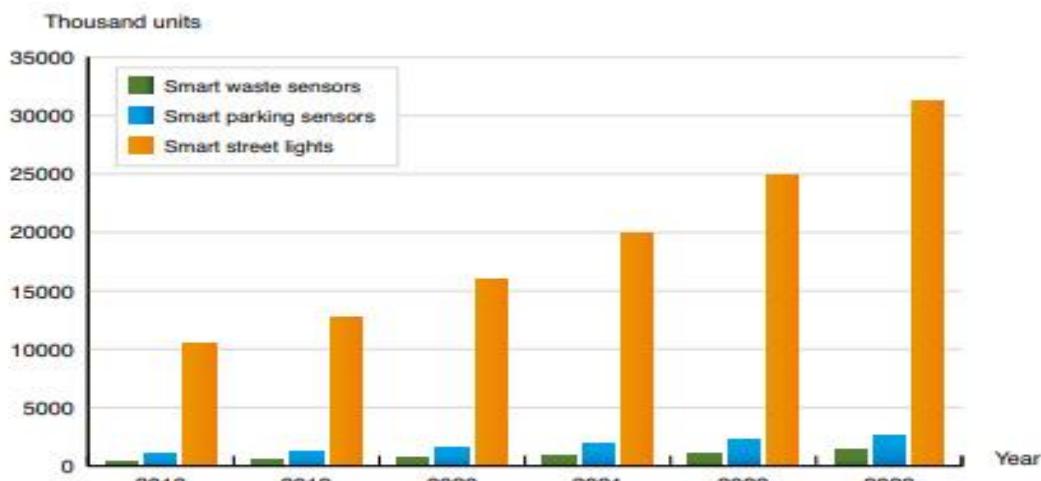


Figure 11 Smart lighting market (Ankita Bhutani, 2018)

The above figure also explains that the global market of the smart lightning is increasing pretty fast. The value of the smart light industry is also very high, and everyone are moving towards the smart lights rather than the normal lights because it has many benefits over the normal lights.



Installed base of smart cities applications (World 2018-2023)

Figure 12 Installed smart lights (news, 2020)

We can also see that smart lights are being installed in a rapid pace as said before people are moving towards the smart lights rather than the normal lights. People are moving towards smart lights and market value of smart lights are increasing as it has many benefits such as

- It helps to save energy as it can use motion sensors and detect motion to turn on and off the lights, it can be controlled via internet and voice control can also control the lights and keeps track if the lights are on or off.
- It is convenient as we can control the lights through our mobile phones so that we can control from our beds and we do not need to physically turn on or off the switch.
- It can change the color, adjust the brightness and be controlled automatically by the time of sunset and sunrise and also it can adjust the brightness while we wake up and go to bed according to our need (crist, 2019).

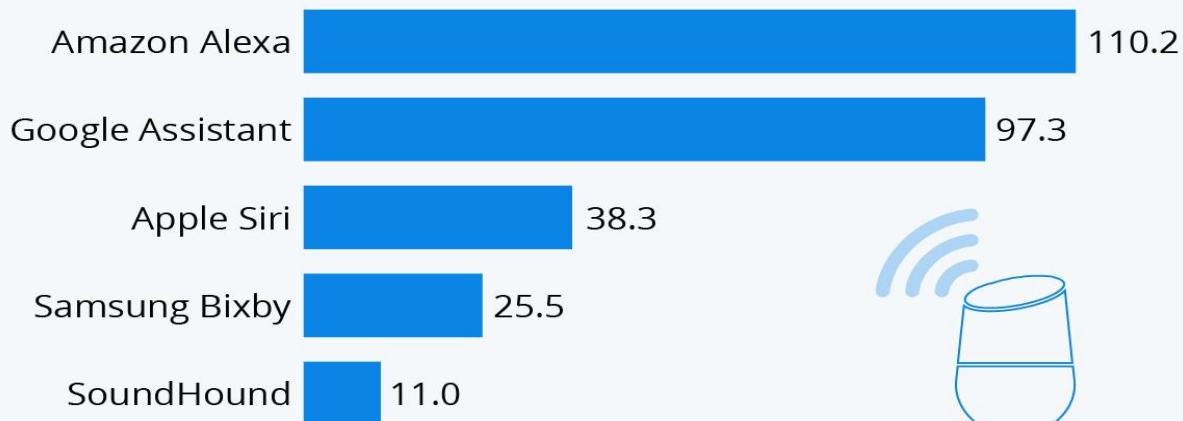
Smart lights are there to make our living comfortable and convenient, home automation and IOT has made those things possible and there are so much potential of the smart light industries later on the future as well because the world is moving towards automation. Implementation of the smart lights has its own benefits as discussed earlier and many people are moving towards smart lighting in their homes.

#### 1.6.5 Status of google assistant

Google assistant is one of the most used voice assistants in today's world. It is available in android mobiles and in google home device. Google has said that there are more than 500 million people who are using google assistant in their mobile phones, TVs and other smart home devices (Southern, 2020). Given the repeated handset update cycles, Google Assistant, which is the default interface on Android smartphones, has a good chance of improving its position in the market. Google Assistant consistently outperformed industry experts, accurately identifying and listening to requests on a regular basis. Google Assistant can understand two commands at once if you have a Google Home speaker, which is an improvement over Amazon Alexa's Follow-Up Mode. If Alexa can tell you the temperature inside and then set the thermostat, Google Assistant can do both. Google Assistant is even simpler thanks to newer, smaller technologies (staff, 2020).

# The Most Important Voice Platforms in 2020

Leading voice platforms worldwide based on Voicebot's Voice Platform Impact Rating\*



\* The rating includes the breadth of use, sentiment, current activity, and future plans stated by voice industry professionals. It is not a gauge of consumer adoption but rather of adoption and expressed intent by industry professionals to support the ecosystems. Scores can range from -250 to 250.

Source: Voicebot.ai



**statista** 

Figure 13 Voice platform in 2020 (Richter, 2020)

From the above it is shown that besides Amazon Alexa, Google Assistant is one of the most important and used voice platform in 2020. Besides Google Assistant there are other voice platform that are also in use. And Google Assistant is expected to grow on a large scale in the future as well.

### 1.6.6 Effect of thermal discomfort in human health

Thermal comfort is very necessary for humans. Extreme heat and cold are a major problem which can affect the health of humans. The temperature should be ideal for us to properly adjust in the environment. Due to exposure to high temperature human health can suffer many difficulties. Heat stress, heat cramps, heat stroke, and mortality may both result from prolonged exposure to excessive heat, as well as intensify preexisting chronic disorders like lung, cerebral, and cardiovascular disorders. These kinds of problems are mainly experienced by elderly people and children. The urban heat island effect is caused by high concentrations of buildings in urban centers, which generate and absorb heat, leaving the city center several degrees hotter than the surrounding areas (Woychik, 2017).

Due to thermal discomfort in housing, it can affect the sleep of the humans, increased wakefulness and reduced rapid eye movement sleep and slow wave sleep are the stereotypical symptoms of hot or cold exposure. Heat exposure while in sleep can increase in wakefulness and decreases slow wave sleep and rapid eye movement sleep which is a major problem related to human life. Sleeping and taking rest is very important and while sleeping, thermal comfort is very important. On the other hand, cold exposure can also lead to problems, cold exposure can lead to cardiac autonomic response during sleep. And compared to heat exposure, cold exposure leads to more impact in real life situations. Thermal discomfort can also affect the human mind as they cannot focus on any work, they feel tired and lethargic (Mizuno, 2012). So, thermal discomfort affects the human life physically as well as mentally and maintaining the thermal comfort is very necessary.

## 1.7 Analyzing the problem domain

Analyzing the problem domain maintained in 1.2.1, the current scenario discussed above also fully supports the problem domain. From the facts and data mentioned in the current scenario tells us that thermal comfort and proper thermal condition is very necessary, and it cannot be ignored in order to maintain the good health condition of peoples and healthy environment of the houses. The outdoor and indoor temperature are different, an ideal room temperature is between 20 to 25 degree Celsius, only based on the outdoor temperature the indoor thermal comfort cannot be achieved. In order to do so there should be calculation of indoor temperature and based on that temperature then only the perfect thermal comfort can be achieved. As shown in the figure 10, it also makes clear that the indoor and outdoor are not the same. There is always variation in the temperature of indoor and outdoor.

From figure 8, we can see that in an entire day the temperature can be different and to maintain the thermal comfort there should be an ideal range of the temperature, which is usually 24 to 28 degree, but it can also be different by the location of the house, and we can see that in figure 9 as well. Due to the continuous change in the temperature in a day maintaining the temperature as desired by the user is necessary to maintain the thermal comfort. Climate change has been occurring from many years and it has affected the indoor temperature. Back in the day the average room temperature would be around 12 but now it has gone up to 17 to 23 degree Celsius. People often spend their time indoor and maintaining the indoor temperature is very important.

From the current scenario we can see that the thermal discomfort can lead to many problems like low work satisfaction, poor job results, lower self-estimated performance, and trouble focusing. Sick building syndrome and elevated brain workload to complete cognitive activities may also be caused by high room temperatures. Unstable heat and cold brings problems in human health as well. Heat stress, heat cramps, heat stroke, and mortality may both result from prolonged exposure to unstable thermal comfort. For both children and elderly people, it can be harmful, it also creates sleep disorders as increased wakefulness and reduced rapid eye movement sleep and slow wave sleep are some of the symptoms that can be seen of hot or cold exposure. And

cold temperature also causes cardiac autonomic response during sleep. So, maintaining the thermal comfort for the wellbeing for every human is equally important as other health related factors.

Lights are necessary for every human being; without the installation of the lights, we cannot do almost anything. Lights also consume a lot of energy, and also people often forget to turn off the lights when not necessary which causes even more consumption of the electricity. So, smart light is a very viable option to go with, as per the data people are moving towards home automation which is a good thing, and it lets the light to turn automatically off when not in use which saves a lot of energy. As per the current scenario people are instating smart light for their home. There are many options for controlling smart lights, if installed properly every system works perfectly.

As mentioned in the problem domain people want everything in their mobile phone, they want to control every device from their own mobile. And people also often forget to turn their devices off while leaving for work which leads to electric loss. And analyzing those problems, a report which is referenced in the first paragraph of problem domain 1.2.1, it mentioned that according to the United Nations Environment Programme (UNEP), residential and industrial buildings use 60% of the world's electrical energy, and there is huge loss of energy due to carelessness of peoples. And people are focused on home automations as it makes our life comfortable and convenient. Another main problem is for the disabled people where they cannot control the home appliances like fan, heater and lights on their own by physically accessing them, so disable people can utilize most of the home automation where they can control the appliances via their mobile phone and also the thermal comfort can be maintained automatically where there is no need of physical access to the fan and heaters. According to the report mentioned in last paragraph of the problem domain, it says that the number of disabled people is projected to expand to 21% of the population by 2040 and 17% of the world population have blindness and visual impact and more than 1% of world population need wheelchair in daily basis, which shows that there are problems for disabled people to control the home appliances.

## 1.8 Project as a solution

As the problems are discussed and analyzed, there should be the implementation of the solution to mitigate the problems, creating a solution to the existing problem is important. As the main aim of this project is to develop a prototype system which automatically controls the room temperature using sensors and microcontrollers and automatically controls the lights using internet time and also the devices can be controlled via google assistant, this project helps to overcome the above-mentioned problems. This project is based on IOT which manages and run without human intervention. With the help of a smart room temperature controller and light with google assistant these problems can be mitigated.

As thermal comfort is important to maintain, this project helps to achieve it by the implementation of the sensors and controllers, where the sensor senses the current temperature of the room and according to the desired temperature set by the user the system maintains the constant room temperature by heating the room if the temperature is below the set temperature and cooling the room if the temperature is higher than the set temperature. And this project helps in implementation of the smart lights, where the lights are automatically controlled by the day and nighttime. If it is daytime the lights will automatically go off and if it is nighttime, it will go on, which helps in saving the energy by turning off the lights when not necessary. People want easy life where they can control the devices by their mobile phone. This project also helps to deal with this problem as it implements the voice control which is the google assistant where the devices like fan, heater, lights can be controlled via google assistant. Another main problem was for the disable people where they were not able to access the devices physically and control them and by the implementation of this system it helps the disable people to control the devices via there own mobile phone, they can use the google assistant to control the devices and also the devices can perform automatically so there is no need to worry for the disable people to control the heating and cooling of the room and also the lights where they are also automatic. And as said earlier they can also control via google assistant as per their need.

So, this project as a whole helps in mitigating the above problems which were discussed and analyzed.

## 2. Chapter 2: Literature review

### 2.1 Analyzing the problems

In the journal title as “Design and simulation of an automatic room heater control system” written by Adamu Murtala Zungeru, Mmoloki Mangwala, Joseph Chuma, Baboloki Gaebolae, Bokamoso Basutli. They talked about the home automation which is important and temperature controller systems are important for homes. They said that temperature should be in habitable range and the issues are faced in the homes where there are infants and elderly people where they need the best thermal comfort, elder people can find their way to deal with the thermal discomfort, but the infants cannot, and this can make the infants discomfort to live in their rooms. They also said that thermal discomfort leads to different health issues as well and the temperature of the perishable food items should also be maintained where their quality can deteriorate due to environmental conditions through time and temperature (Adamu Murtala Zungeru, 2020).

In the journal titled as “Temperature Control System” written by Emmanuel C. Ogu, Ekundayo John, Oyedesu Olumide. The authors states that there has been very unpredictable and unfavorable temperature conditions in the 21<sup>st</sup> century. Our atmosphere has been revealed as a result of the Green House impact, resulting in several uncertainties in our weather and environment in general. The need to keep the temperature of certain areas within a certain range has grown in recent years. Temperature Control Systems have become essential as a result of this. In homes there is the need of thermal comfort for a peaceful environment, in industries there should be temperature regulation in a specific range as some of the materials can be inflammable or explosive when the rise of the temperature. Hospitals need thermal comfort for the patients and morgues need to maintain the temperature for the bodies to prevent decay (Emmanuel C. Ogu, 2011).

In the journal titled as “Design and Implementation of a Room Temperature Control System: Microcontroller-Based” written by A. L. Amoo, H. A. Guda, H. A. Sambo, T. L. G. Soh. They said that dedicated room temperature regulation is no longer just a key problem in ensuring employee satisfaction and, as a result, improved job output; it's also a health and safety issue. As the weather becomes more erratic, maintaining a comfortable room temperature has become more difficult for homes and businesses. Individual thermal regulation has been shown in many studies to boost workplace comfort, fitness, and productivity. In industry as well as in homes adequate

heating and ventilation, especially in office buildings with high employee densities and in homes has become increasingly important (A. L. Amoo, 2014).

In the journal titled as “Design an Automatic Temperature Control System for Smart Electric Fan Using PIC” written by Zairi Ismael Rizman, Kim Ho Yeap, Nuraiza Ismail, Norizan Mohamad, Nur Hafizah Rabi’ah Husin. They stated that in this current world of changing temperature there needs to be implementation of temperature control fan which run on the basis of temperature of the room. This is to ensure that the cooling process runs more efficiently and effectively, particularly in large spaces and during hot weather caused by global warming. Humans can live a happier life by implementing the circuit. For senior citizens, making their lives easier is extremely practical. The circuit is also appropriate for people who are unable to manually switch on the fan (Zairi Ismael Rizman, 2013).

In the journal titled as “Literature Review on Home Automation system for Physically disabled Peoples” written by Saeed Faroom, Muhammad Nauman Ali, Sheraz Yousaf. They talked that why home automation is important for everyone especially elder and disabled people. As home automation makes the devices automatic and can perform in their own and disable people do not need to worry about controlling the devices physically as the devices are automated and also people who are busy in their life can also make a huge use of the home automation systems. Disable and elder people who are very important part of life, we cannot neglect their problems, so home automation can help with their life (Saeed Faroom, 2018).

In the journal titled as “Implementation of Smart LED Lighting and Efficient Data Management System for Buildings” written by Arun Kumar and Pushpendu Kar. They have said that the existing lightning system consumes a lot of energy compared to the smart LED lightning system which also provides better visual comfort in the working environment. They also stated that without compromising the visual occupants the smart LED lighting system utilizes the different energy-efficient technique. They added that energy consumption and cost increment are the problem of the existing non smart LED lightning system (Arun Kumar, 2017).

In the journal titled as “Design and Application of a Smart Lighting System Based on Distributed Wireless Sensor Networks” written by Yusi Cheng, Chen Fang, Jingfeng Yuan and

Lei Zhu. This journal points out the problems of the energy consumption of the buildings sectors which applies both for the houses and buildings. The inefficient controlling of the lights can lead to a huge wastage of the energy. The International Energy Agency predicts that by 2050 the energy demand of buildings will increase by 50%. In residential areas and houses energy consumption from lights are increasing which are causing a huge wastage of energy (Yusi Cheng, 2020).

In the journal “Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant” written by M. Poongothai, K. Sundar, B. Vinayak Prabhu. The Internet of Things (IoT) is a framework that enables devices to be remotely linked, sensed, and managed over a network infrastructure. In human absence controlling and monitoring the devices which consume power is a major inability. For better comfort, better utilization of the devices and a smart environment smart connection is necessary. For efficient control of devices and monitor them google assistant can be used. The introduction of Google Assistant not only makes it more accessible to users, but it also makes the process more social with its responses (by M. Poongothai, 2018).

## 2.2 Analyzing the solutions

In the journal titled as “Design an Automatic Temperature Control System for Smart Electric Fan Using PIC” written by Zairi Ismael Rizman, Kim Ho Yeap, Nuraiza Ismail, Norizan Mohamad, Nur Hafizah Rabi’ah Husin. The author designed the system where the temperature senses the temperature with LM35 sensor and the microcontroller used is PIC16F876A and when the temperature is high then the fan turns on and also the LCD shows the information of the temperature and the buzzer goes on when the temperature reaches the unusual value (Zairi Ismael Rizman, 2013).

In the journal titled as “Automatic Temperature Controller for Various Applications” written by H. P. Thakre, Akhil K. Gonde, Swapnil D. Balge. In this project to upgrade the functionality to an embedded automation feature, the microcontroller (8051) based automatic fan system is used. In compliance with the ambient temperature rise, the electric fan will automatically turn on. In order to control the fan according to temperature variations, the circuit uses a microcontroller. The device tests the temperature of the integrated circuit, where the fan is regulated in accordance with the programming environment. The system's temperature is also measured using a sensor. This value is given to the microcontroller. The microcontroller then sends a signal to the heater coil to increase or decrease the input voltage such that the heater's temperature stays within the required range (H. P. Thakre, 2017).

In the journal titled as “Design and Implementation of a Room Temperature Control System: Microcontroller-Based” written by A. L. Amoo, H. A. Guda, H. A. Sambo, T. L. G. Soh. The author has designed a prototype system where the LM35 sensor measures the temperature and sends to the microcontroller which compares the value of the room temperature and the desired set temperature. Then the signal is sent to the relays and connected switch which then activate the components connected to the system for maintaining the temperature in the desired range (A. L. Amoo, 2014).

In the journal titled as “Design of Temperature Control System for Computer Rooms Based on AT89C51 Single-chip” written by Kunliang Xu. The author has developed a system which measures the temperature and the calculated temperature and room temperature data set by the keyboard control circuit centered on the temperature sensor circuit were processed by the MCU. The temperature of the room is shown in real time on the LCD panel. In addition, the temperature measured is compared to the temperature set. If the temperature exceeds the set temperature the fan would turn on automatically (Xu, 2015).

In the journal titled as “Smart Room Temperature Controller IoT System” written by Erman Hamid, Muhammad Akmal Zolkepli, Nazrulazhar Bahaman, Syarulnaziah Anawar, Zakiah Ayop. Here the authors developed a system which uses the LM35 temperature sensor and NodeMCU as a microcontroller, and when the temperature rises then the set temperature the DC fan goes on and also it uses LCD for temperature information and ESP Notify Android Application for the notification (Erman Hamid, 2021).

In the journal titled as “Literature Review on Home Automation system for Physically disabled Peoples” written by Saeed Faroom, Muhammad Nauman Ali, Sheraz Yousaf. Here the author discusses about the system where it can automatically control the fan and other electronic devices using microcontrollers and sensors like temperature sensor and motion sensor. They also mentioned that the voice assistant is best for disabled people where they can control the electronic appliances. It takes command from user and perform the task and it can also perform automatically. The author mainly focused for disabled people and make a system where the devices perform automatically with sensors and controllers and can also be controlled via voice assistant (Saeed Faroom, 2018).

In the journal titled as “Development and Implementation of Smart Street Lighting System based on Lora Technology” written by Ngo Thanh Tung, Le Minh Phuong, Nguyen Minh Huy, Nguyen Hoai Phong, Ta Le Dinh Huy, Nguyen Dinh Tuyen. The authors have described about the design and implementation of a smart street lighting control device based on Lora Wireless connectivity and LED lamps. The smart lighting system uses wireless communication frequencies below 1 GHz to power and track equipment. Hochiminh City University of Technology developed the smart lighting system to follow data transmission requirements. When attached to the center,

the automatic mode is maintained: Monitor the light according to the control center's preset scenario or time control, and the sensor emerges. The lights can also be controlled remotely (Ngo Thanh Tung, 2019).

In the journal titled as “Implementation of Smart LED Lighting and Efficient Data Management System for Buildings” written by Arun Kumar and Pushpendu Kar. The authors discussed how to implement smart LED lighting in smart buildings without losing occupants' visual comfort. The proposed lighting scheme used ZigBee and Wi-Fi connectivity to monitor the lights in commercial/residential buildings based on available natural daylight, occupancy, or the needs of the building's occupants. To account for varying uses, the lighting system can be run in three different modes: manual, automatic, and hybrid. The data on the use of personalized smart LED lights by building inhabitants is collected using a wireless sensor and actuator network (WSAN). Despite of using the sensors the lights can also be controlled by the current data of sunset and sunrise (Arun Kumar, 2017).

In the journal titled as “The implementation of Voice Command in Smart Homes” written by Fredrik Norberg and Zelal Yildirim. The authors discuss about the voice recognition, available voice assistants, use of voice assistant in homes and its benefits. Voice and speech recognition is a system which can operate on the voice of the human beings and which can answer the given query and perform certain tasks. Apple’s Siri, Amazon Alexa, Microsoft Cortana and Google Assistant are the voice assistant which is available today. Among these google assistant has the minimum error rate at 4.9% which is the lowest among all. They said that people use most of the voice assistant when their hands and eyes are busy, and they can only talk for example in cars. They mentioned that voice control helps people with disabilities as well and voice assistant can be implemented to any home appliances that can support voice control. Voice assistant is widely being used and it is a good practice they added (Fredrik Norberg, 2018).

In the article titled as “Voice Assistants: How Artificial Intelligence Assistants Are Changing Our Lives Every Day” written by Diana Ramos. The writer says that many of the gadgets we use on a daily basis include voice assistants. They're on our smartphones and in our home's smart speakers. They're used by a lot of smartphone applications and operating systems. Voices can also control certain technologies in automobiles, as well as in retail, education, healthcare, and

telecommunications settings. Voice assistants help us to perform a number of tasks without having to use our hands, which is one of the main reasons why so many people enjoy using them, especially on their phones. Siri is an Apple product. Google phones, as well as the majority of Android devices, have Google. Bixby is a virtual assistant developed by Samsung. Cortana is used on Windows mobile. According to the writer, the future of voice assistant is high, and majority of people are moving toward voice assistant as it is easy and convenient (Ramos, 2018).

## 2.3 Implementation of the solutions

In the journal titled as “Automatic Room Temperature and Monitoring System Using Arduino” written by Swetha S, Ilakkiya SN2, Nevetha R3, Sarathy S4, Deepa R5. Here the authors have developed a system where it uses the Arduino microcontroller as the main process controlling unit. The DHT11 temperature sensor monitors temperature and humidity. In the Liquid Crystal Display, the calculated value of temperature and humidity is shown. The relay in this system is used as the switching factor to activate the devices according to changes in temperature. The temperature information is already set by the user. The relays activate the heater if the temperature goes below the temperature set by the user and the relay activates the air conditioner if the temperature goes above the set temperature (Swetha S, 2019).

In the journal titled as “Automatic Temperature Control System Using Arduino” written by Kyi Kyi Khaing, K. Srujan Raju, G. R. Sinha, Wit Yee Swe. Here in this project for the temperature sensor it uses LM35 sensor which measures the temperature. And here Arduino is used, and the temperature is set according to the user. The temperature sensor measures the temperature and according to the set temperature, if the temperature is high, it turns on the fan and if the temperature is low the fan is off. And also, an LCD screen is connected where the temperature is shown. Here a final system is designed where it controls the fan according to the temperature measured (Kyi Kyi Khaing, 2020).

In the journal title as “Design and simulation of an automatic room heater control system” written by Adamu Murtala Zungeru, Mmoloki Mangwala, Joseph Chuma, Baboloki Gaebolae, Bokamoso Basutli. The authors have designed a system where it allows to set the desired temperature for the user and using a temperature sensor LM35 which measures the room temperature. If the set temperature is high, then fan would turn on and if the temperature is low

then the fan would turn on. They have used PIC16F877A for the microcontroller (Adamu Murtala Zungeru, 2020).

In the journal titled as “Temperature Control System” written by Emmanuel C. Ogu, Ekundayo John, Oyetesu Olumide. Here the authors have proposed a system where it control the room temperature, the user set the temperature and when the room temperature exceeds the set temperature then the fan would turn on and if the temperature is below the set temperature, then the heater would turn on. It also uses an LCD display for showing temperature information (Emmanuel C. Ogu, 2011).

In the journal titled as “Wireless Sensor Network for Temperature and Humidity Monitoring Systems Based on NodeMCU ESP8266: written by Wan Hafiza binti Wan Hassan, Ahmad Zaki Annuar, Wan Mariam Wan Muda. Here in this system, it uses DHT11 sensor for temperature and humidity sensor and NodeMCU as the microcontroller. The sensor measures the humidity and based on that, if the humidity get high it turns on the fan automatically and it also uses a cloud platform ThingSpeak to store data and it can be accessed via mobile as well. The fan is controlled manually, and it also operates automatically when the humidity is high (Wan Hafiza binti Wan Hassan, 2020).

In the journal titled as “Internet of Things Based Intelligent Street Lighting System for Smart City” written by Parkash Tambare, Prabu Venkatachalam. This project develops a system using IR transmitter and IR Receiver couple, when any object is detected then the lights would go on and when the objects go away the lights goes off (Parkash Tambare, 2016).

In the journal titled as “Design and Application of a Smart Lighting System Based on Distributed Wireless Sensor Networks” written by Yusi Cheng, Chen Fang, Jingfeng Yuan and Lei Zhu. Luminaires, switches, a distributed wireless sensor network (WSN), and a rule base for lighting control are all part of the proposed scheme. Each luminaire includes a sensing module that regulates the dimming level based on daytime illuminance, occupant presence, and schedules. The lights are controlled by the sensor, as the daylight is low then the lights become brighter and vice versa (Yusi Cheng, 2020).

In the journal “Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant” written by M. Poongothai, K. Sundar, B. Vinayak Prabhu. Here the authors have made the use of google assistant in their work place the devices like fan, lights can be controlled by google assistant. It uses blink api and NodeMCU for the central control unit for the system. Then relay is connected to the controller and end devices which then interacts with the google assistant (by M. Poongothai, 2018).

In the journal titled as “Design and Implementation of IoT-Based Smart Home Voice Commands for disabled people using Google Assistant” written by Haris Isyanto, Ajib Setyo Arifin, Muhammad Suryanegara. The authors have developed a system which operates with google assistants in order to help the people with disabilities, the system uses NodeMCU, mobile phone with google assistant. The end devices are connected via the relay module and the pin are connected to NodeMCU. And if the pronunciation is correct as set for the google assistant, it helps to control the devices as needed by the user (Haris Isyanto, 2020).

In the journal titled as “Measurement of Temperature and Humidity by using Arduino Tool and DHT11” written by Deeksha Srivastava, Awanish Kesarwani, Shivani Dubey. The authors have used DHT11 sensor for monitoring the temperature and humidity of the surrounding. They have used the Arduino IDE serial monitor for displaying the result of temperature and humidity (Deeksha Srivastava, 2018).

In the journal titled as “Monitoring environmental parameters: humidity and temperature using Arduino based microcontroller and sensors” written by Nagendra Dangi. The author has used the DHT11 sensor for recording the temperature of three different places, one is inside the room, another is outside the building and another is inside the isolated wooden box. Three different temperature and humidity were recorded, and it was displayed in the LCD. It verifies that the DHT11 can work for every possible environment (Dangi, 2017).

In the article titled as “Globally controlled multiple relays using NODE MCU” written by Kundan Ghosh, Monidip Bhowmick, Dipanwita Joddar. They have developed a system using NodeMCU which is connected to relay with multiple loads. The loads are then controlled by the

user globally via the NodeMCU. The devices of the home can be controlled remotely with the help of web browser (Kundan Ghosh, 2018).

In the report titled as “A SIMPLE SMART HOME BASED ON IOT USING NODEMCU AND BLYNK” written by AHMED H.H IMAM. The author has proposed a system where it uses Blynk app and NodeMCU which are connected with relay module with lights. By the Blynk app and NodeMCU the author has controlled the lights by the mobile phone through the internet with the help of NodeMCU. The Blynk app also shows the status of the lights as well (IMAM, 2019).

In the journal titled as “IoT-based Home Appliances Control System Using NodeMCU and Blynk Server” written by Rudrendu Mahindar, Madhav Prakash, Sananda Ghosh, Sumani Mukherjee and Dr. Rabindranath Ghosh. The proposed device helps the customer to monitor his home appliances remotely from anywhere at any time via a smart phone. Through reading sensor data in his smartphone application, the user can conveniently manage his equipment over the internet and track parameters of his household environment (Rudrendu Mahindar, 2018).

In the report titled as “Case Study: SITINA - A Software Engineering Project Using Evolutionary Prototyping” written by Nuno Jardim Nunes, Joo Falco E Cunha. The EDM utility company needed to track two small, fully automated hydroelectric power plants, so the SITINA project was born. The key aim was to create a low-cost application that would enable the board of directors to track and retrieve statistical data on the power plants production. Here doing this project the evolutionary prototype methodology was used because of its flexibility in the project (Nuno Jardim Nunes, 1999).

In the Article title “Applying Evolutionary Prototyping Model in Developing Stream-based Lecturing System” written by Nian-Shing Chen, Shin-Yi Huang. They develop a stream-based lecturing device that can completely interact with web-based teaching materials and recur conventional lecturing scenarios in low-bandwidth environments. Using an evolutionary prototyping development model, the authors suggest three variations of a stream-based lecturing method (Nian-Shing Chen, 2002).

## 2.4 Identification of the main Aims and Objectives

*Based on those literature reviews the proposed aim is logical and helps to mitigate the potential discussed problems. The objectives are in accordance with the research papers and the literature review, and the aims and objective of this project is also valid with the proposed literature review.*

As mentioned in the literature review, problems related to thermal comfort, use of normal lightning, potential loss of energy and problems faced by disabled people regarding controlling the home appliances were discussed and potential solutions to solve those problems were discussed. Analyzing those review implementations of the discussed solution can help to solve those problems. From the literature review it is found that thermal comfort is important, and a proper thermal condition leads humans for better lifestyle and problems regarding the human health due to thermal discomfort can also be decreased. Implementation of smart lights is a smart move for energy saving, it also mentions that disabled people are having problems controlling the home appliances as they can't access the devices physically. The main aim of this project is to manage the thermal comfort to eradicate the potential problem related to thermal discomfort and saving energy with the implementation of smart lights, on the other hand implementation of google assistant is there for disabled people to control the devices easily. Based on those literature reviews the proposed aim is logical and helps to mitigate the potential discussed problems.

From the literature review the problems were identified and implementation of the solution to mitigate those problems were also discussed. It is found that implementation of room temperature controller system and smart lights with google assistant can solve the discussed problems. To meet the discussed aim, the objective of the project is placed, there is the use of sensor to measure the temperature of the room. Microcontroller is connected with the sensor and relay where processing is done to control the end devices automatically for controlling the room temperature. Implementation of smart lights where time is recorded from the internet to control the lights is done for potential energy saving. Implementation of google assistant with Adafruit and IFTTT is carried out in order to control the devices. Disabled people can take the huge advantage of the system as it performs automatically based on sensors and microcontroller and with the implementation of google assistant it is even easier to control the devices for disabled and

normal people as well. The objectives are in accordance with the research papers and the literature review, and the aims and objective of this project is also valid with the proposed literature review.

### 3. Chapter 3: Background and Theoretical Foundation

Understanding the basic backend working and what component does the system uses is necessary. To complete a project, it is necessary to know the background and theory behind it. For this project hardware like sensors, microcontrollers, LCD display and other components are necessary and for the software Arduino uno for coding, google assistant are the basic necessities for this project which is described below. And besides that, MQTT protocol is also necessary for the communication purpose and its basic knowledge and foundation are described below as well. So, this section provides the background and theoretical foundation of the tools and techniques that are used.

#### 3.1 MQTT protocol

MQTT (Message Queuing Telemetry Transport) is a lightweight messaging protocol which was developed by IBM and first released in 1999. It is a publish and subscribe network protocol which transports messages between devices. MQTT is mainly used for machine-to-machine communication or for IoT connections. It's a low-latency, low-bandwidth, and insecure messaging protocol (subscribe and publish) intended for small devices and networks. Its architecture guidelines are intended to minimize network latency and system resource needs while still ensuring supply protection (router, 2021).

MQTT was found by Dr. Andy Stanford-Clark and Arlen Nipper in 1999, it was originally created for the purpose to allow monitoring the devices used in oil and gas industry to send the data to the remote servers. These tracking systems were mostly used in remote areas where establishing a landline, wired link, or radio communication connection would be difficult, if not impossible. At the time, satellite communications were the only choice for such situations, and they were very costly and charged depending on how much data was used. In 2013, the Organization for the Advancement of Structured Information Standards (OASIS) standardized MQTT as an open access protocol. The MQTT standard is now controlled by OASIS (explained, 2021).

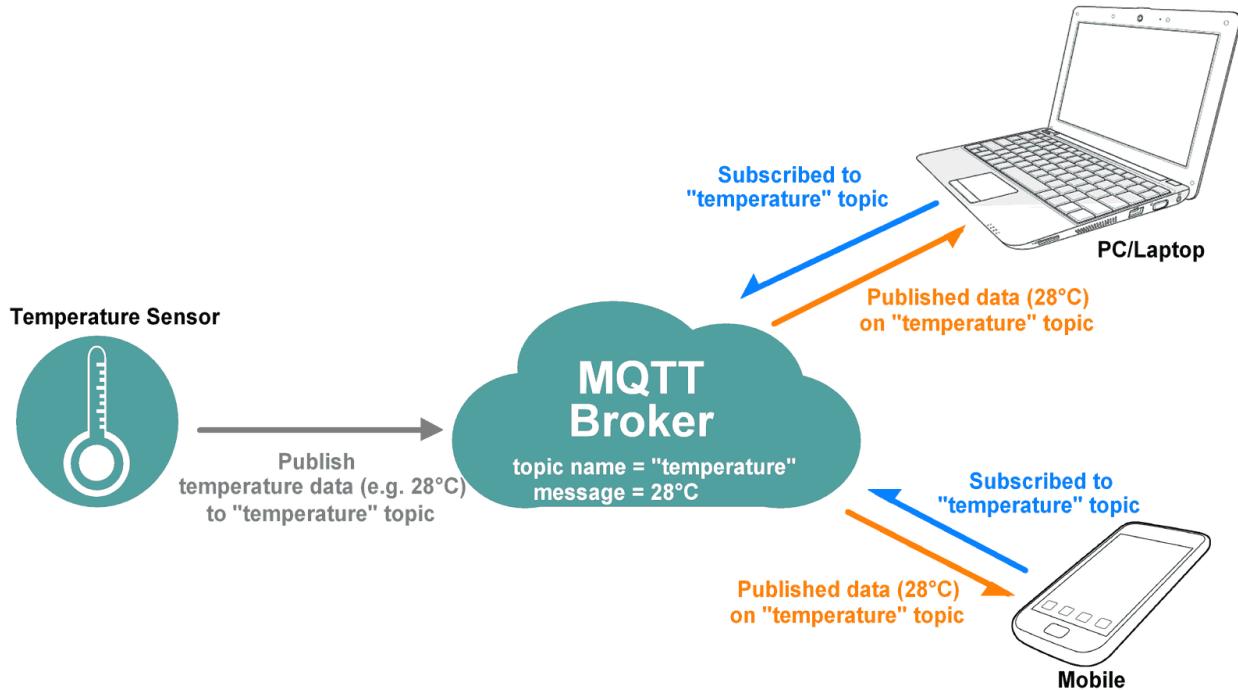


Figure 14 MQTT architecture (Dave, 2018)

The above figure describes the architecture of the MQTT. MQTT uses a PUSH/SUBSCRIBE topology to operate on top of TCP/IP. There are two kinds of applications in MQTT architecture: clients and brokers. The server with which the clients connect is known as a broker. Client emails are received by the broker, who then forwards them to other clients. Clients bind to the broker rather than communicating individually with one another. Each client may be either a publisher, a subscriber, or both (Spofford, 2019).

### MQTT broker

Any Publish/Subscribe protocol revolves around the MQTT-Broker. A broker can handle thousands of MQTT clients at the same time, depending on the implementation. The broker is in charge of processing all messages, filtering them, deciding who has subscribed to each message, and then delivering it to others who have subscribed. All persistent clients' meetings, including subscriptions and missed calls, are held by the Broker. Any message must be routed via the Broker, who is the central hub. As a result, it's critical that the broker be highly flexible, communicate with

back-end processes, be simple to track, and, of course, be fail-safe. Broker stores, transmits and helps the client in subscription where the sharing of the message would be easy and without the broker in MQTT it is not possible for the communication between the clients (Team, 2019).

## MQTT client

Any device that runs a MQTT library and connects to a MQTT broker over a network is a MQTT client. The MQTT client, for example, may be a very small, resource-constrained device that connects via wireless and has a bare-minimum library. For research purposes, the MQTT client may also be a regular device running a graphical MQTT client. An MQTT client is essentially any application that talks MQTT over a TCP/IP stack. The MQTT protocol's client implementation is very simple and straightforward. One of the reasons MQTT is suitable for small devices is its simplicity of implementation. Server libraries for MQTT are available in a wide range of programming languages. Android, Arduino, C, C++, C#, Go, iOS, Java, JavaScript, and.NET are just a few examples (Team, 2019).

## MQTT topic

A UTF-8 string that the broker uses to filter messages for each linked client is referred to as a Subject. One or two subject layers make up the topic. A forward slash separates each subject level (topic level separator). MQTT topics are rather straightforward as compared to message queues. Until publishing or subscribing to a subject, the client is not required to construct it. In MQTT, topics are not generated specifically. If a broker receives data that needs to be released to a subject that doesn't exist yet, the topic is automatically generated, and clients will subscribe to it (Yuan, 2020).

## Adafruit IO MQTT API

A MQTT client library is needed to use the MQTT API exposed by Adafruit IO. Adafruit's IO libraries support MQTT and are available for Python, Ruby, and Arduino. Look for a MQTT library that implements the MQTT 3.1.1 protocol in other languages or platforms. The majority of Adafruit IO connections are made up of plain, automatic devices and MQTT client scripts. A rogue ESP8266 transmitting MQTT SUBSCRIBE packets within an Arduino sketch's main loop()

function can send up to 500 packets every minute. If we didn't apply rate caps on any action, it wouldn't take many badly written clients connecting to our MQTT broker to crash the service for all (Adafruit, 2019).

To connect to a MQTT client to Adafruit IO following connection details should be considered:

- Host: io.adafruit.com
- Port: 1883 or 8883 (for SSL encrypted connection)
- Username: Personal Adafruit account username
- Password: Personal Adafruit IO key

The Adafruit IO device is built around feeds. The feed contains information about the details that are send to Adafruit IO. This provides options for making the data public or private, as well as a basic overview of the data and the license under which it is kept. The sensor data values that are pushed to Adafruit IO from the computer are also included in the feed. The MQTT API from Adafruit IO exposes feed data via special topics. People can subscribe to a feed's topic to be updated anytime the feed has a new value, or they can post a new value for a feed to its topic. Feeds keeps the record for the data and the feed update automatically whenever any data are sent to the Adafruit (Adafruit, 2019).

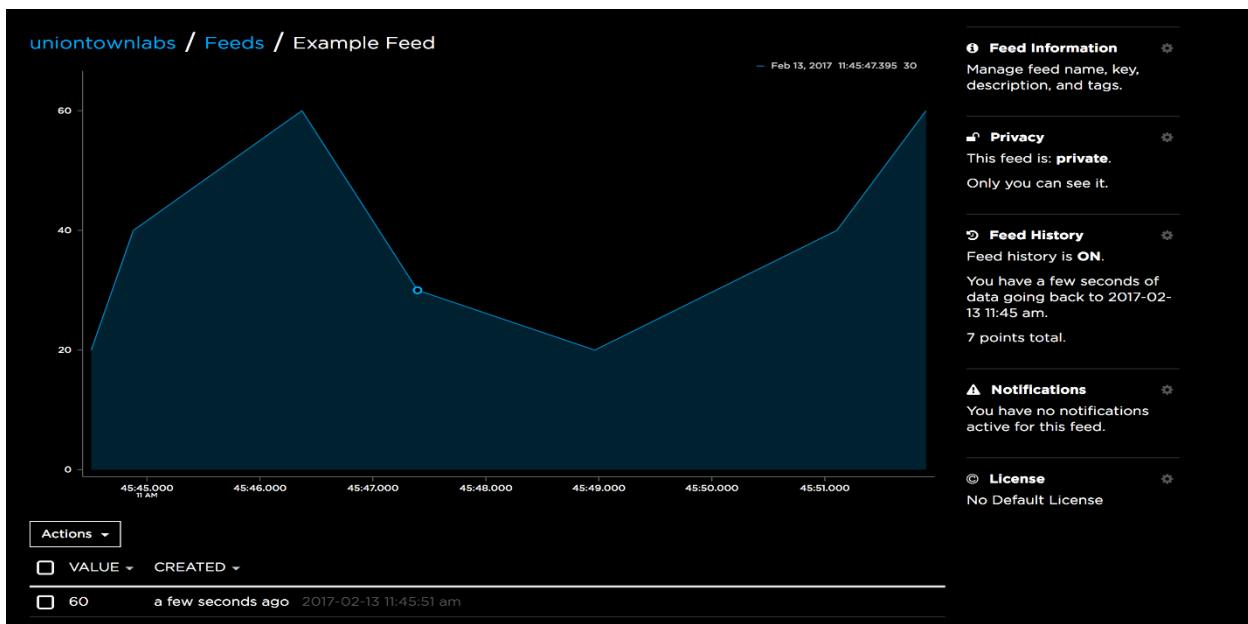


Figure 15 Example of a feed (Adafruit, 2019)

Besides this Adafruit and IFTTT are also the main components used in this project, an overview of Adafruit and IFTTT can be found in the section 1.4 and also the overview of google assistant is done in section 1.5, current status of google assistant is in the section 1.6.5.

Adafruit MQTT API is needed for the communication of the devices through the internet, in IFTTT applets are created to link the devices between Adafruit and the google assistant. In the microcontroller (NodeMCU) discussed below contains a proper coding including the Adafruit IO key and username. Hardware like the fan and led are connected to NodeMCU and with the WIFI module of the NodeMCU it helps the devices to connect to the Adafruit MQTT API with the IFTTT and google assistant. Without the proper selection of the hardware, these components mention are of no use. These components like the MQTT protocol, Adafruit, IFTTT and google assistant work in hand to hand with the hardware components mentioned below in order to achieve a required result. With the help of the hardware the Adafruit is able to store the current status of the devices as well, if it is on or off, record of the devices when it was turned on and off and many more.

## 3.2 Hardware and Software

Proper hardware and software requirement for a project is a basic need, in this kind of project, the proper selection of hardware and software should be done for the best result. The things that we can see and feel lie the sensors, microcontrollers, LCD displays are some of the hardware components used and the Arduino IDE, google assistant, protocols for establishing communication are the software requirements which connects the hardware to generate a result. Here in this section the hardware and software used are described.

### 3.2.1 NodeMCU

NodeMCU is a microcontroller unit which is open source IOT platform which is based in the ESP8266 Wi-Fi SoC from Espressif Systems. Since NodeMCU is an open-source framework, anyone may update, change, or build its hardware. The ESP8266 Wi-Fi enabled chip is included in the NodeMCU Dev Kit/board. The ESP8266 is a low-cost Wi-Fi chip with TCP/IP protocol developed by Espressif Systems. The firmware is written in Lua, an easy-to-learn scripting language that combines a basic programming environment with a quick scripting language that

links you to a large developer community (Aqeel, 2018). Here in this project it is one of the main component and is the heart of the project where all the processing are done. Its general benefits are:

- NodeMCU is Simple to use.
- It is programmability using the Arduino IDE or the LUA programming languages.
- It's possible to use it as an entry point or a station. Applicable in APIs of Event-Driven Events.
- The presence of an internal antenna
- There are 13 GPIO pins, 10 PWM channels, I2C, SPI, ADC, UART, and 1-Wire connections on this board (Hosseini, 2019).

The basic specification of NodeMCU is as follows:

- Clock speed: 80MHz
- USB to serial: CP2102
- USB connector: Micro USB
- Operating voltage: 3.3v
- Input voltage: 4.5-10v
- Flash Memory/SRAM: 4 MB / 64 KB
- Digital I/O Pin: 11
- Analog in Pins: 1
- Wi-Fi Built-In: 802.11 b/g/n
- Temperature Range: -40C - 125C (Aqeel, 2018)

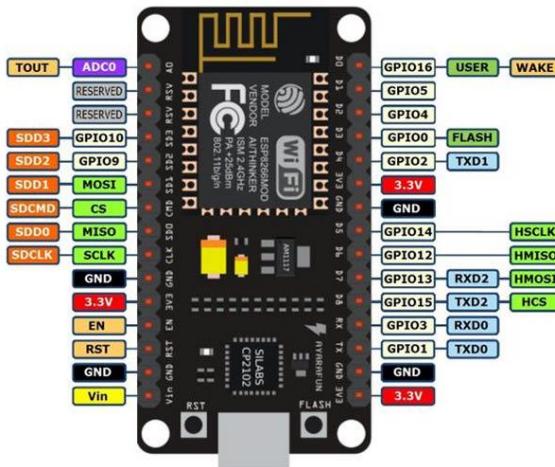


Figure 17 NodeMCU pins (Components, 2020)



Figure 16 NodeMCU (Components, 2020)

**Power pin** – One VIN pin and three 3.3V pins make up the four power pins. If there is a controlled 5V voltage source, the VIN pin can be used directly to supply the ESP8266 and its peripherals. The 3.3V pins are the output of a voltage regulator on the surface. Power can be supplied to external components via these pins.

**GND** – It is a ground pin of ESP8266 NodeMCU development board.

**I2C pins** – I2C Pins are used to connect all kinds of I2C sensors and peripherals. I2C Master and Slave are also assisted. I2C protocol features can be implemented programmatically, with a maximum clock frequency of 100 kHz. It should be remembered that the I2C clock frequency should be higher than the slave device's slowest clock frequency (engineers, 2021).

**GPIO pins** – The ESP8266 NodeMCU has 17 GPIO pins that can be programmatically allocated to different functions including I2C, I2S, UART, PWM, IR Remote Control, LED Light, and Button. Each digitally activated GPIO can be set to high impedance or internal pull-up or pull-down. It can also be set to edge-trigger or level-trigger to produce CPU interrupts when programmed as an input.

**UART pins** – The ESP8266 NodeMCU has two UART interfaces, UART0 and UART1, which can communicate at up to 4.5 Mbps and have asynchronous connectivity (RS232 and RS485). For connectivity, UART0 (TXD0, RXD0, RST0, and CTS0 pins) may be used. It facilitates fluid

control. However, since UART1 (TXD1 pin) only transmits data, it is typically used for printing logs.

Control pins – The ESP8266 is controlled via control pins. Chip Enable pin (EN), Reset pin (RST), and WAKE pin are among these pins.

- EN pin – When the EN pin is pulled HIGH, the ESP8266 chip is powered. When the chip is pulled LOW, it uses the least amount of power possible.
- RST pin – RST pin is used to reset the ESP8266 chip.
- WAKE pin – Wake pin is used to wake the chip from deep-sleep (engineers, 2021).

Microcontrollers are the heart of any IOT projects, there are different microcontrollers available and according to the project requirement the microcontroller should be selected. In this project NodeMCU is used because it comes with the Wi-Fi module attached and with that it helps the system to be connected to the internet. As this project need the internet connection for the google assistant to control the devices, NodeMCU plays a huge role in it. With the availability of the Wi-Fi module, there is no need to add any extra interface or install other components to gain the access to the internet, simply a library should be included in the Arduino IDE platform and it is a very easy process to connect to the internet. Example code can also be found in the Arduino IDE where the actual coding is done for the NodeMCU. Brief discussion of Arduino IDE is also done below. As NodeMCU is the main hardware component required in this system it controls all the other components, like the DHT11 sensor sends the data to NodeMCU and with respect with the data main coding is done in the Arduino IDE, and with the help of that, components like fan, led and relays are controller via the NodeMCU. Description of sensor and other components are also mentioned below. So, NodeMCU is the main hardware component here and it controls all the devices, and the entire system depends on it as it is the main processing unit of the system.

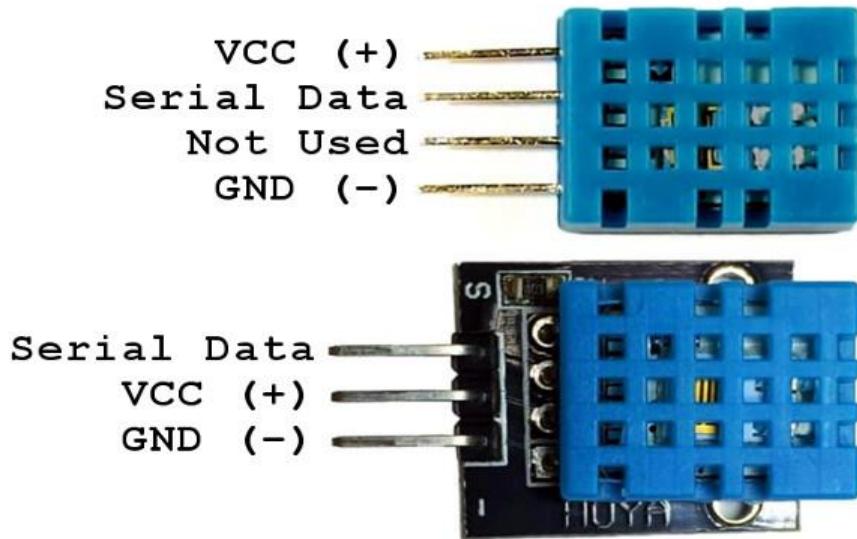
### 3.2.2 DHT11 Temperature and Humidity sensor

Sensors are an important component that record and measure the data of any environment or any objects. A brief description of sensors is already discussed above in the section 1.3. In this project DHT11 sensor is used to measure the temperature of the room and by measuring the temperature, it is then sent to the NodeMCU for further processing of the data and based on the temperature further work is carried out. the sensor is connected to the NodeMCU via the breadboard.

DHT11 is a temperature and humidity sensor which can be used in DIY projects and can be implemented in different places to record the temperature and humidity of that place. Its temperature ranges from 0 to 50 degree Celsius with +- 2 degree accuracy and from 20 to 80 percentage of humidity with 5 percentage accuracy. DHT11 is based on a technology that is extremely dependable and therefore offers a high level of stability. It's lightweight, inexpensive, and simple to use. This sensor is also used to measure air temperature and humidity in our weather stations. For measuring the humidity, it consists of capacitive humidity sensor and it has a thermistor inserted in it for temperature control, which is a resistive and wet NTC temperature measuring unit (Ali, 2019). DHT11 is used to measure the temperature of the room in this project.

The basic specification of DHT11 is as follows:

- Operating voltage: 3.5 to 5.5v
- Operating current: 0.3 to 5.5mA
- Sampling rate: 0.5 Hz
- Dimensions: 27mm x 59mm x 13.5mm (1.05" x 2.32" x 0.53").
- Weight: 2.4g (Ali, 2019)



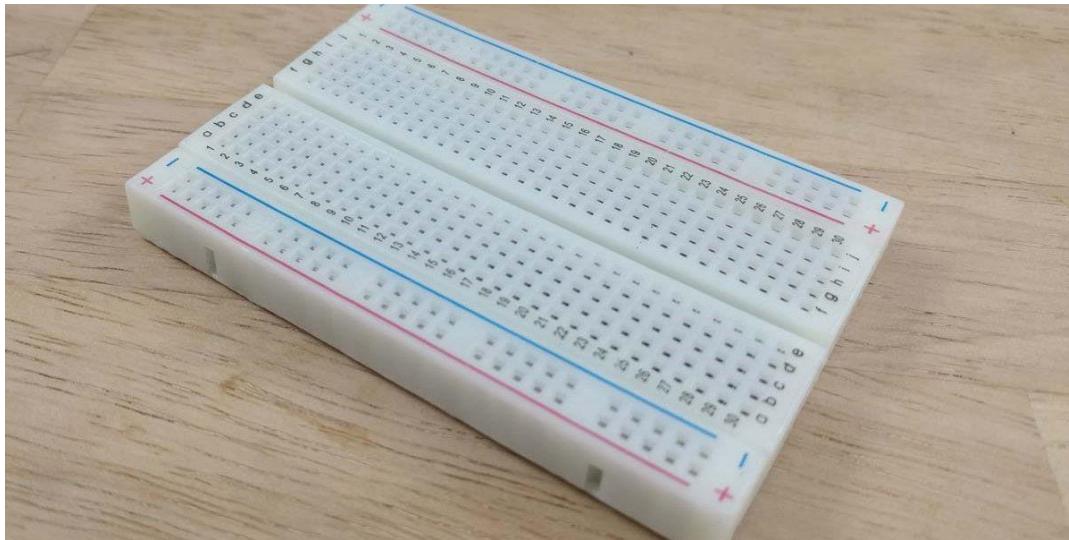
*Figure 18 DHT11 sensor (admin, 2018)*

### 3.2.3 Breadboard

Breadboards are a useful, reusable piece of electronics hobby equipment that allows for simple circuit creation. The breadboard is a circuit-building method that eliminates the need for soldering or permanent connections to create circuits quickly. Breadboards almost always have common rows where the holes in a row are electrically linked. Leaded parts are placed into holes containing metal grips that softly lock onto the lead, and breadboards almost always have common rows where the holes in a row are electrically connected. Breadboards can accommodate huge bits, such as DIP 40 ICs, and others have control rails on either side of the key rows. Most breadboards have clips on the front, back, and sides that can be used to attach them to other breadboards to create more complicated circuits. A breadboard is a good way to prototype and validate a basic circuit that works at relatively low frequencies. On a computer, one can use microcontrollers and complex ICs like I2C and SPI devices (Mitchell, 2018). Here in this project all the connections are established via breadboard, sensors, power supply and led are connected through it.

Here in this system breadboard is used for circuit connection and the DHT11 sensor discussed above is also attached in this breadboard. It has negative and positive rails and the power supply from NodeMCU(VCC) is connected to the positive rail of the breadboard and ground pin of the NodeMCU(GND) is connected to the negative rail of the breadboard. And from that power

supply to the breadboard, LCD and Relay modules are connect to the breadboard for the use of the power given from the VCC and GND pin of the NodeMCU. Sensor and led are also connected and signal, VCC and ground pin of both are linked with the NodeMCU as well. So here breadboard has helped to establish a connection with sensor, led, LCD and relay with the NodeMCU and breadboard is a very necessary hardware component used in this project.



*Figure 19 Breadboard (Cannaday, 2016)*

### 3.2.4 Relay module

A relay is essentially a switch that either electronically or mechanically opens and closes a circuit. In other words, a relay is an electromechanical switch that uses electromagnetism to switch higher current or voltage for various equipment using small current or voltage. In an electrical circuit, a relay is used to transfer smaller currents. The amplification effect of Relay is also visible. Due to touch switching, a slight voltage applied to the coil within the relay induces a higher voltage. It has two simple contacts: NO (Normally Open) and NC (Normally Closed) (Normally Closed). NC changes to NO and NO changes to NC as input voltage is applied across the coil. The relay is said to be energized as it receives input voltage. (Nasir, 2012)

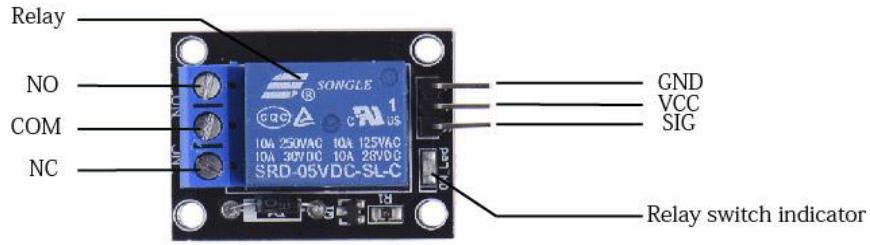


Figure 20 Relay module (Osoyoo, 2017)

The above figure is of the 1 channel relay module with pins specification, it has normally open (NO), normally closed (NC) and COM and on the other side it has ground, VCC and signal pins. Relay module is used for controlling the power supply of the fan where it has its own adapter and separate power supply in this project.

#### Relay module specifications:

- Supply voltage – 3.75V to 6V
- Quiescent current: 2mA
- Current when the relay is active: ~70mA
- Relay maximum contact voltage – 250VAC or 30VDC
- Relay maximum current – 10A (Osoyoo, 2017)

Relay module is connected with the NodeMCU through the breadboard and relay is used to control the fan in this system, signal pin is connected with the NodeMCU and positive and negative pins are connected through the breadboard. Relay module has helped in connection with the fan which requires a separate 5v power supply which is given from an adapter.

### 3.2.5 LCD display

LCD stands for liquid crystal display and is often used to display various values in various electronic projects and equipment. Liquid crystal displays (LCDs) use liquid crystals to provide transparent images. A standard LCD module used in DIY electronic projects and circuits is a 16 x 2 liquid crystal display. LCDs come in a variety of configurations, including (8 x 1), (10 x 2), and (16 x 1), but the 16 x 2 liquid crystal is most often used in embedded designs. There are thirty-two characters in this liquid crystal display, each of which is made up of 5 x 8 pixels. The LCD display which comes with the I2c model is easy to use and connect as it only has 4 pin, signal pins, VCC and ground pins. It generally operates in 5-volt, LCD display is very useful for DIY projects as the data can be visualized through the LCD display and we do not need to depend on the serial monitor of the Arduino ide (Jones, 2019). In this project it is used to display the information regarding the temperature, time, date.

LCD display is used to display the current room temperature which is measured from the DHT11 sensor mentioned above. Along with the current temperature it shows the set temperature set by the user in the actual code done in the Arduino IDE. And another LCD display is used for the smart lights which shows the current time and date. LCD display is the interface where users can view the current status and the final output of the system. It is connected to the NodeMCU via the breadboard, and it is also one of the important components used in this system.

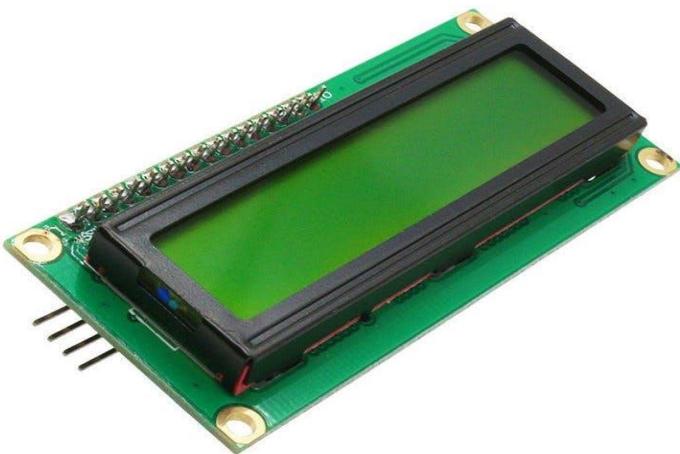


Figure 21 LCD display (MisterBotBreak, 2018)

### 3.2.6 5v DC fan

Here a 5v DC fan is used in this system which is connected with the NodeMCU via the relay module. the DC fan requires a separate power supply and a 5v adapter is used for power supply to the fan and a relay mode helps in establishing a connection of the fan with the NodeMCU and the adapter. Here this fan is controlled automatically as discussed earlier if the temperature is more than the set temperature the fan would turn on and also this fan can be controlled by the google assistant as well. The main purpose of using a 5v fan is to demonstrate how the system works and a bigger fan can be used for the system as well and it is only a prototype system so a small fan is used but as mentioned a bigger fan can also be implemented.

### 3.2.7 LED light

A light-emitting diode (LED) is a semiconductor chip that absorbs light when an electric current is passing through it in its most basic form. As the current-carrying particles (known as electrons and holes) collide inside the semiconductor material, light is emitted. LEDs are solid-state devices and light is emitted inside the solid semiconductor material. The word "solid-state lighting," which includes organic LEDs (OLEDs), separates this type of lighting from those that use heated filaments (incandescent and tungsten halogen lamps) or gas discharge (fluorescent lamps) (magazine, 2004).



Figure 22 LED (rowan07, 2018)

### 3.2.8 Arduino IDE

The Arduino IDE is a free and open-source program for writing and compiling code for the Arduino Module. It is official Arduino program that makes code compilation so simple that even a non-technical person can get their feet wet with the learning process. It runs on the Java Platform and is compatible with operating systems such as MAC, Windows, and Linux. It has built-in functions and commands that are useful for debugging, writing, and compiling code in the environment. On the board of each of them is a microcontroller that is programmed and accepts data in the form of code. The key code, also known as a sketch, generated on the IDE platform will eventually produce a Hex File, which will be transferred and uploaded to the board's controller. The coding is done in C and C++ language (Aqeel, 2018). All the coding is done in Arduino IDE and the preference is by default set to Arduino uno, but the preference should be change to NodeMCU for this project and all the code are uploaded in NodeMCU via Arduino IDE.

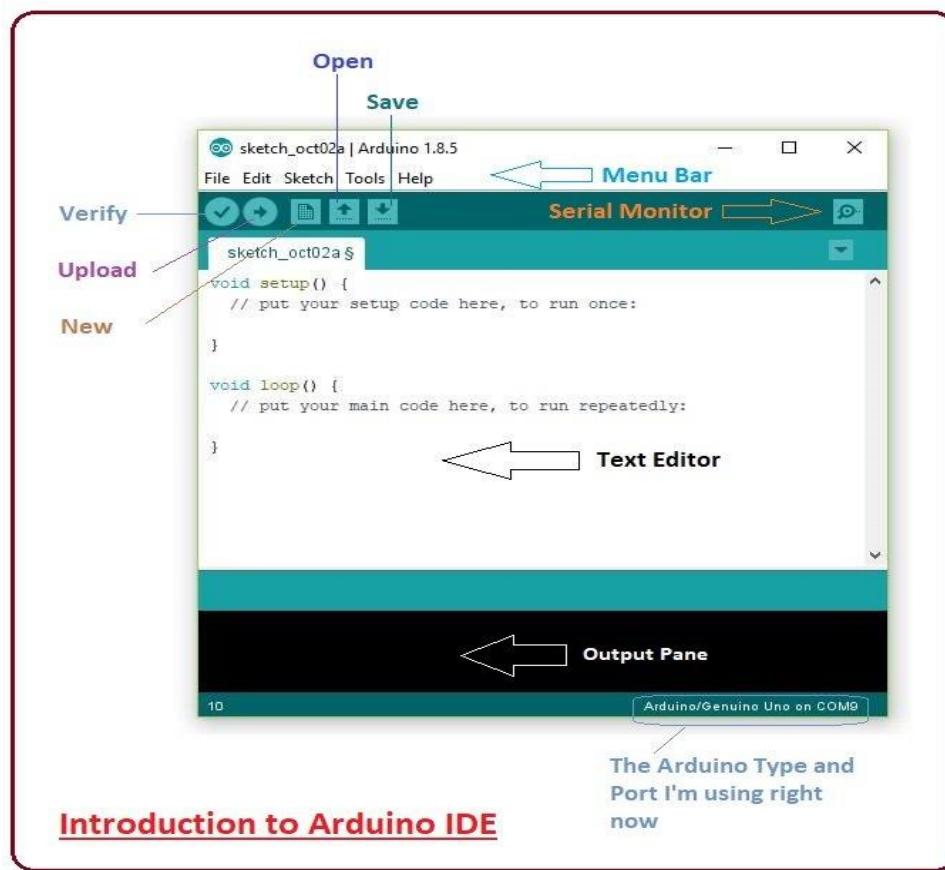


Figure 23 Arduino IDE (Aqeel, 2018)

The above figure shows the Arduino IDE where the actual coding is done, there are different buttons for different purpose and there is the menu bar, serial monitor button, text area and output area.

There are different buttons present which have different functions:

- File – It allows to create new programs and it consists of saving options, example codes, preferences.
- Edit – This option allows to edit and modify the code.
- Sketch – It allows to very, compile, include the library for the program.
- Tools – It allows all access to edit the board, select the preferred board, manage library and options related to manage the boards setting.
- Help – It helps to troubleshooting and know about the Arduino.
- Verify – It allows to verify the written code in the text editor and let the user know if it is compiled or t has error.
- Upload – It allows to upload the code to the connected board.
- New – It allows to create a new file.
- Arrows – First is the open arrow used to open the existing file and another is the sav arrow to save the current file.
- Search button – It is the button to open the serial monitor to view the result of the code.

This is the platform where all the coding is done, NodeMCU is connected to this interface and code is written which can be uploaded to the NodeMCU to process the code. Without Arduino IDE this system cannot be made, and it allows us to create new sketch, edit, compile and upload. It also gives us some example code which can be run to test the working of the internet, led, sensors and many more. It also comes with the serial monitor where the results can be view according to the coding done in the interface. Here in project Arduino IDE is the platform where all the coding is done and uploaded to the NodeMCU to generate a perfect result for the system.

### 3.2.9 Fritzing

Fritzing is a piece of software that assists artists in turning their designs into finished goods. The software, which was developed at the University of Applied Sciences in Potsdam, is an open-source software platform. It is compatible with Linux, Mac OS X, and Microsoft Windows. Fritzing is an excellent open-source tool for teaching, sharing, and prototyping electronic projects. It enables you to create a schematic, and thus a component, that can then be applied to professional-looking wiring diagrams. Three components of fritzing are:

Breadboard view – Fritzing will show the circuit in breadboard view, making it simple to see how components can connect and be wired. In the Breadboard view, Fritzing has a large library of parts to represent all major components.

Schematic View – This is the standard representation of the circuit in books. To set up the Schematic View, Fritzing has a huge library of schematic pieces.

Printed circuit board view – Electronic modules are electrically wired on copper tracks laminated on a non-conducting substrate on a printed circuit board (PCB). This view is needed for the circuit's PCB fabrication (Andi, 2014).

### 3.2.10 Adafruit, IFTTT, Google assistant

Adafruit, IFTTT and google assistant are also the software components used in this project and a detailed overview of these content is done earlier. An overview of Adafruit and IFTTT can be found in section 1.4 and also the overview of google assistant is done in section 1.5, current status of google assistant is in section 1.6.5. google assistant is used via mobile phone for controlling the devices and in IFTTT applets are created for that and Adafruit is there for the feed and dashboard of the devices and it manages its information. These three components are related with each other and perform accordingly to control the devices which is connected via NodeMCU.

### 3.2.11 End Users

Every developed system is made to be used for our own use or for the targeted customers. The need and preferences of the customers should be kept in mind while developing a system. Comfortable and convenient life is important for every human being, as discussed, thermal comfort and good thermal condition is very important for us to be healthy and live comfortably in every environment. Along with thermal comfort smart lights are also a necessity for people because it helps in energy saving, people need not to worry about turning on and off the lights manually as the smart lights are automatic. Implementation of google assistant is there for easy control of the devices and also people with disabilities can control the appliances without any problem. Every customer has their own opinion about the system and by conducting the post survey of the system it helped to understand the customer and their need and preference about the system.

By the survey results, users were very concerned about the thermal comfort and condition in their room and they understand how important it is to manage the thermal comfort for them. Some of the end users were familiar about the room temperature controller system and some were not but they all wanted to implement the room temperature system because they know that thermal comfort is very important. The end user also liked the concept of the smart lights as they work automatically, and the users don't need to physically access them. They thought that implementation of the smart lights is the smart move for them. Home automation is growing and by the introduction of this system to the end users they admired the concept and were happy to install this system for their personal use as well. Another important feature that the end users liked was the implementation of the google assistant to control the devices. They admired the use of google assistant and this feature is very useful in homes and end users were aware that this system can make their daily life easier and more convenient. And talking about the google assistant end users also liked the concept that this system can be very helpful for the disabled people as well. The end users appreciated that the system also thought about the disabled people rather than focusing only on the normal people. So overall the end users liked the idea of this whole system and this system has a potential for doing great in the market.

## 4. Chapter 4: Details on Applied Methodology and Project Development

For a project to be completed properly and successfully, there should be a proper team, a proper planning, proper selection of the methodology. There is different methodology for different projects, a project developer should be aware of that and according to the project a proper methodology should be finalized. A developer should know that without the proper selection of the methodology the project cannot deliver a proper end result and the project would be a failure. So according to the project, one should select a proper methodology and carry the project along with that selected methodology.

Before selecting a preferred methodology, we should always consider similar methodologies and then by comparing and analyzing, a final methodology should be selected. Here in this section, for this project there is the considered methodologies and a final selected methodology and based on that selected methodology the entire project is carried on. This section also provides a detail description and testing of the final developed system.

### 4.1 Considered methodologies

Before selecting a proper methodology for any project, all the available possible methodology should be analyzed and based on those a perfect one should be selected which match the requirement of the project. Here three methodology are considered which are similar to the selected methodology and they are described below.

#### 4.1.1 Agile development methodology

The approach of AGILE is a technique that facilitates constant iteration of development and testing during the project's software development lifecycle. In agile methodology the software is developed in a repeated manner that contain mini-increments of the new functionality. scrum, crystal, extreme programming (XP), and feature-driven development (FDD) are different types of agile methodology. Its advantage is that it allows the software to be released in repeated manner where the teams can detect or fix the bug if found any (Team, 2017).

The specifications are decomposed into several small pieces that can be built incrementally in the Agile model. Iterative development is seen in the Agile process. Each incremental

component is created iteratively. Each version is supposed to be tiny and manageable, and it should only take a couple of weeks to finish. The advantages of agile methodology are:

- Working as a team produces less errors rather than working alone.
- It helps in reduction of the time.
- Customers are provided with the idea of the software after each step and iteration, and it is easy to change any result if needed (PAL, 2018).

Some of the disadvantages are as follows:

- Since there are no written documents, there is inconsistency, and crucial choices made at various stages may be misinterpreted by different team members at any moment.
- When a project is completed and the developers are transferred to another project, management of the developed project can become a challenge due to a lack of proper documentation (PAL, 2018).



*Figure 24 Agile Methodology (Contributor, 2018)*

#### 4.1.2 Waterfall development method

It is one of the traditional development methods. It is more straight forward method which consists of requirements, design, implementation, verification, maintenance. It is easy to handle and easy to maintain. But it is not that efficient because it is quite slow and costly, and people prefer other than this method (Team, 2017).

The life cycle is divided into stages in the traditional waterfall model. This model assumes that one process will begin after the previous phase has been completed. That is, one phase's output will be used as the input for the next. As a result, the creation process can be seen as a waterfall with a linear flow. It is one of the simplest methodologies as its phases are easy to understand and easy to implement as well (Team, 2017). Some of the advantages of this methodology are as follows:

- In this model, phases are processed one by one.
- The steps are clearly defined and easy to interact with.
- Documentation about the process and result are properly managed.
- Small projects and projects with minimal requirements are best suited for this methodology (PAL, 2019).

Some of the disadvantages of this methodology are as follows:

- It only focuses on development and result, it doesn't have any method for error correction and user validation.
- The requirements of the customers can change at any time during the development and in this methodology after the specifications design process is completed, it is impossible to meet any modification demands.
- It has very simple phases and it is not suitable for large and complex projects which require regular testing (PAL, 2019).

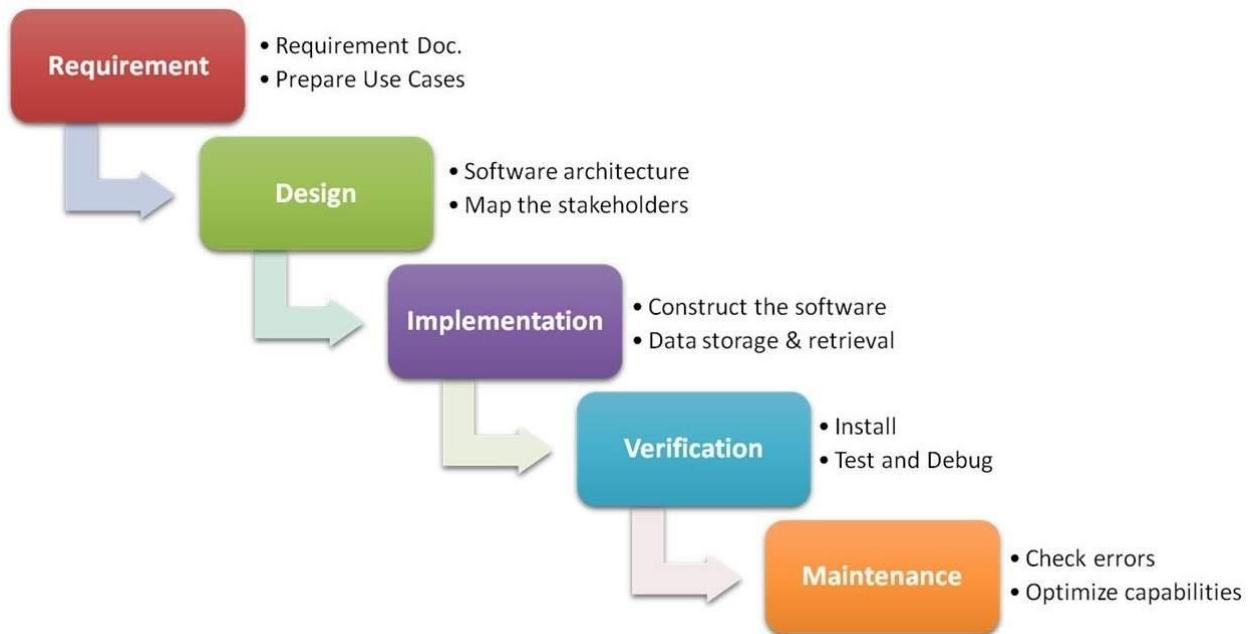


Figure 25 Waterfall development method (UKessays, 2019)

#### 4.1.3 Prototyping model

Prototyping model is the process in which first the prototype is developed the idea is presented then finally the final product is delivered. Prototype is delivered to the client and when finalized then only the work on the final product is started. All the needed equipment is collected, and ideas are provided with features and improvement and the final product is delivered. There are four types of prototype methodology which are the Rapid throwaway Prototype, Evolutionary prototype, Incremental Prototype, Extreme prototype (T, 2020).

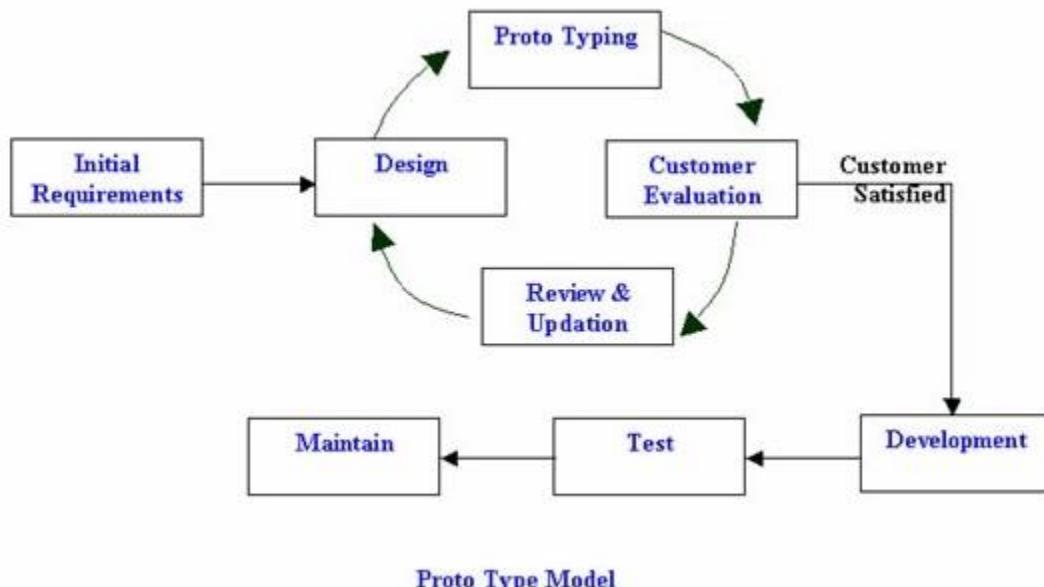
The method is partly applied before or after the review step of this process model, allowing consumers to see the commodity early in the life cycle. Interviewing consumers and creating an unfinished high-level document model are the first steps in the process. This manual is used to create the first version, which only includes the most basic features requested by the user. If the consumer has identified the issues, the prototype is fine-tuned to eliminate them. The procedure continues until the customer accepts the version and is satisfied with the operating sample (02DCE, 2020). Some of the advantages of this methodology are as follows:

- Error can easily be detected, and improvement can be done to the system.

- The customers are provided with the system development in the early stage and they can give the feedback.
- New attachments can be added as it allows for updates.
- It helps in better understanding of the customer's needs.
- The design and development are more flexible (guru99, 2021).

Some of the disadvantages of this methodology are as follows:

- It is a bit costly with respect to the time.
- The requirement should always be evaluated by the customers.
- Errors can be seen in the documentation due to constant changes in the system.
- Customer's satisfaction is a bit difficult, and developers feel difficult to develop due to many changes made by the customers (guru99, 2021).



*Figure 26 Prototyping Model (Team, 2018)*

## 4.2 Selected methodology

### 4.2.1 Evolutionary prototype model

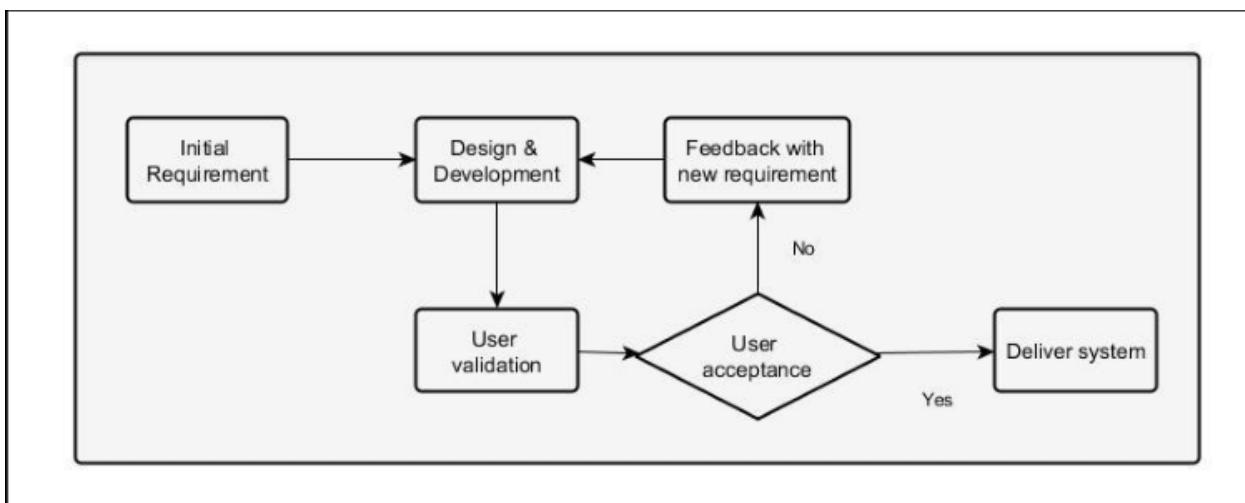
Evolutionary prototyping is a software development process in which a prototype is built first by the developer or development team. Following the customer's initial input, successive iterations are developed, each with new features or enhancements, before the final product appears. The evolutionary development model breaks down the development cycle into simpler, incremental waterfall models, with consumers gaining access to the product at the completion of each cycle. Users give feedback on the product for the next cycle's planning stage, and the production team responds by modifying the product, schedule, or operation. Breaking down job into smaller chunks, prioritizing them, and then bringing those chunks to the consumer one by one is suggested by the evolutionary paradigm. The number of chunks, as well as the number of sales to the consumer, is enormous (pp\_pankaj, 2019). Some of the advantages are as follows:

- In an evolutionary model, a person is given the opportunity to test a partly constructed structure.
- It helps in reducing the errors in code as well as in system because it is tested thoroughly.
- Customers can make changes and regarding their changes the system can be modified as well.
- It is suitable for projects which required feedbacks and test on a regular basis (pp\_pankaj, 2019).

Some of the disadvantages are as follows:

- It can be difficult to split an issue into many iterations that are satisfactory to the consumer and can be introduced and distributed in stages.
- It can be difficult to break down a problem into several iterations that satisfy the customer and can be implemented and delivered in stages.
- When a customer is unhappy with the original version, he or she may lose confidence in the finished model (guru99, 2021).

Besides all the methodology mentioned above, the evolutionary prototype model is more suitable for this project. It lets us add or remove any features and we can improve according to the market need, so it is a bit more flexible than other methodology. Especially in IOT projects the methodology should be flexible as we can add features of our choice and in the need of the market choice. It freely allows us to design, test, add and improve so that we can make a proper product. In this model first initial requirements are fulfilled which is the planning, device selection and after that design and development is carried out and user requirements are fulfilled and if there is necessary to add new features then it is added accordingly and finally the whole system is made and delivered.



*Figure 27 Evolutionary Prototype model (Shaharin, 2016)*

In this methodology it contains of 4 steps which are as follows:

- Initial requirement – In this step all the requirements are fulfilled first, which are the devices analysis, topic analysis, cost benefit analysis, availability of the hardware and software, area of study of the project. In this step all the resource material are collected, needs of the customers are considered. After all the requirement and planning is done then only the next step is considered (Point, 2018).
- Design and development – In this step the designing of the project is done, here it is finalized how to design and what to mention and then the development of the project is carried out. For the designing part, first the basic sketch of the system is made to analyze

that what the system can look like and the circuit diagram is made based on the equipment's collected for the system. After designing, development is carried out by assembling the hardware and installation of the necessary software's. After some development of the system users validations are noted.

- User validation – Here in this step there is the validation from the user or the supervisor either it is ok or not and then only further work is carried out. the user validation is very important because the final system is being made for the user. If the user is satisfied with the design and development further work is carried and not then changes are made (Point, 2018).
- User acceptance and delivery of the system – In this step if the user or supervisor is satisfied of what we are going to deliver then after that the project is tested whether it is performing well or not and after that the user or the supervisor accepts the project and finally the system is delivered.

#### 4.2.2 Validation of Methodology

As discussed above, it is clear that a proper methodology is very important for any project to be completed properly and successfully. A proper methodology helps the developer to manage the project efficiently and deal with the customers properly as well. Based on the selected methodology the developers of the project can easily plan and work on the project and it builds a strong base which keeps the project on track.

The selected methodology of the project is evolutionary prototype as discussed above and it matches the requirement of the project. To verify that the selected methodology is practical and is effective a literature review was done in the section 2.3 implementation of the solution, a report titled as “Case Study: SITINA - A Software Engineering Project Using Evolutionary Prototyping” written by Nuno Jardim Nunes, Joo Falco E Cunha. The author developed a system and stated that using the evolutionary prototype it is flexible and easy to update. And in another article titled as “Applying Evolutionary Prototyping Model in Developing Stream-based Lecturing System” written by Nian-Shing Chen, Shin-Yi Huang. The author stated that the methodology is suitable for the project. From both the review it is clear that this methodology is flexible for improvement and changes can be made during the development. So, by the literature review it is clear that evolutionary prototype methodology is a perfect methodology for this kind of development project. Thus, this is the suitable and selected methodology for this project.

## 4.3 Project development with evolutionary prototype methodology

### 4.3.1 Task 1: Circuit designing

The first task was to design the circuit and based on that designing further connections and work were carried out. There are two circuit diagrams for two separate systems. One for the room temperature controller and another is for the smart lights. Below are the figure of the circuit design.

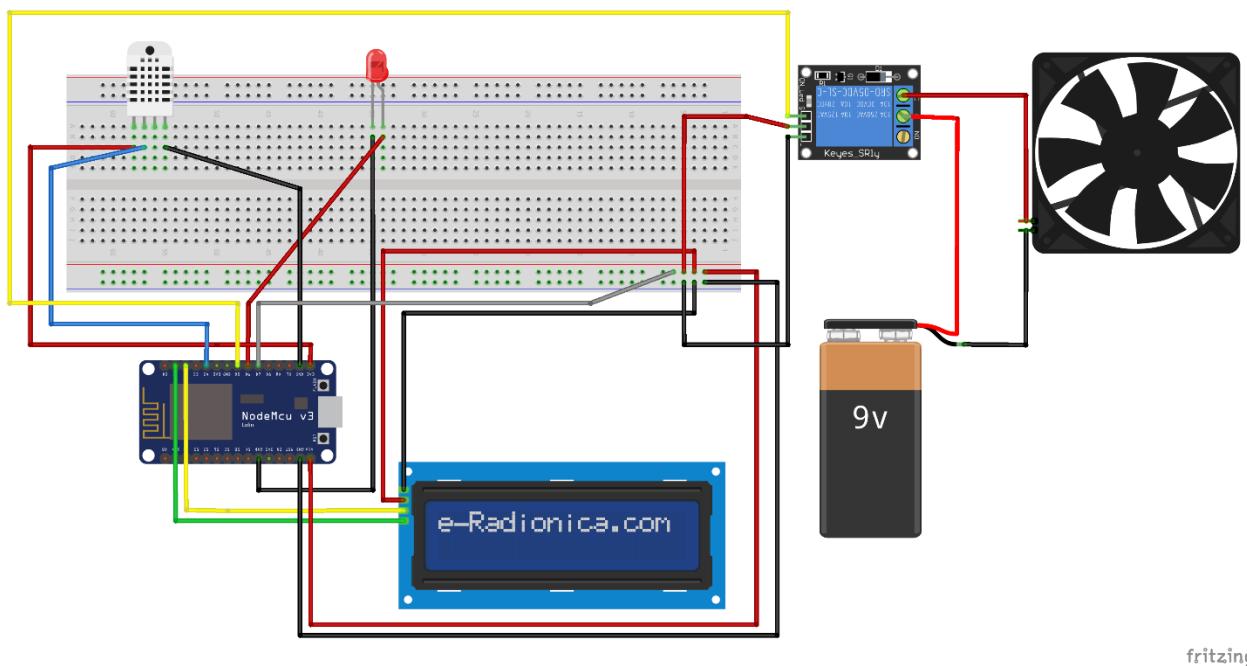
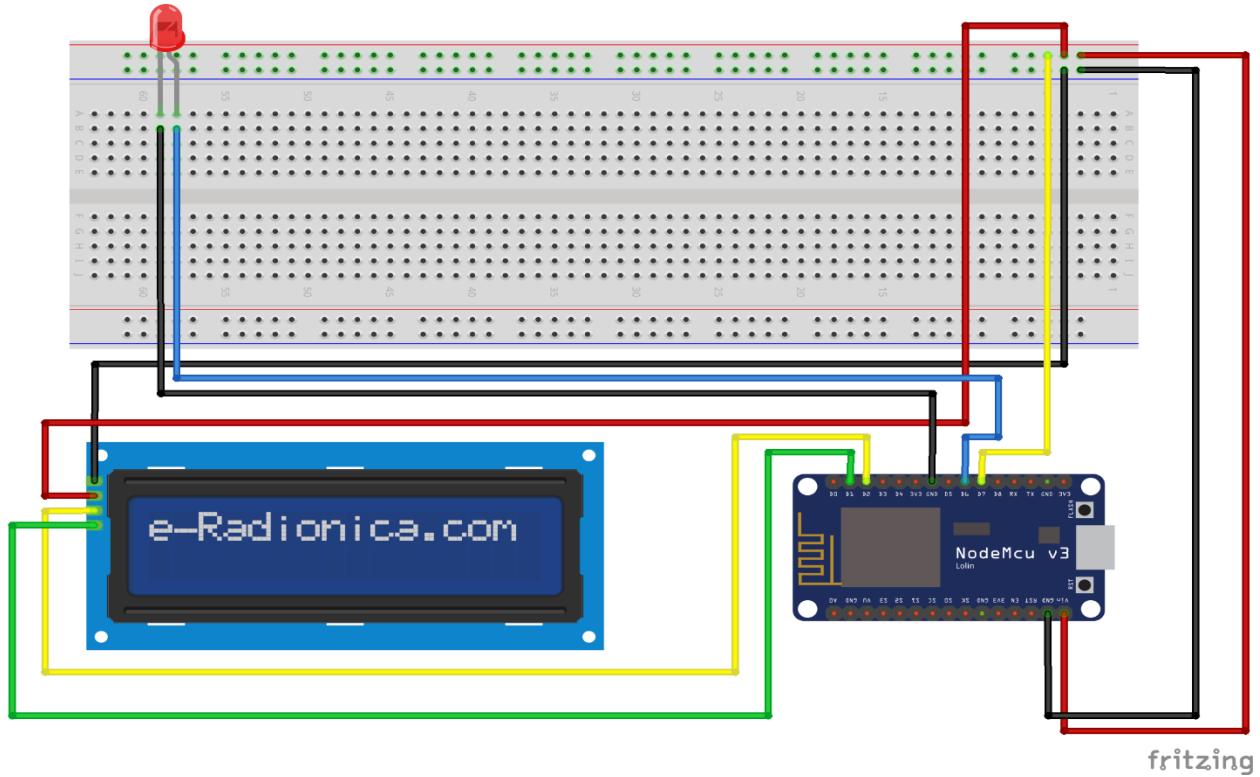


Figure 28 Circuit diagram of smart room temperature controller

This is the circuit diagram for the smart room temperature controller, here the components shown are the NodeMCU, DHT11 sensor and LED (which is used to demonstrate the work for the heater) which are placed in the breadboard, LCD display, a relay module for the fan and a separate power supply for the fan.



*Figure 29 Circuit diagram of smart light*

This is the circuit diagram for the smart light, here the components used are NodeMCU, the LED is placed in the breadboard and there is the LCD display.

### 4.3.2 Task 2: DHT11 sensor for serial monitor

Here the working of the DHT11 sensor is shown along with its result, here its result is shown in the serial monitor. The sensor is placed in the breadboard and positive pin is connected to 3v3 pin, negative pin is connected to GND pin and signal pin is connected to D4 pin in the NodeMCU.

#### 4.3.2.1 Programming the DHT11 sensor for serial monitor

Programming is done in the Arduino IDE and the DHT library is also added. The below figure shows the actual coding done in Arduino IDE for displaying the result of temperature and humidity in serial monitor using DHT11 sensor.



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** Temp\_display\_in\_serial\_monitor | Arduino 1.8.13
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Standard toolbar icons for file operations.
- Code Editor:**

```
#include "DHT.h"          // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11      // DHT 11
#define DHTPIN 2

DHT dht(DHTPIN, DHTTYPE);
void setup(void)
{
    dht.begin();
    Serial.begin(9600);
    Serial.println("Humidity and temperature\n\n");
    delay(700);

}
void loop() {
    float h = dht.readHumidity(); // read humidity
    float t = dht.readTemperature(); // read temperature
    Serial.print("Current humidity = ");
    Serial.print(h);
    Serial.print("% ");
    Serial.print("temperature = ");
    Serial.print(t);
    Serial.println("C ");
    delay(800);
}
```

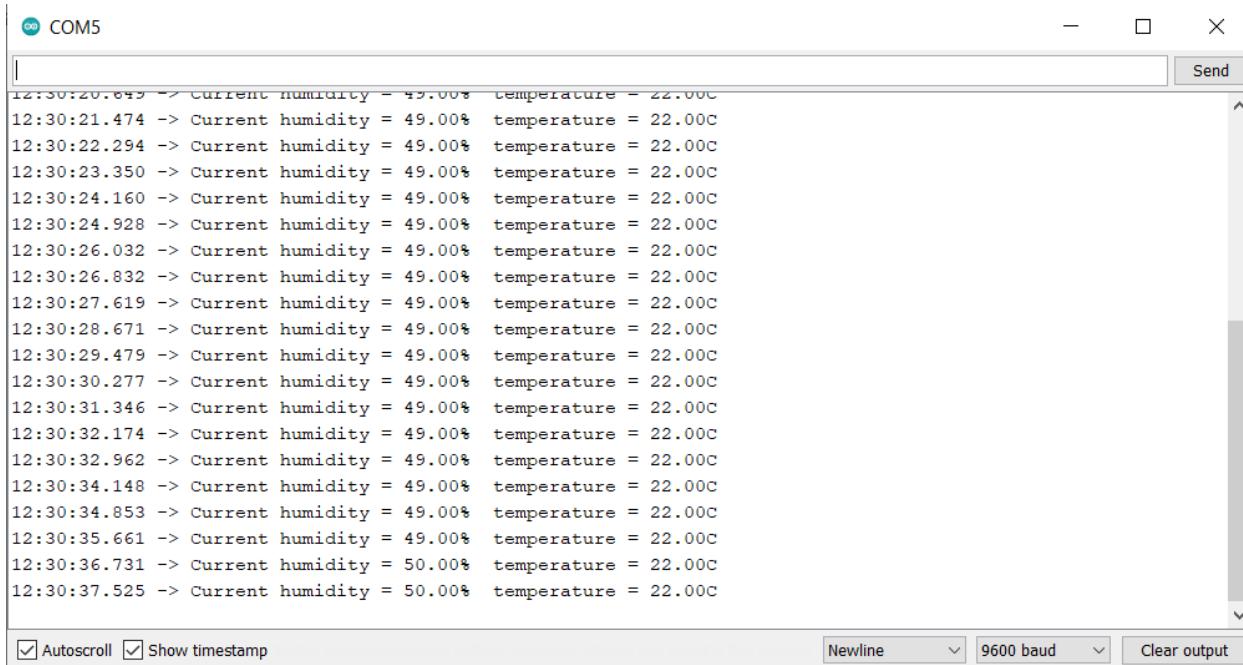
Figure 30 Temperature sensor code for serial monitor

#### 4.3.2.2 Testing the DHT11 sensor for serial monitor

Objective	To test the working of the DHT11 sensor and displaying the result in serial monitor.
Expected result	The sensor would work properly and display the temperature and humidity in the serial monitor.
Actual result	The sensor worked properly and the temperature and humidity are shown in the serial monitor.
Conclusion	The test was successful.

Table 1 Test for the DHT11 sensor for serial monitor

Proof:



```

12:30:20.649 -> Current humidity = 49.00% temperature = 22.00C
12:30:21.474 -> Current humidity = 49.00% temperature = 22.00C
12:30:22.294 -> Current humidity = 49.00% temperature = 22.00C
12:30:23.350 -> Current humidity = 49.00% temperature = 22.00C
12:30:24.160 -> Current humidity = 49.00% temperature = 22.00C
12:30:24.928 -> Current humidity = 49.00% temperature = 22.00C
12:30:26.032 -> Current humidity = 49.00% temperature = 22.00C
12:30:26.832 -> Current humidity = 49.00% temperature = 22.00C
12:30:27.619 -> Current humidity = 49.00% temperature = 22.00C
12:30:28.671 -> Current humidity = 49.00% temperature = 22.00C
12:30:29.479 -> Current humidity = 49.00% temperature = 22.00C
12:30:30.277 -> Current humidity = 49.00% temperature = 22.00C
12:30:31.346 -> Current humidity = 49.00% temperature = 22.00C
12:30:32.174 -> Current humidity = 49.00% temperature = 22.00C
12:30:32.962 -> Current humidity = 49.00% temperature = 22.00C
12:30:34.148 -> Current humidity = 49.00% temperature = 22.00C
12:30:34.853 -> Current humidity = 49.00% temperature = 22.00C
12:30:35.661 -> Current humidity = 49.00% temperature = 22.00C
12:30:36.731 -> Current humidity = 50.00% temperature = 22.00C
12:30:37.525 -> Current humidity = 50.00% temperature = 22.00C

```

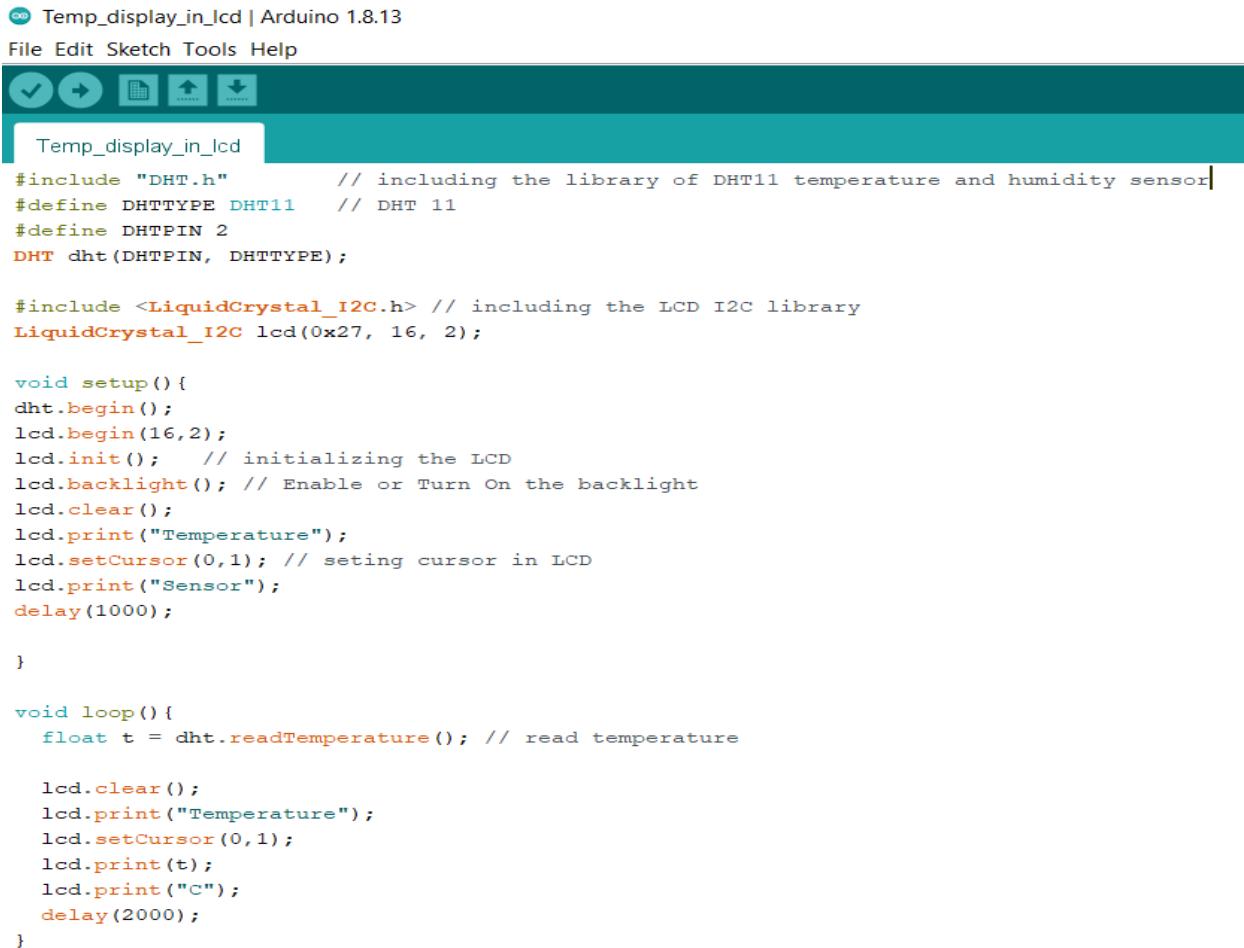
Figure 31 Result of temperature and humidity in serial monitor

### 4.3.3 Task 3: DHT11 sensor for LCD display

Here the working of the DHT11 sensor is shown along with its result, here its result is shown in the LCD display. The sensor is placed in the breadboard and positive pin is connected to 3v3 pin, negative pin is connected to GND pin and signal pin is connected to D4 pin in the NodeMCU. And the LCD display is also connected to the NodeMCU with VCC, GND, SDA, SCL pins.

#### 4.3.3.1 Programming the DHT11 sensor for LCD display

Here the actual coding of the DHT11 sensor for LCD display is shown which displays the temperature information of the room in the LCD display.



```

Temp_display_in_lcd | Arduino 1.8.13
File Edit Sketch Tools Help
Temp_display_in_lcd
#include "DHT.h"           // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11     // DHT 11
#define DHTPIN 2
DHT dht(DHTPIN, DHTTYPE);

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
dht.begin();
lcd.begin(16,2);
lcd.init();    // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1); // seting cursor in LCD
lcd.print("Sensor");
delay(1000);

}

void loop(){
float t = dht.readTemperature(); // read temperature

lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1);
lcd.print(t);
lcd.print("C");
delay(2000);
}

```

Figure 32 Temperature sensor code for LCD display

#### 4.3.3.2 Testing the DHT11 sensor for LCD display

Objective	To test the working of the DHT11 sensor and display the temperature in LCD display.
Expected result	The sensor would work properly, and the temperature would be displayed in the LCD display.
Actual result	The sensor worked properly, and the temperature was displayed in the LCD display.
Conclusion	The test was successful.

Table 2 Test of the DHT11 sensor for the LCD display

Proof:

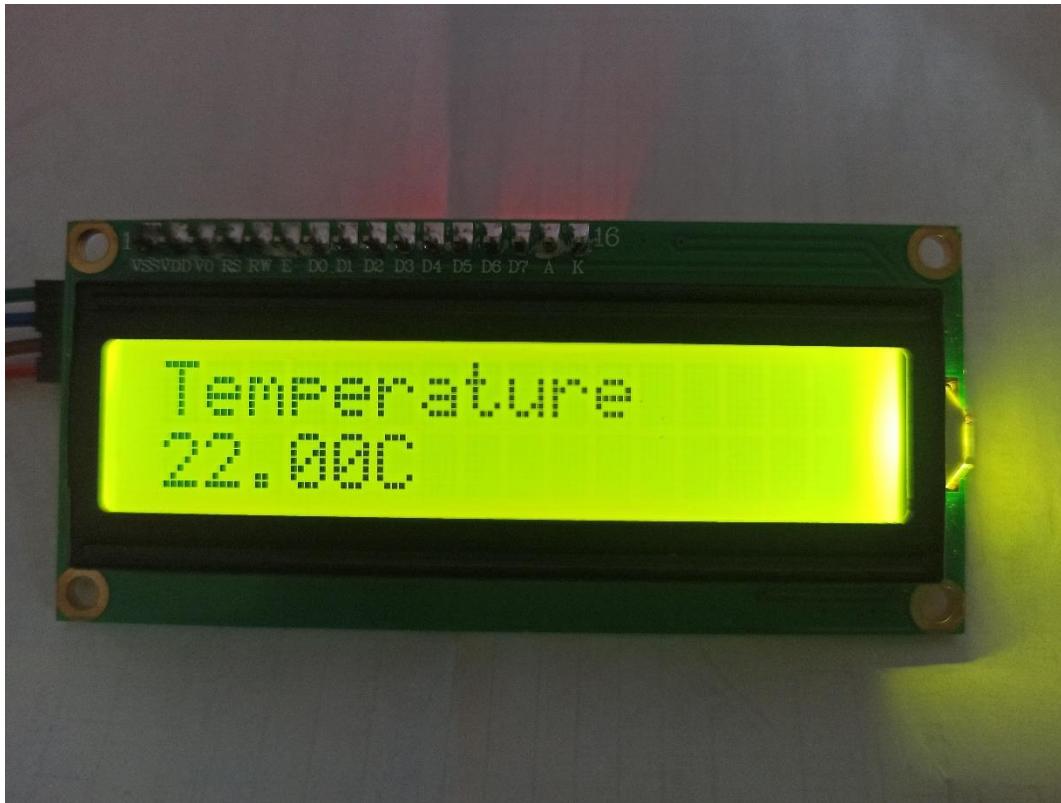


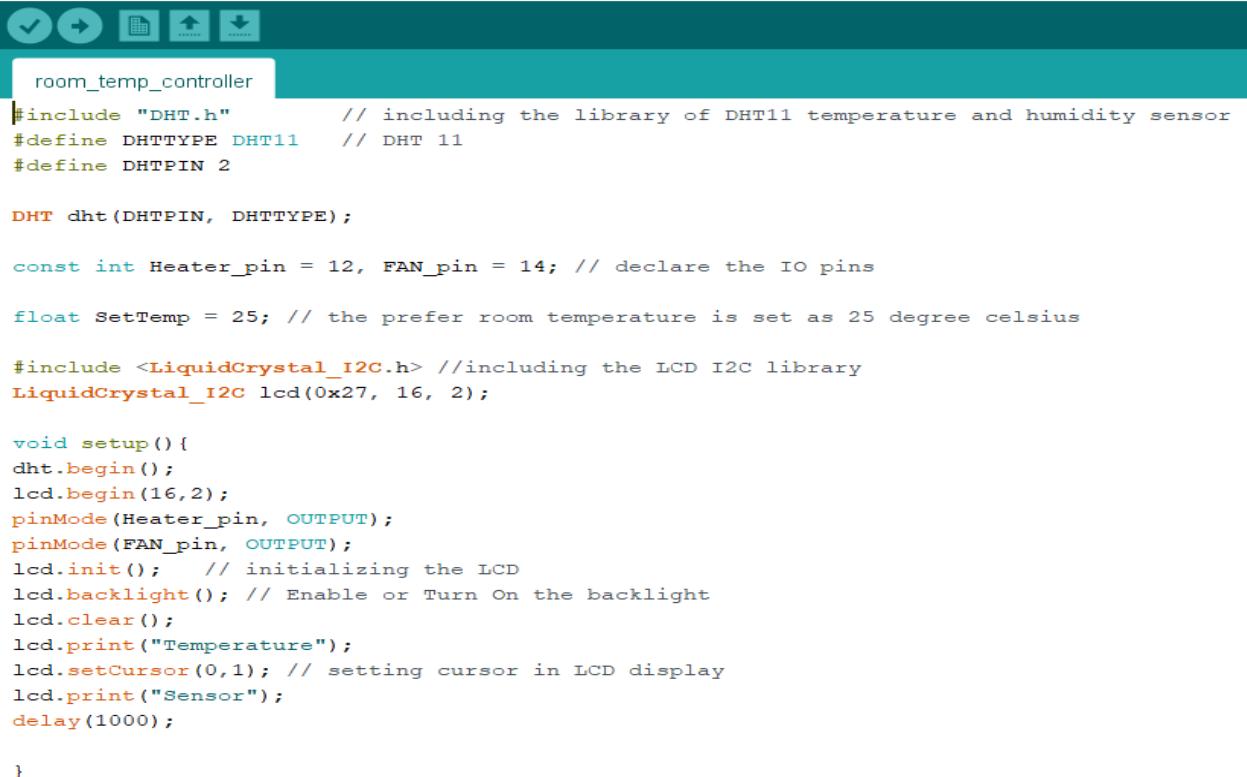
Figure 33 Temperature in LCD

#### 4.3.4 Task 4: Room temperature controller

Here the automatic control of the fan and heater (LED in this case) is shown, based on the temperature recorded by the DHT11 sensor, if the temperature is above the set temperature than the fan would turn on and if the temperature is below the set temperature the heater (LED in this case) would turn on. The LED is connected to the GND and D6 pin in the NodeMCU. For the fan relay module is connected to the NodeMCU via the breadboard.

##### 4.3.4.1 Room temperature controller programming

Coding is done based on the DHT11 sensor temperature and the temperature set by the user. LCD display also shows the temperature and the heater (LED in this case) and fan are controller automatically.



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** room\_temp\_controller | Arduino 1.8.13
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for back, forward, save, and upload.
- Sketch Area:** Displays the C++ code for the 'room\_temp\_controller' sketch.

```
#include "DHT.h"           // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11      // DHT 11
#define DHTPIN 2

DHT dht(DHTPIN, DHTTYPE);

const int Heater_pin = 12, FAN_pin = 14; // declare the IO pins

float SetTemp = 25; // the prefer room temperature is set as 25 degree celsius

#include <LiquidCrystal_I2C.h> //including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
dht.begin();
lcd.begin(16,2);
pinMode(Heater_pin, OUTPUT);
pinMode(FAN_pin, OUTPUT);
lcd.init(); // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1); // setting cursor in LCD display
lcd.print("Sensor");
delay(1000);
}
```

```

void loop() {
    float t = dht.readTemperature(); // read temperature

    lcd.clear();
    lcd.print("Temperature");
    lcd.setCursor(0,1);
    lcd.print(t);
    lcd.print("C");
    delay(2000);

    // condition is applied for the fan and heater
    if(t > SetTemp) {
        digitalWrite(FAN_pin, HIGH);
        delay(2000);
    }
    else{
        digitalWrite(FAN_pin, LOW);
    }

    if(t < SetTemp) {
        digitalWrite(Heater_pin, HIGH);
        delay(2000);
    }
    else{
        digitalWrite(Heater_pin, LOW);
    }
}

```

Figure 34 Code for room temperature controller

#### 4.3.4.2 Testing for room temperature controller

Objective	To test whether the heater (LED) and fan works automatically based on the set temperature.
Expective result	The heater (LED) would turn on automatically is the temperature is below the set temperature and the fan would turn on automatically if the temperature is above the set temperature.
Actual result	The heater (LED) turned on automatically when the temperature was below the set temperature and the fan turned on automatically when the temperature was above the set temperature.
Conclusion	The test was successful.

Table 3 Test for the room temperature controller

Proof:

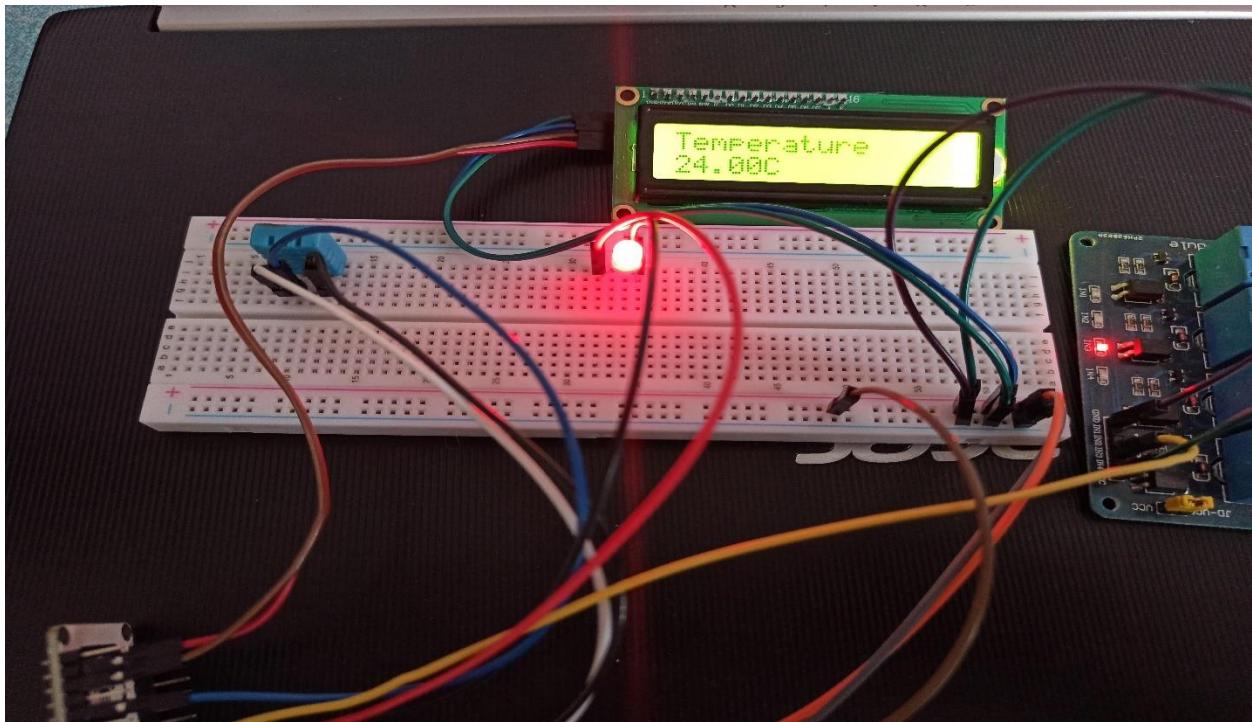


Figure 35 Heater (LED) on

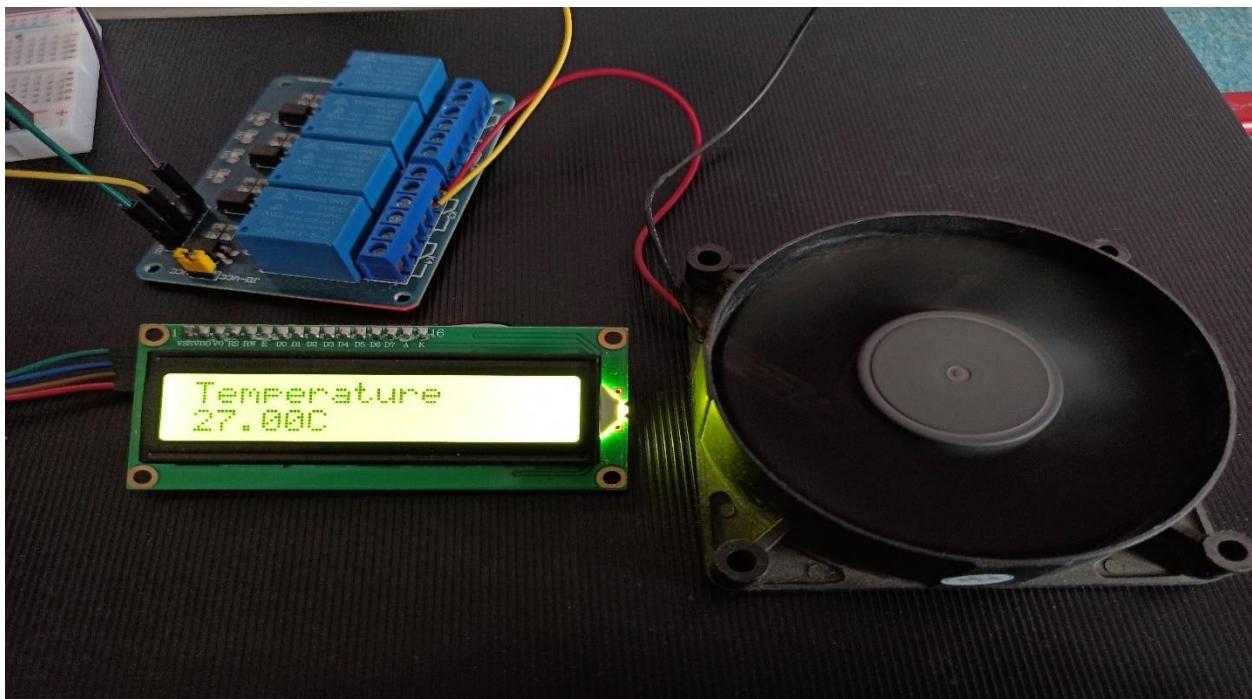


Figure 36 Fan on

#### 4.3.5 Task 5: LED light test

Here the LED light is tested if the light would turn on or not. The LED light is placed in the breadboard and the negative pin is connected to the GND pin and the positive pin is connected to D6 pin of the NodeMCU.

##### 4.3.5.1 Programming for the LED light test.

Here a code is written for the LED light to test whether it would turn on or not.



```

File Edit Sketch Tools Help
led_blink
int Led = 12; // setting the IO pin for LED

void setup() {
    pinMode(Led, OUTPUT);      // Initialize the LED_BUILTIN pin as an output
}

void loop() {
    digitalWrite(Led, HIGH);   // Turn the LED off by making the voltage HIGH
}

```

Figure 37 Code for LED light testing

##### 4.3.5.2 Testing the LED light

Objective	To test whether the LED light would turn on or not.
Expected result	The LED light would turn on.
Actual result	The LED light was turned on.
Conclusion	The test was successful.

Table 4 Test for the LED lights

Proof:

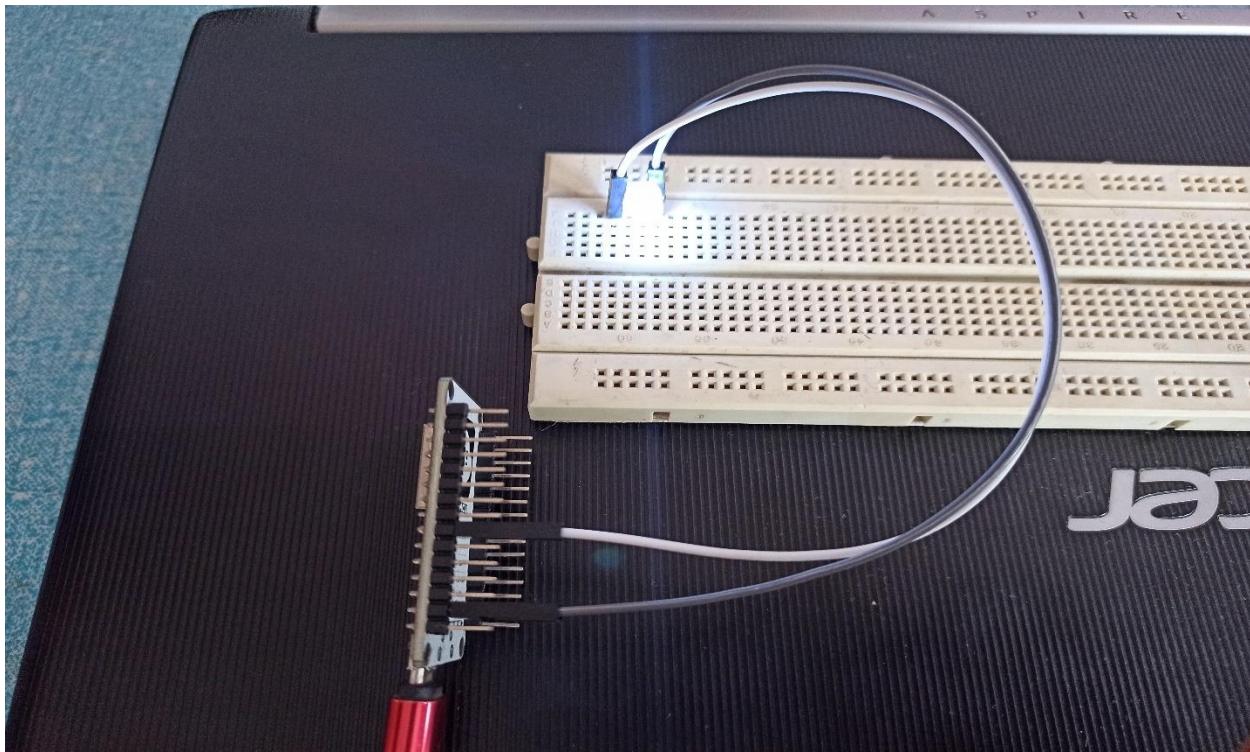


Figure 38 LED light on

#### 4.3.6 Task 6: Smart lights

Here the data of the daytime and nighttime is taken from the internet, NTP server. All the credentials like hour, minute, second, day, month, year are recorded. From the time taken from the internet, if it is daytime the lights would turn off and if it is night time the lights would turn on. LED light is placed in the breadboard where the positive is connected to D6 and negative is connected to the GND pin of the NodeMCU. Also, LCD display is connected to show the current time and date.

##### 4.3.6.1 Programming the smart lights

Coding for the smart lights is done by taking the time and date form the NTP server and based on the current time the lights would turn on and off according to the day and nighttime. For the daytime it is set for 6 am and night is set for 6 pm.

smart\_light | Arduino 1.8.13

File Edit Sketch Tools Help



```

smart_light

#include <ESP8266WiFi.h> // including the library for the wifi
#include <NTPClient.h> // including the librart for the ntp client
#include <WiFiUDP.h>

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Replace with your network credentials
const char * ssid      = "Home wifi1";
const char * password = "sweethome09";

int ledpin = 12; // setting the IO pin for the LED

// Define NTP Client to get time
WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP, "pool.ntp.org");

//Week Days
String weekDays[7]={"Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"};

//Month names
String months[12]={"January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December"};

void setup() {
  pinMode(ledpin,OUTPUT);
}

lcd.begin(16,2);
lcd.init(); // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight

```

```
  // Initialize Serial Monitor
  Serial.begin(115200);

  // Connect to Wi-Fi
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }

  // Initialize a NTPClient to get time
  timeClient.begin();
  timeClient.setTimeOffset(20700);
}

void loop() {
  timeClient.update();

  unsigned long epochTime = timeClient.getEpochTime();
  Serial.print("Epoch Time: ");
  Serial.println(epochTime);

  String formattedTime = timeClient.getFormattedTime();
  Serial.print("Formatted Time: ");
  Serial.println(formattedTime);

  int currentHour = timeClient.getHours();
  Serial.print("Hour: ");
  Serial.println(currentHour);

  int currentMinute = timeClient.getMinutes();
  Serial.print("Minutes: ");
  Serial.println(currentMinute);
```

```

int currentSecond = timeClient.getSeconds();
Serial.print("Seconds: ");
Serial.println(currentSecond);

//Get a time structure
struct tm *ptm = gmtime ((time_t *)&epochTime);

int monthDay = ptm->tm_mday;
Serial.print("Month day: ");
Serial.println(monthDay);

int currentMonth = ptm->tm_mon+1;
Serial.print("Month: ");
Serial.println(currentMonth);

int currentYear = ptm->tm_year+1900;
Serial.print("Year: ");
Serial.println(currentYear);

//Print complete date:
String currentDate = String(currentYear) + "-" + String(currentMonth) + "-" + String(monthDay);
Serial.print("Current date: ");
Serial.println(currentDate);

Serial.println("");

lcd.setCursor(0,0); // setting cursor in LCD display
lcd.print("TIME=");
lcd.setCursor(5,0);
lcd.print(formattedTime);

lcd.setCursor(0,1); // setting cursor in LCD display
lcd.print("DATE=");
lcd.setCursor(5,1);
lcd.print(currentDate);

// condition is applied when to turn on and off the light
if(currentHour >= 7 && currentHour <= 17){
    digitalWrite(ledpin,LOW);
}
else{
    digitalWrite(ledpin,HIGH);
}

delay(1000);
}

```

Figure 39 Code for smart light

#### 4.3.6.2 Testing the smart light

Objective	To test whether the time is correctly fetched from NTP server or not and testing whether the lights are automatically turning on and off or not.
Expected result	The time would be fetched, and the LED would work automatically.
Actual result	The time is correctly fetched, and the LED are turning on and off based on the day and nighttime.
Conclusion	The test was successful.

Table 5 Test for the smart light

Proof:

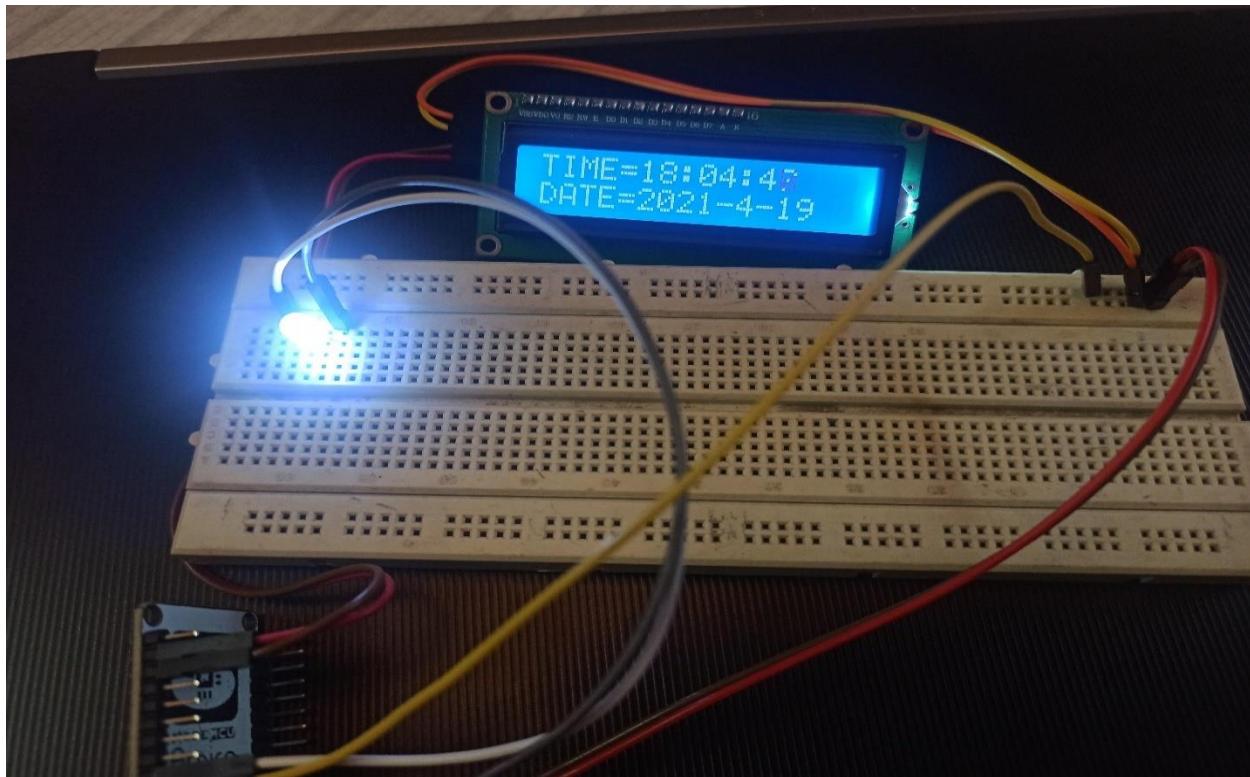


Figure 40 Light on in nighttime

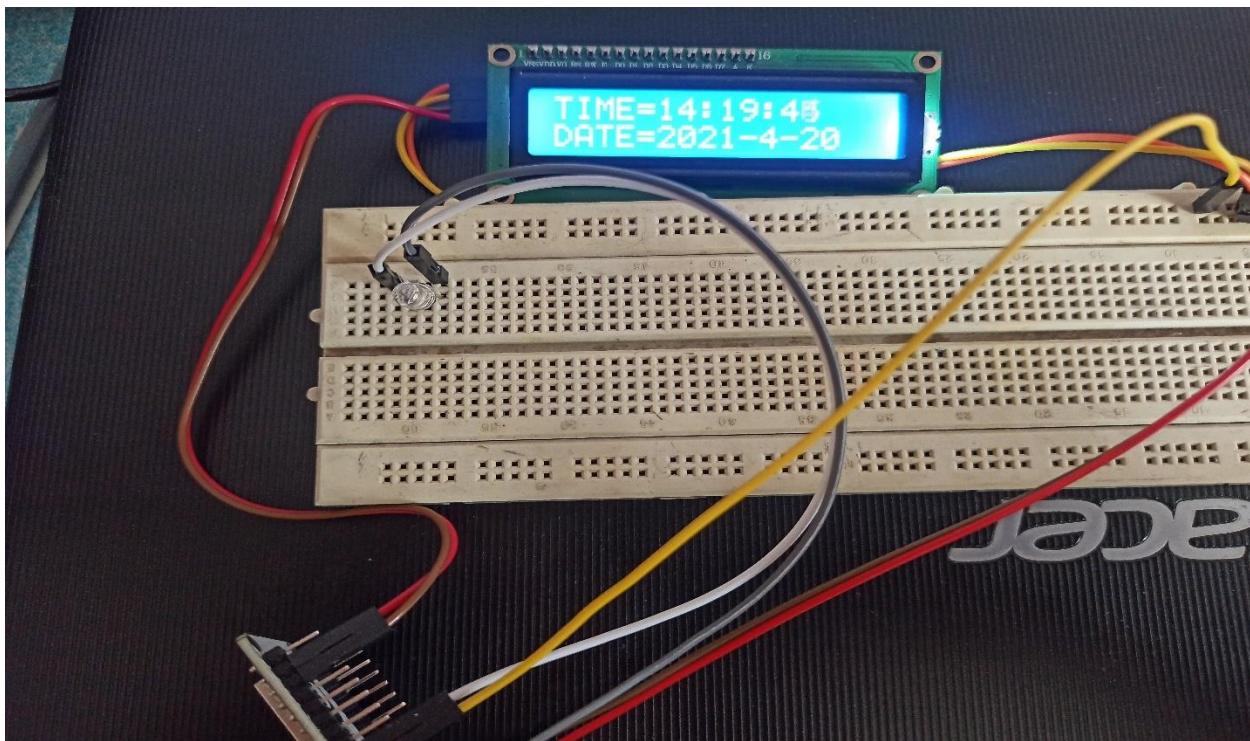


Figure 41 Light off in daytime

#### 4.3.7 Task 7: Google assistant

Here google assistant is implemented to LED to check whether the adafruit and IFTTT work well or not. Dashboards and feeds are created in the Adafruit and applets are created in IFTTT. Via the mobile phone commands for the google assistant are given.

##### 4.3.7.1 Programming for the google assistant

The coding is done for the google assistant, where all the Adafruit keys, feed names and Wi-Fi status and other connection interfaces are provided.



```

led_using_google_assistant | Arduino 1.8.13
File Edit Sketch Tools Help
void setup() {
    Serial.begin(115200);
    delay(10);

    pinMode(12, OUTPUT);

    // Connect to WiFi access point.
    Serial.println(); Serial.println();
    Serial.print("Connecting to ");
    Serial.println(WLAN_SSID);

    WiFi.begin(WLAN_SSID, WLAN_PASS);
}

void loop() {
    WiFiClient client;      // Create an ESP8266 WiFiClient class to connect to the MQTT server.

    // Setup the MQTT client class by passing in the WiFi client and MQTT server and login details.
    Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
    Adafruit_MQTT_Subscribe lightcontrol = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds/lightcontrol");

    void MQTT_connect();
}

```

```

while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}

Serial.println();
Serial.println("WiFi connected");
Serial.println("IP address: "); Serial.println(WiFi.localIP());
mqtt.subscribe(&lightcontrol);
}

uint32_t x=0;
void loop() {
    MQTT_connect();

    Adafruit_MQTT_Subscribe *subscription;

    while ((subscription = mqtt.readSubscription(5000))) {
        if (subscription == &lightcontrol) {
            Serial.print(F("Got: "));
            Serial.println((char *)lightcontrol.lastread);
            if (!strcmp((char *) lightcontrol.lastread, "ON"))
            {
                digitalWrite(12, HIGH);
            }
            else
            {
                digitalWrite(12, LOW);
            }
        }
    }
}

void MQTT_connect() {
    int8_t ret;

    // Stop if already connected.
    if (mqtt.connected()) {
        return;
    }

    Serial.print("Connecting to MQTT... ");

    uint8_t retries = 3;

    while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected

        Serial.println(mqtt.connectErrorString(ret));
        Serial.println("Retrying MQTT connection in 5 seconds...");
        mqtt.disconnect();
        delay(5000); // wait 5 seconds
        retries--;
        if (retries == 0) {
            // basically die and wait for WDT to reset me
            while (1);
        }
    }

    Serial.println("MQTT Connected!");
}

```

Figure 42 Code for google assistant

#### 4.3.7.2 Testing the google assistant

Objective	To test whether the google assistant is working or not.
Expected result	The google assistant would work, data is sent to the feeds and LED is controlled.
Actual result	The google assistant worked properly and the feed were updated, and LED was controlled.
Conclusion	The test was successful.

Table 6 Test for the google assistant

Proof:

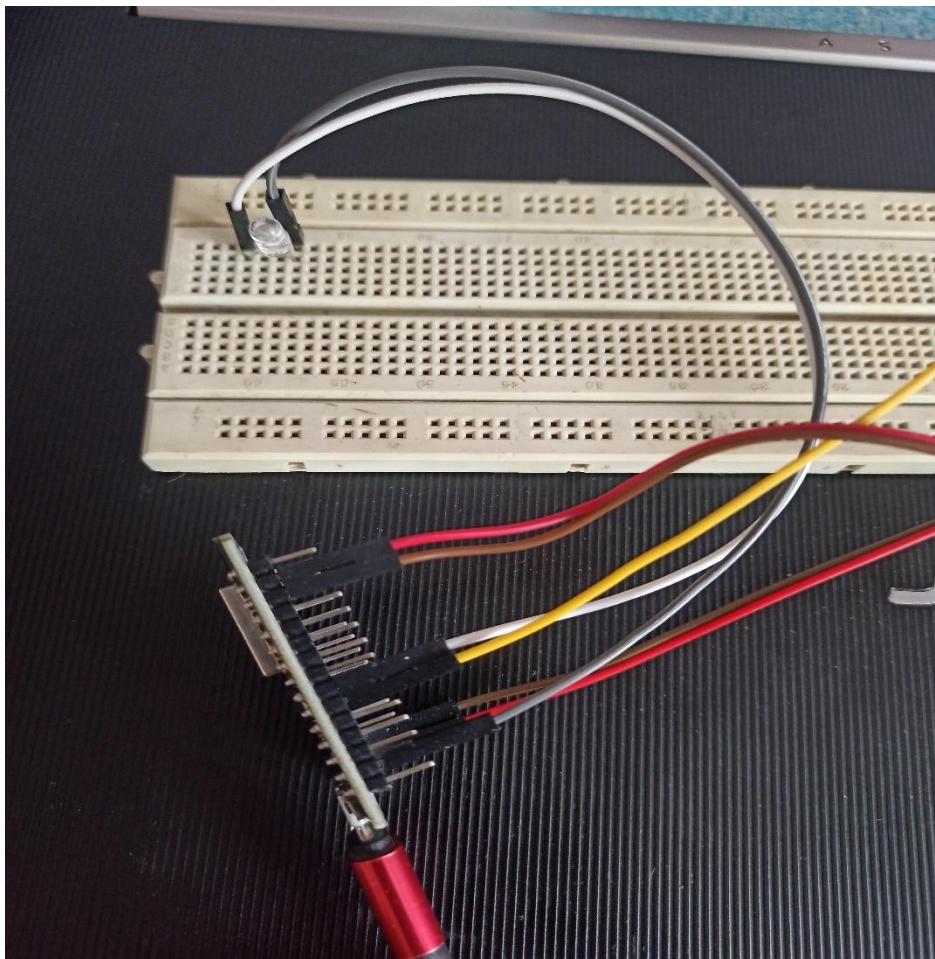


Figure 43 Light off by google assistant

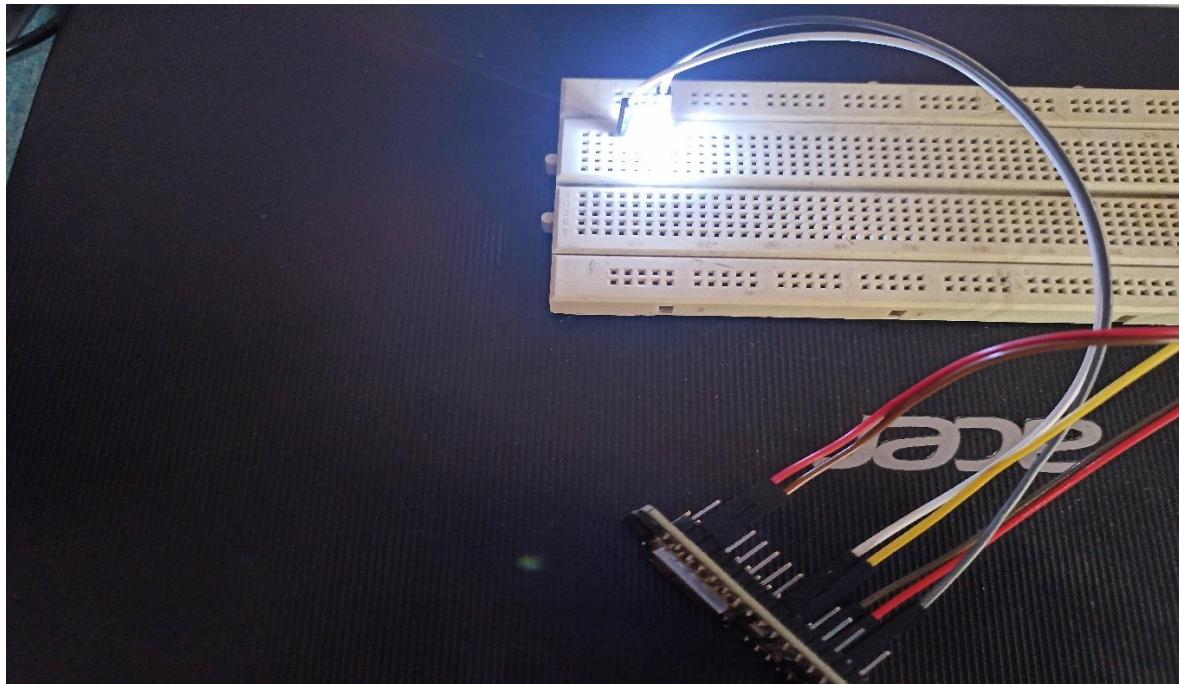


Figure 44 Light on by google assistant

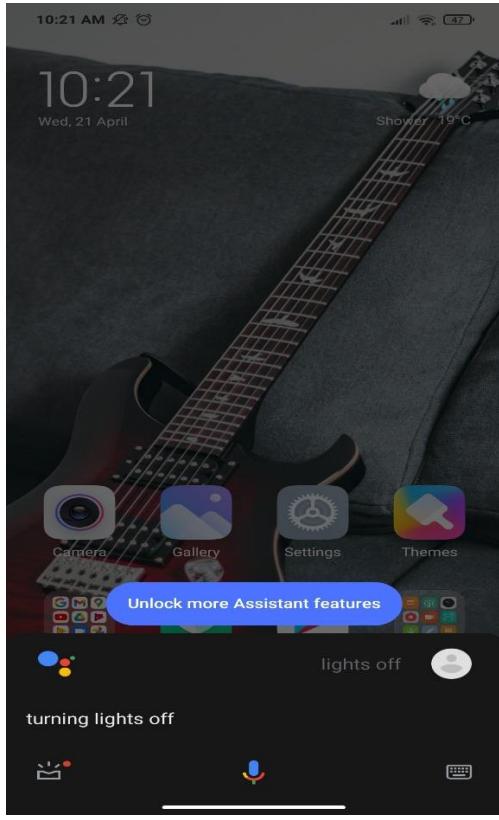


Figure 46 Command for light off

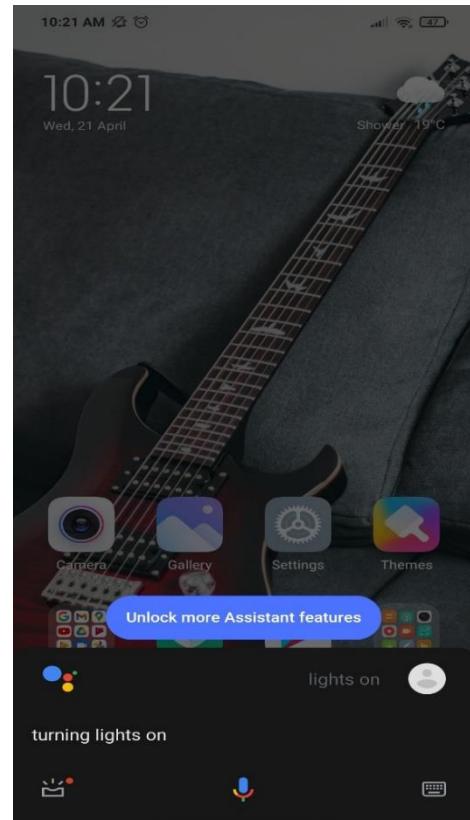


Figure 45 Command for light on

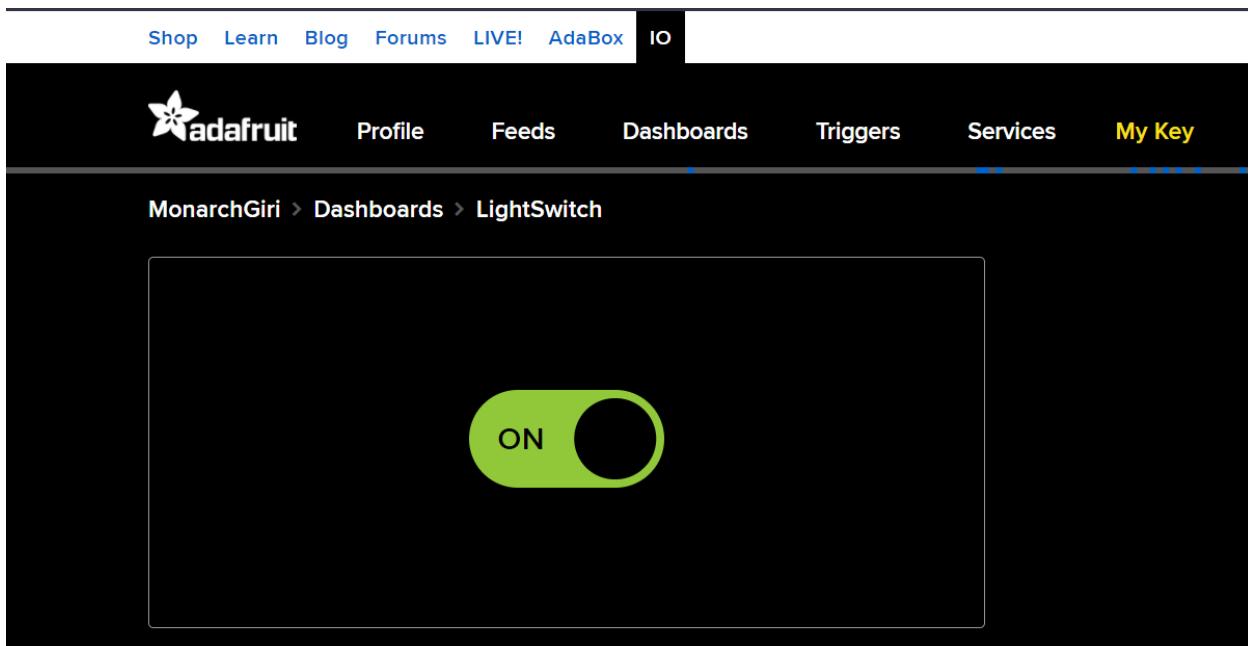


Figure 47 Adafruit dashboard showing light is on

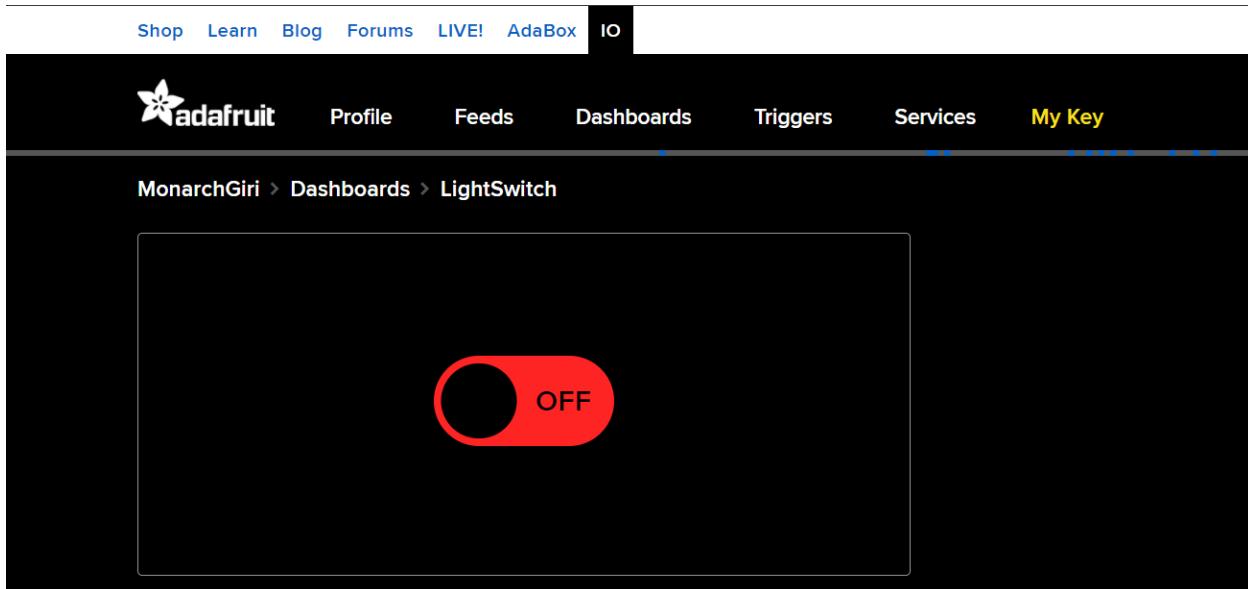


Figure 48 Adafruit dashboard showing light is off

# My Applets

 Filter

All (2)

Created by me (2 of 3)

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You have 1 available Applet. Upgrade to Pro to create unlimited Applets. [Learn more](#)

Upgrade

If You say "turn off lights", then Send data to lightcontrol feed

by monarchgiri818

Connected

1

0

0

If You say "turn on lights", then Send data to lightcontrol feed

by monarchgiri818

Connected

1

0

0

Create

Figure 49 IFTTT applets

### 4.3.8 Task 8: Room temperature controller with google assistant

Here the implementation of the google assistant is done with the room temperature controller, the room temperature controller and google assistant are combined together and perform accordingly. The room temperature controller would be working automatically and along with that, implementation of google assistant is also done for controlling the fan, heater (LED).

#### 4.3.8.1 Programming for the room temperature controller with google assistant

The code is written for the google assistant and room temperature controller combined, the two-separate code for the room temperature controller and google assistant are combined together to work accordingly.



```

room_temp_controller_with_google_assistant | Arduino 1.8.13
File Edit Sketch Tools Help
room_temp_controller_with_google_assistant

#include <ESP8266WiFi.h> // including the library for wifi
#include "Adafruit_MQTT.h" // adafruit mqtt
#include "Adafruit_MQTT_Client.h" // adafruit mqtt client
#include "DHT.h" // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11 // DHT 11
#define DHTPIN 2

DHT dht(DHTPIN, DHTTYPE);

#define WLAN_SSID      "Home wifi"
#define WLAN_PASS      "sweethome09"
#define AIO_SERVER     "io.adafruit.com"
#define AIO_SERVERPORT 1883
#define AIO_USERNAME   "MonarchGiri"
#define AIO_KEY        "aio_VHpo77TWwUV6IzGjUjUEi71Q1leB"

const int Heater_pin = 12, FAN_pin = 14, man = 13; //declare the IO pins

float SetTemp = 25; // teh prefer room temperature is set as 25 degree celsius

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

WiFiClient client; // Create an ESP8266 WiFiClient class to connect to the MQTT server.

// Setup the MQTT client class by passing in the WiFi client and MQTT server and login details.
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
Adafruit_MQTT_Subscribe LED_Control = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds/LED_Control");

void MQTT_connect();
void setup() {

Serial.begin(115200);
delay(10);
dht.begin();
lcd.begin(16, 2);

```

```
pinMode(Heater_pin, OUTPUT);
pinMode(FAN_pin, OUTPUT);
pinMode(man, INPUT);

lcd.init(); // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1);
lcd.print("Sensor");
delay(1000);

// Connect to WiFi access point.
Serial.println(); Serial.println();
Serial.print("Connecting to ");
Serial.println(WLAN_SSID);

WiFi.begin(WLAN_SSID, WLAN_PASS);
while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}

Serial.println();
Serial.println("WiFi connected");
Serial.println("IP address: "); Serial.println(WiFi.localIP());
mqtt.subscribe(&LED_Control);

}

uint32_t x=0;
```

```
void loop() {  
    MQTT_connect();  
  
    float t = dht.readTemperature();  
  
    lcd.clear();  
    lcd.print("Temp.");  
    lcd.setCursor(0,1);  
    lcd.print(t);  
    Serial.print(t);  
    lcd.print("C");  
    delay(1000);  
  
    Adafruit_MQTT_Subscribe *subscription;  
  
    if (digitalRead(man) == HIGH) {  
        lcd.setCursor(7,0);  
        lcd.print("Auto ON");  
        if (t > SetTemp) {  
            digitalWrite(FAN_pin, HIGH);  
            delay(1000);  
        }  
        else {  
            digitalWrite(FAN_pin, LOW);  
        }  
  
        if(t < SetTemp){  
            digitalWrite(Heater_pin, HIGH);  
            delay(1000);  
        }  
        else{  
            digitalWrite(Heater_pin, LOW);  
        }  
    }  
}
```

```

    else {
        lcd.setCursor(7,0);
        lcd.print("Auto OFF");
        while ((subscription = mqtt.readSubscription(1000))) {
            if (subscription == &LED_Control) {
                Serial.print(F("Got: "));
                Serial.println((char *)LED_Control.lastread);
                if (!strcmp((char*) LED_Control.lastread, "FAN ON"))
                {
                    fanOn();
                }
                if (!strcmp((char*) LED_Control.lastread, "HEATER ON"))
                {
                    fanOff();
                }
                if (!strcmp((char*) LED_Control.lastread, "ALL OFF"))
                {
                    allOff();
                }
            }
        }
    }
}

void fanOn() {
    digitalWrite(FAN_pin, HIGH);
    digitalWrite(Heater_pin, LOW);
}
void fanOff(){
    digitalWrite(Heater_pin, HIGH);
    digitalWrite(FAN_pin, LOW);
}
void allOff(){
    digitalWrite(FAN_pin, LOW);
    digitalWrite(Heater_pin, LOW);
}

```

```

void MQTT_connect() {
    int8_t ret;

    // Stop if already connected.
    if (mqtt.connected()) {
        return;
    }

    Serial.print("Connecting to MQTT... ");

    uint8_t retries = 3;

    while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected
        Serial.println(mqtt.connectErrorString(ret));
        Serial.println("Retrying MQTT connection in 5 seconds...");
        mqtt.disconnect();
        delay(5000); // wait 5 seconds
        retries--;
        if (retries == 0) {
            // basically die and wait for WDT to reset me
            while (1);
        }
    }
    Serial.println("MQTT Connected!");
}

```

---

*Figure 50 Code for room temperature controller with google assistant*

#### 4.3.8.2 Testing for the room temperature controller with google assistant

Objectives	To test whether the implementation of the google assistant would work properly with the room temperature controller or not.
Expected result	The implementation of the google assistant with the room temperature controller would work simultaneously.
Actual result	The google assistant worked properly with the room temperature controller and the devices were able be controlled via google assistant.
Conclusion	The test was successful.

*Table 7 Test for the room temperature controller with google assistant*

Proof:

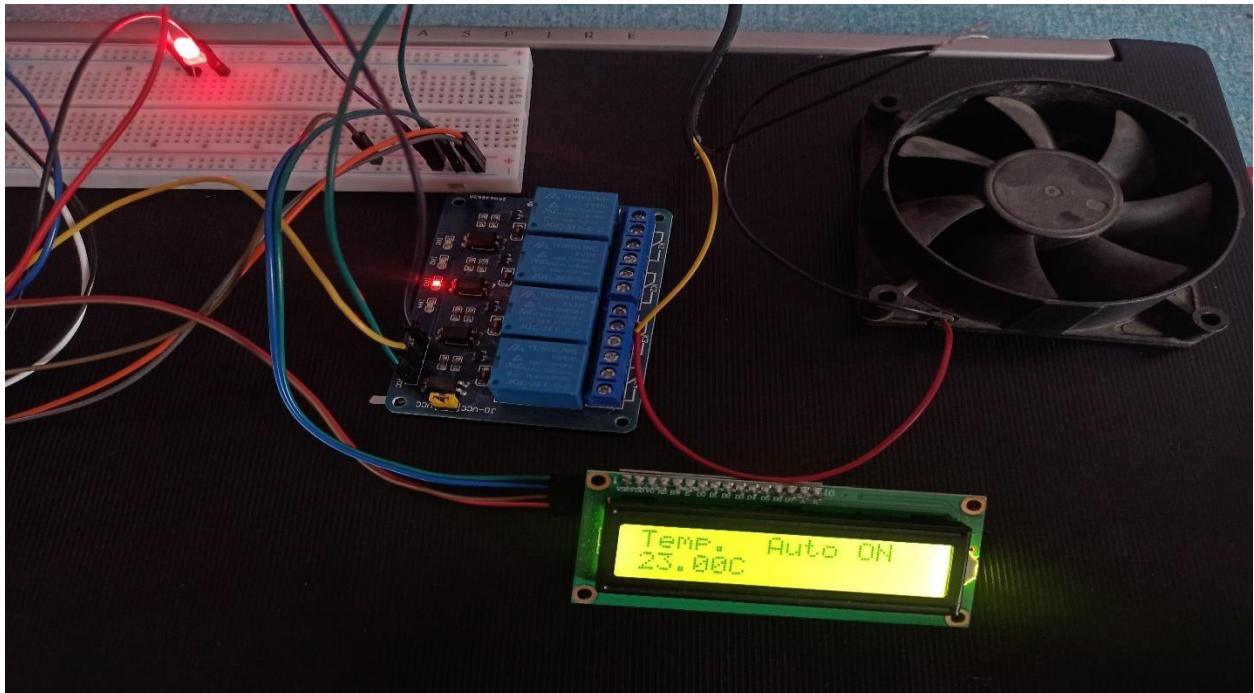


Figure 51 Heater (LED) on while low temp

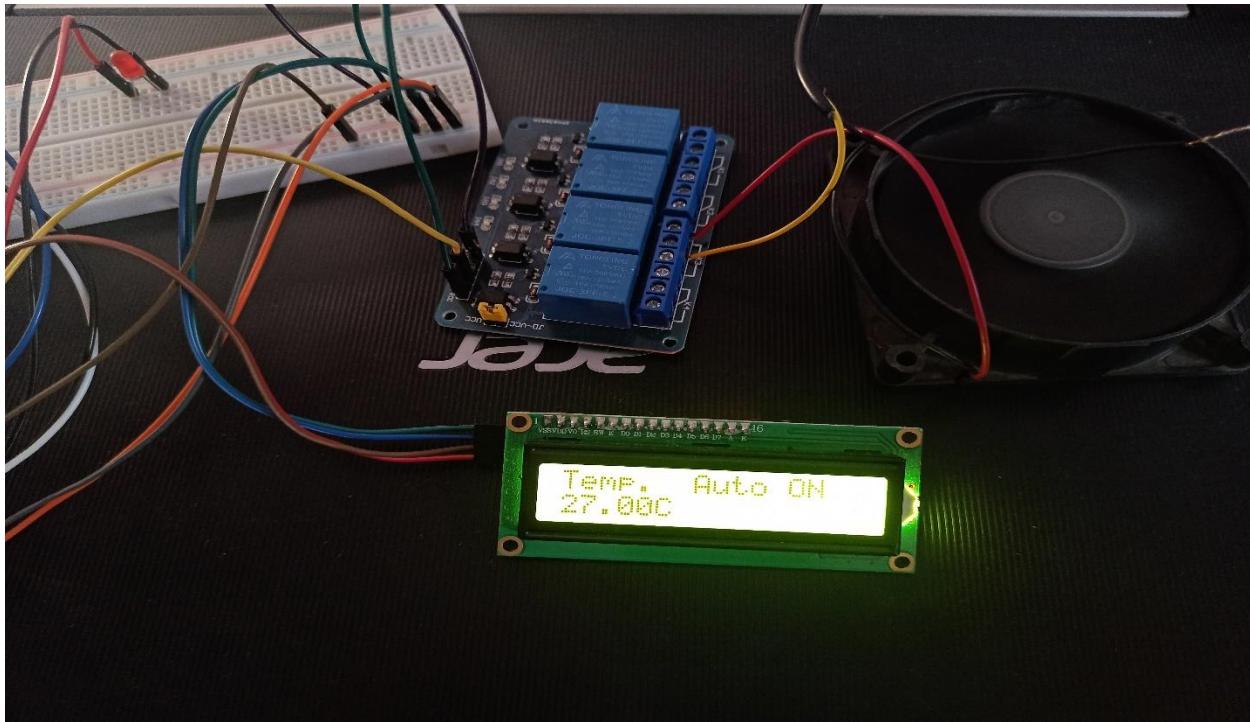


Figure 52 Fan on while high temp

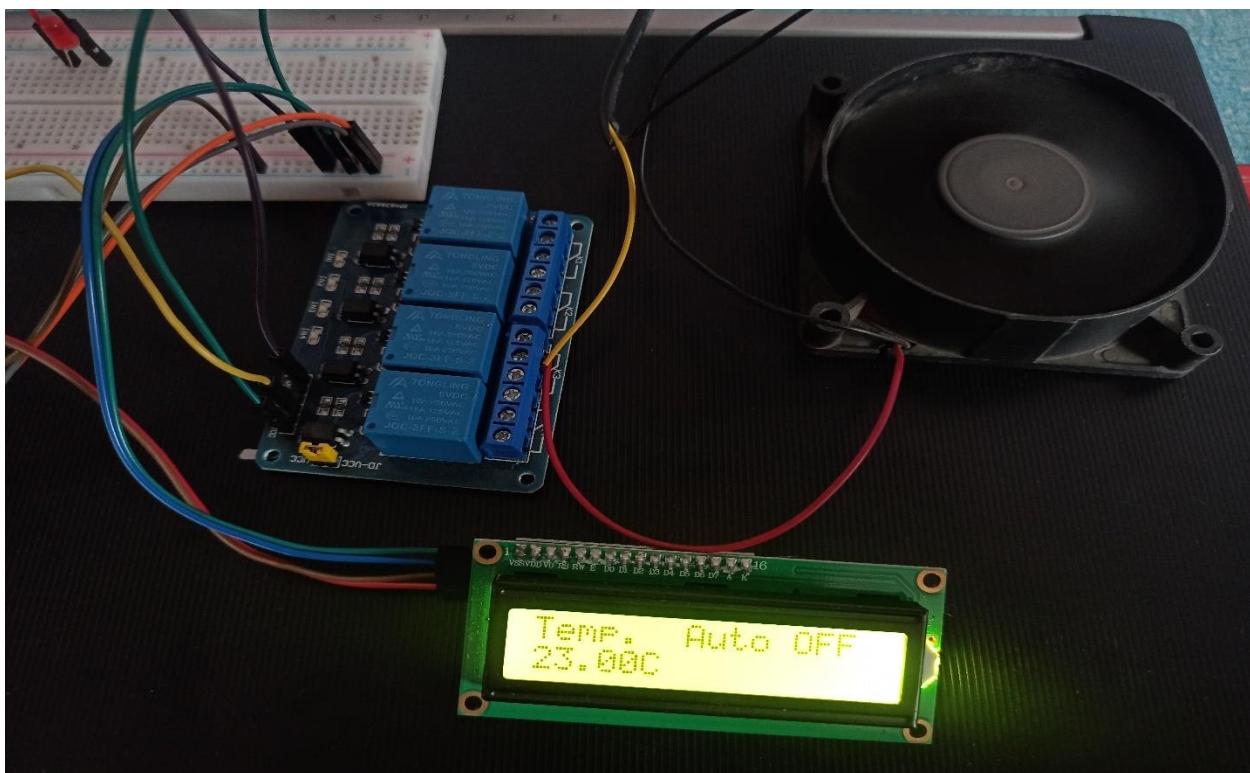


Figure 53 Fan on via google assistant

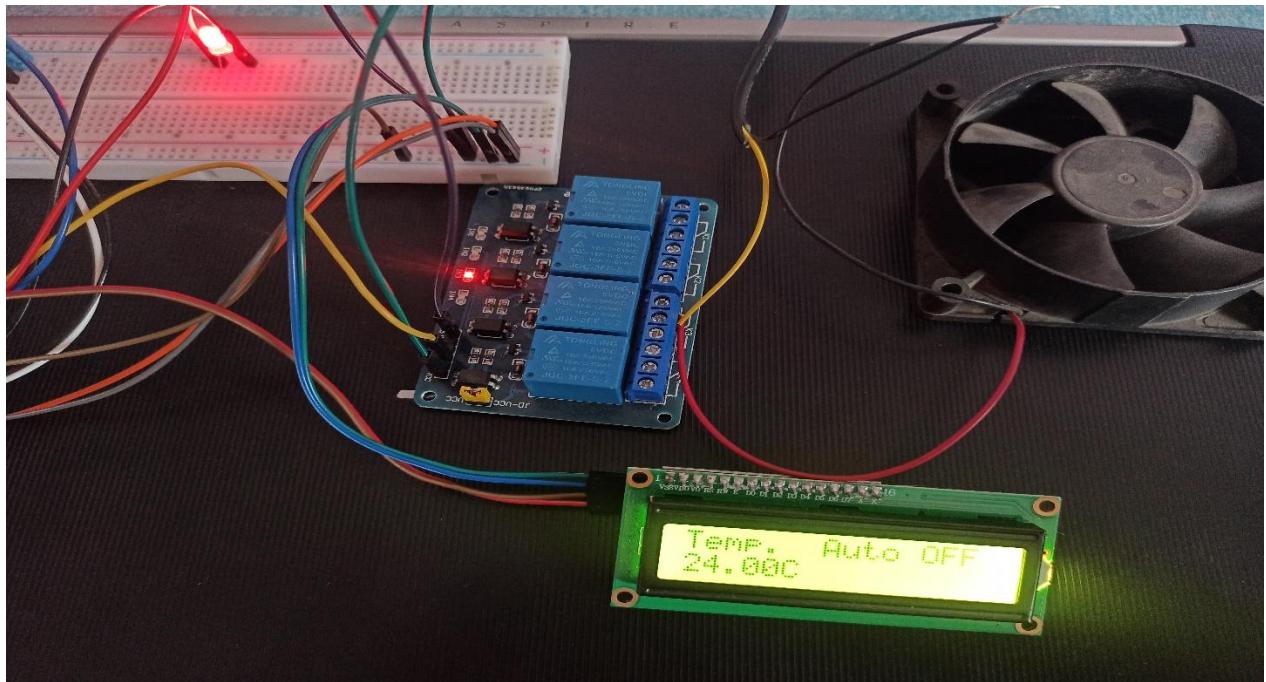


Figure 54 Heater (LED) on via google assistant

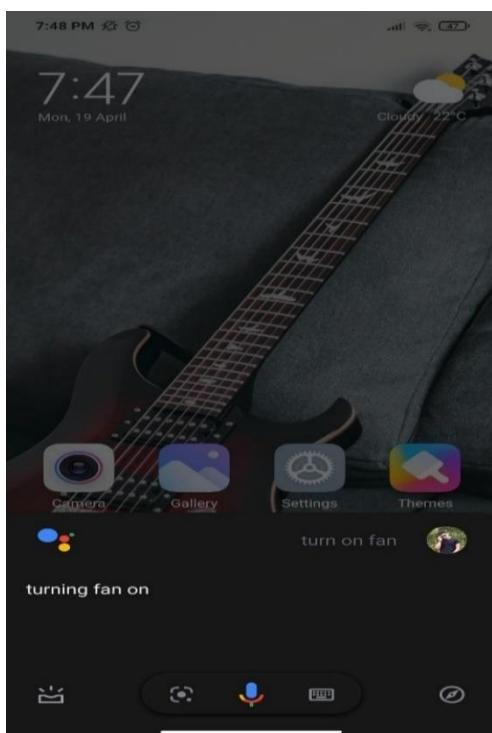


Figure 56 Command for fan on

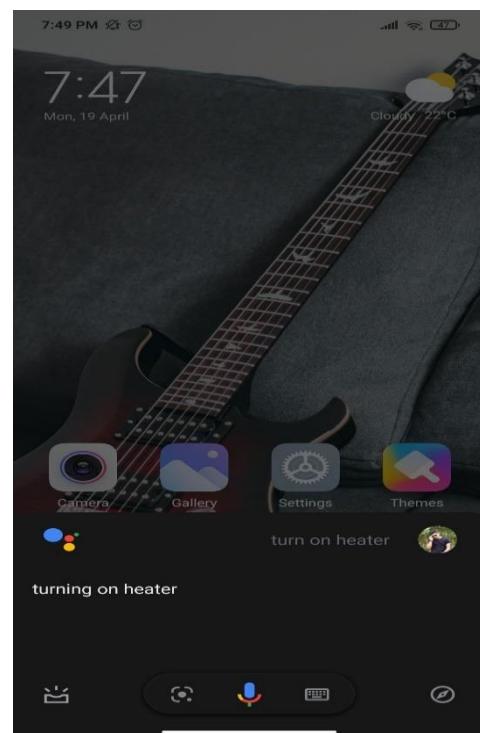


Figure 55 Command for heater (LED) on

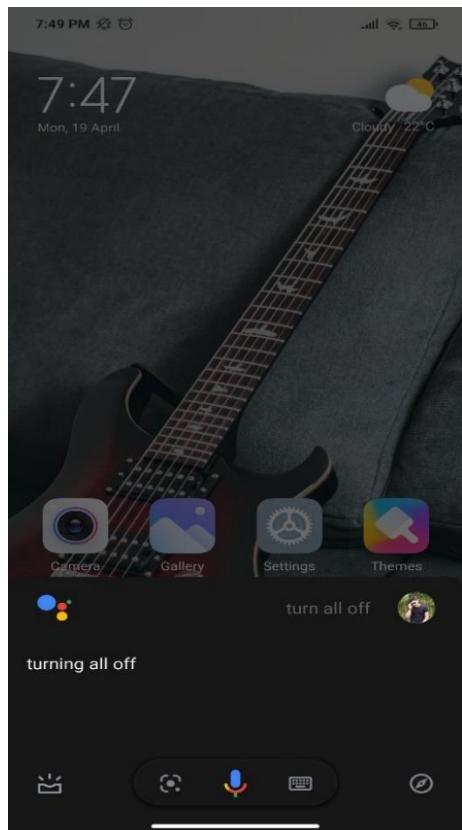


Figure 57 Command for all off

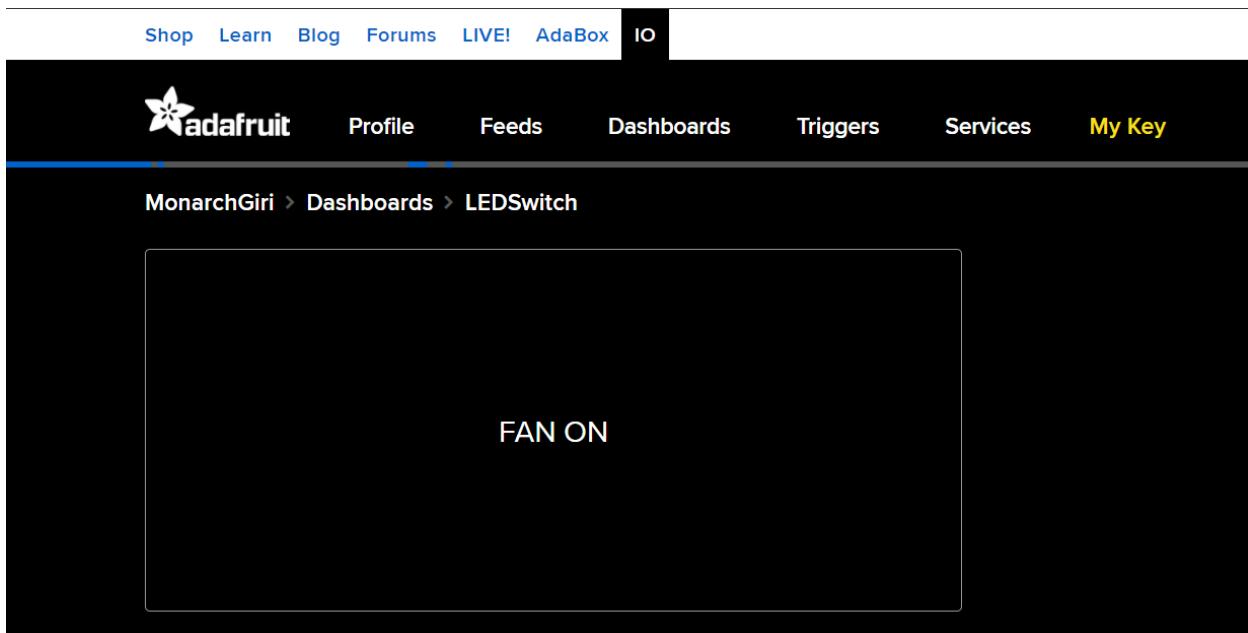


Figure 58 Adafruit dashboard showing fan on

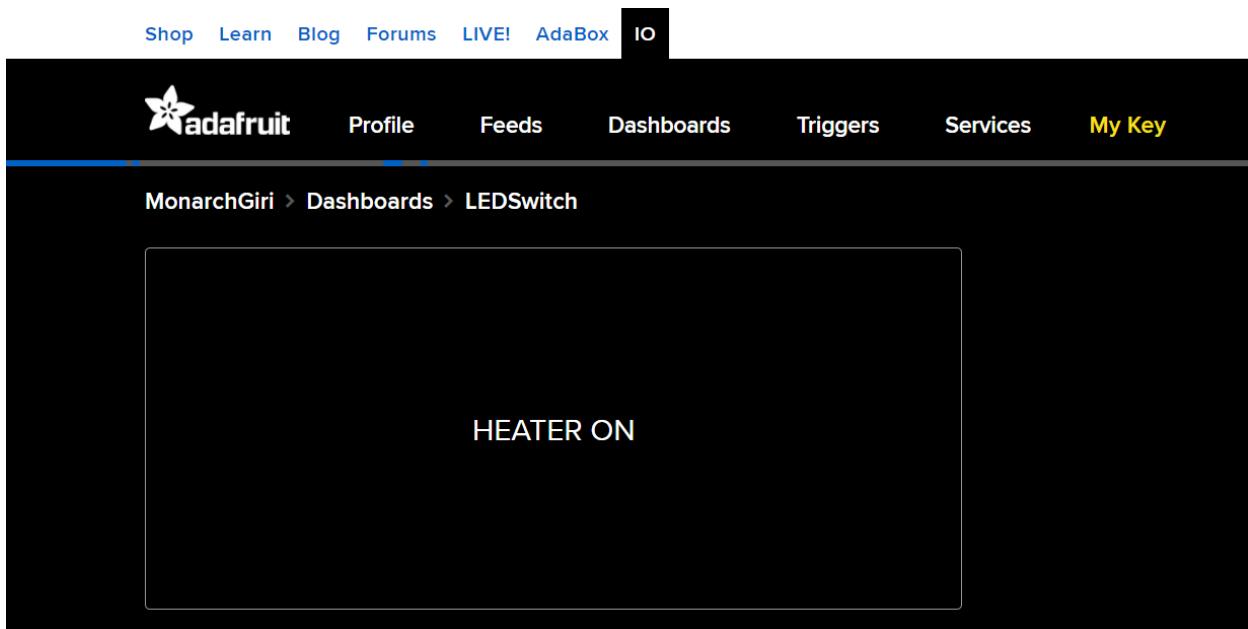


Figure 59 Adafruit dashboard showing heater on

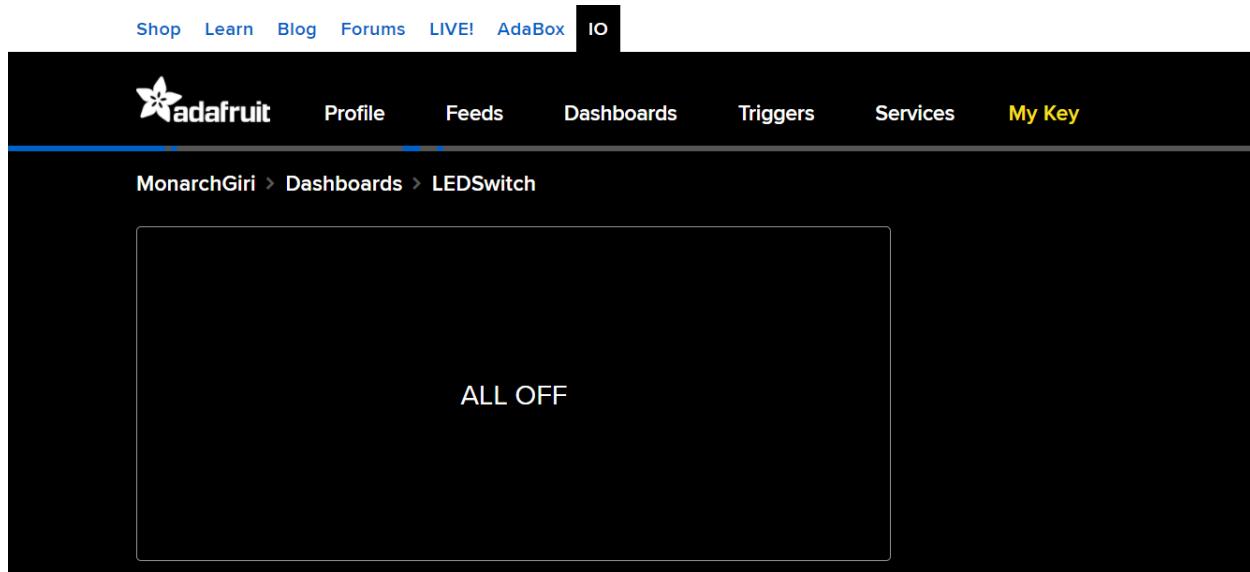
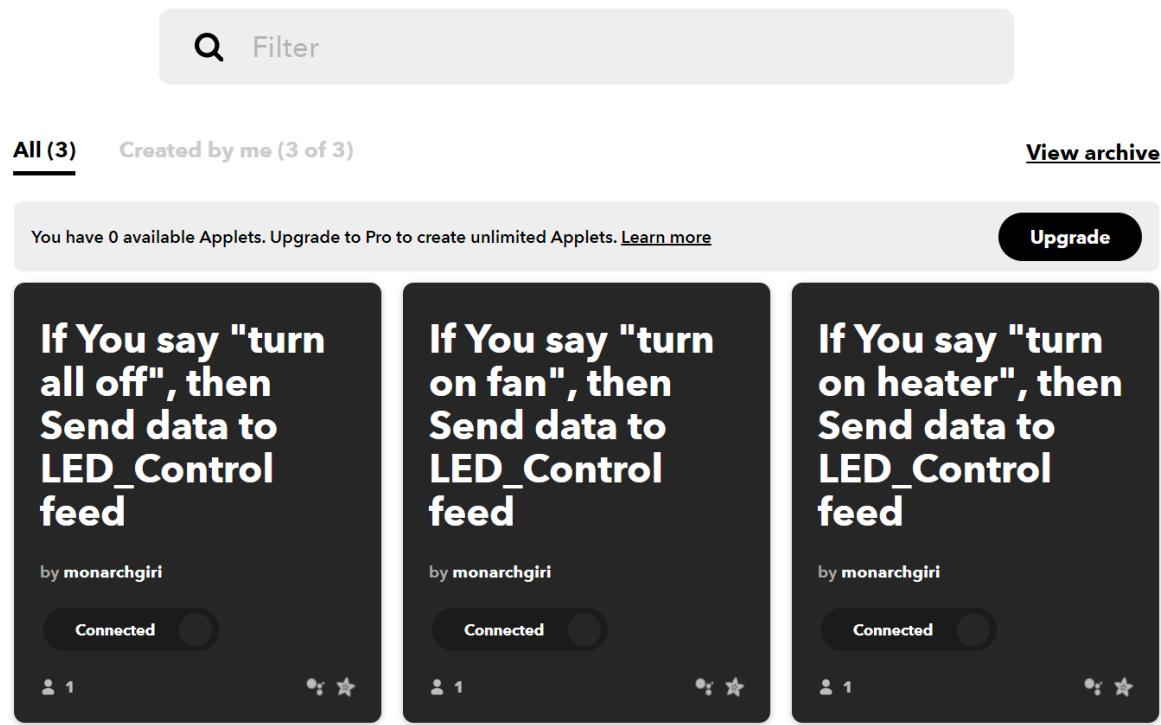


Figure 60 Adafruit dashboard showing all off

## My Applets



The screenshot shows the "My Applets" dashboard. At the top, there's a search bar with a magnifying glass icon and the word "Filter". Below the search bar, there are three tabs: "All (3)" (which is underlined), "Created by me (3 of 3)", and "View archive". On the right side of the dashboard, there's a button labeled "Upgrade".

Under the tabs, there are three applet cards, each with a dark background and white text:

- If You say "turn all off", then Send data to LED\_Control feed**  
by monarchgiri | Connected | 1 user | 0 reviews
- If You say "turn on fan", then Send data to LED\_Control feed**  
by monarchgiri | Connected | 1 user | 0 reviews
- If You say "turn on heater", then Send data to LED\_Control feed**  
by monarchgiri | Connected | 1 user | 0 reviews

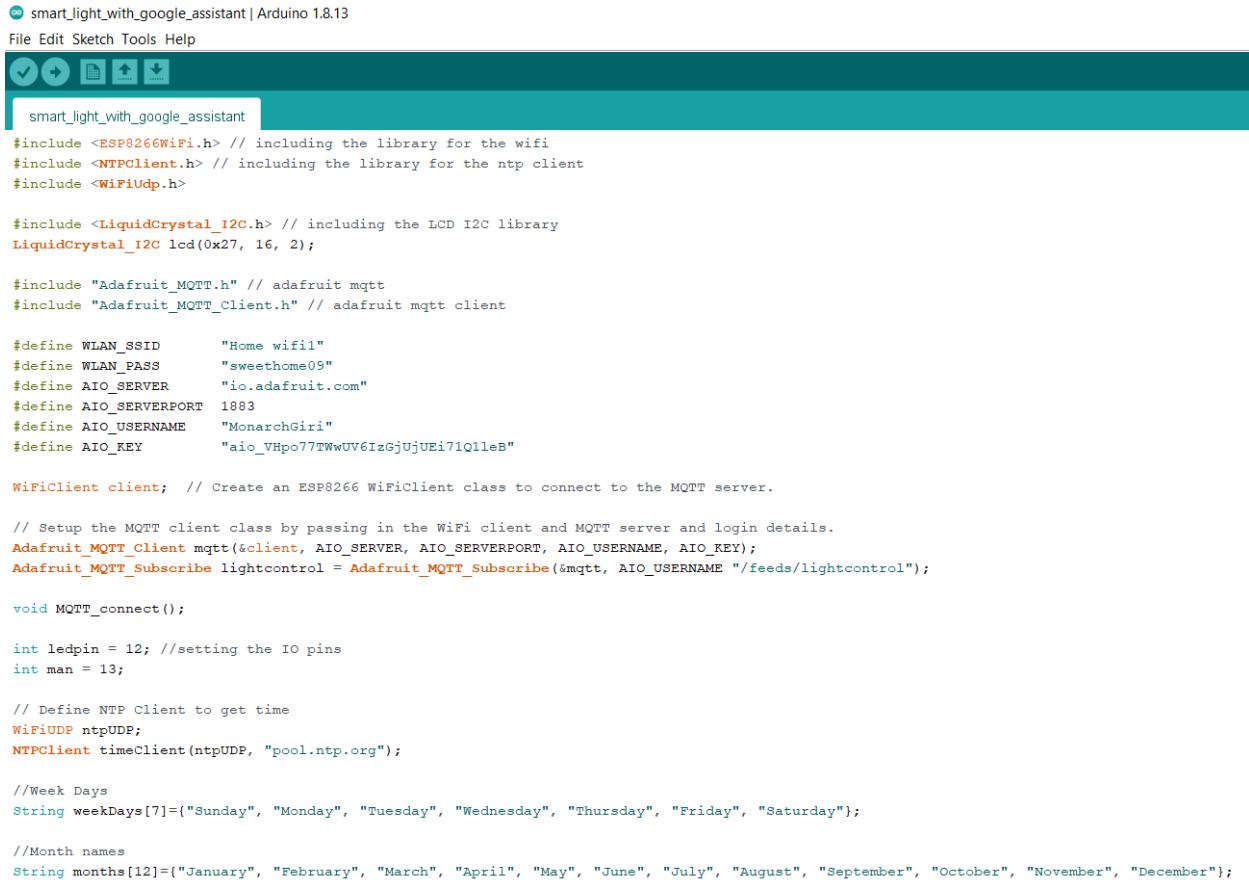
Figure 61 IFTTT applets

### 4.3.9 Task 9: Smart light with google assistant

Here the implementation of the google assistant is done with the smart lights, the two separate codes are combined, and the system would perform automatically, and the LED light can be controlled via the google assistant as well.

#### 4.3.9.1 Programming for the smart light with google assistant

The code of the smart light and the google assistant are combined where it can perform automatically as well the light can be controlled via google assistant.



```

smart_light_with_google_assistant | Arduino 1.8.13
File Edit Sketch Tools Help
smart_light_with_google_assistant
#include <ESP8266WiFi.h> // including the library for the wifi
#include <NTPClient.h> // including the library for the ntp client
#include <WiFiUDP.h>

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

#include "Adafruit_MQTT.h" // adafruit mqtt
#include "Adafruit_MQTT_Client.h" // adafruit mqtt client

#define WLAN_SSID      "Home wifi1"
#define WLAN_PASS      "sweethome09"
#define AIO_SERVER     "io.adafruit.com"
#define AIO_SERVERPORT 1883
#define AIO_USERNAME   "MonarchGiri"
#define AIO_KEY        "aio_VHpo77tWwUV6IzGjUjUEi7iQ1leB"

WiFiClient client; // Create an ESP8266 WiFiClient class to connect to the MQTT server.

// Setup the MQTT client class by passing in the WiFi client and MQTT server and login details.
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
Adafruit_MQTT_Subscribe lightcontrol = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds/lightcontrol");

void MQTT_connect();

int ledpin = 12; //setting the IO pins
int man = 13;

// Define NTP Client to get time
WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP, "pool.ntp.org");

//Week Days
String weekDays[7]={"Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"};

//Month names
String months[12]={"January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December"};

```

```
void setup() {
    pinMode(ledpin,OUTPUT);

    lcd.begin(16,2);
    lcd.init(); // initializing the LCD
    lcd.backlight(); // Enable or Turn On the backlight

    // Initialize Serial Monitor
    Serial.begin(115200);

    // Connect to WiFi access point.

    Serial.println(); Serial.println();
    Serial.print("Connecting to ");
    Serial.println(WLAN_SSID);

    WiFi.begin(WLAN_SSID, WLAN_PASS);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }

    Serial.println();
    Serial.println("WiFi connected");
    Serial.println("IP address: "); Serial.println(WiFi.localIP());
    mqtt.subscribe(&lightcontrol);

    // Initialize a NTPClient to get time
    timeClient.begin();
    timeClient.setTimeOffset(20700);

}
```

```
uint32_t x=0;

void loop() {
    MQTT_connect();
    timeClient.update();

    unsigned long epochTime = timeClient.getEpochTime();
    Serial.print("Epoch Time: ");
    Serial.println(epochTime);

    String formattedTime = timeClient.getFormattedTime();
    Serial.print("Formatted Time: ");
    Serial.println(formattedTime);

    int currentHour = timeClient.getHours();
    Serial.print("Hour: ");
    Serial.println(currentHour);

    int currentMinute = timeClient.getMinutes();
    Serial.print("Minutes: ");
    Serial.println(currentMinute);

    int currentSecond = timeClient.getSeconds();
    Serial.print("Seconds: ");
    Serial.println(currentSecond);

    //Get a time structure
    struct tm *ptm = gmtime ((time_t *)&epochTime);

    int monthDay = ptm->tm_mday;
    Serial.print("Month day: ");
    Serial.println(monthDay);

    int currentMonth = ptm->tm_mon+1;
    Serial.print("Month: ");
    Serial.println(currentMonth);
```

```
int currentYear = ptm->tm_year+1900;
Serial.print("Year: ");
Serial.println(currentYear);

//Print complete date:
String currentDate = String(currentYear) + "-" + String(currentMonth) + "-" + String(monthDay);
Serial.print("Current date: ");
Serial.println(currentDate);

Serial.println("");

lcd.setCursor(0,0);
lcd.print("TIME=");
lcd.setCursor(5,0);
lcd.print(formattedTime);

lcd.setCursor(0,1);
lcd.print("DATE=");
lcd.setCursor(5,1);
lcd.print(currentDate);

Adafruit_MQTT_Subscribe *subscription;

if (digitalRead(man) == HIGH) {
    if(currentHour >= 7 && currentHour <= 17){
        digitalWrite(ledpin,LOW);
    }
    else{
        digitalWrite(ledpin,HIGH);
    }
    delay(1000);
}
```

```

else{
    while ((subscription = mqtt.readSubscription(1000))) {
        if (subscription == &lightcontrol) {
            Serial.print(F("Got: "));
            Serial.println((char *)lightcontrol.lastread);
            if (!strcmp((char*) lightcontrol.lastread, "ON"))
            {
                digitalWrite(ledpin, HIGH);
            }
            else
            {
                digitalWrite(ledpin, LOW);
            }
        }
    }
}

void MQTT_connect() {
int8_t ret;

// Stop if already connected.
if (mqtt.connected()) {
    return;
}
Serial.print("Connecting to MQTT... ");

uint8_t retries = 3;
while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected
    Serial.println(mqtt.connectErrorString(ret));
    Serial.println("Retrying MQTT connection in 5 seconds...");
    mqtt.disconnect();
    delay(5000); // wait 5 seconds
    retries--;
}

if (retries == 0) {
    // basically die and wait for WDT to reset me
    while (1);
}
}
Serial.println("MQTT Connected!");
}

```

*Figure 62 Code for smart light with google assistant*

#### 4.3.9.2 Testing for the smart light with google assistant

Objectives	To test whether the implementation of the google assistant would work properly with the smart light or not.
Expected result	The implementation of the google assistant with the smart light would work simultaneously.
Actual result	The google assistant worked properly with the smart light and the LED light was able be controlled via google assistant
Conclusion	The test was successful.

Table 8 Test for the smart light with google assistant

Proof:

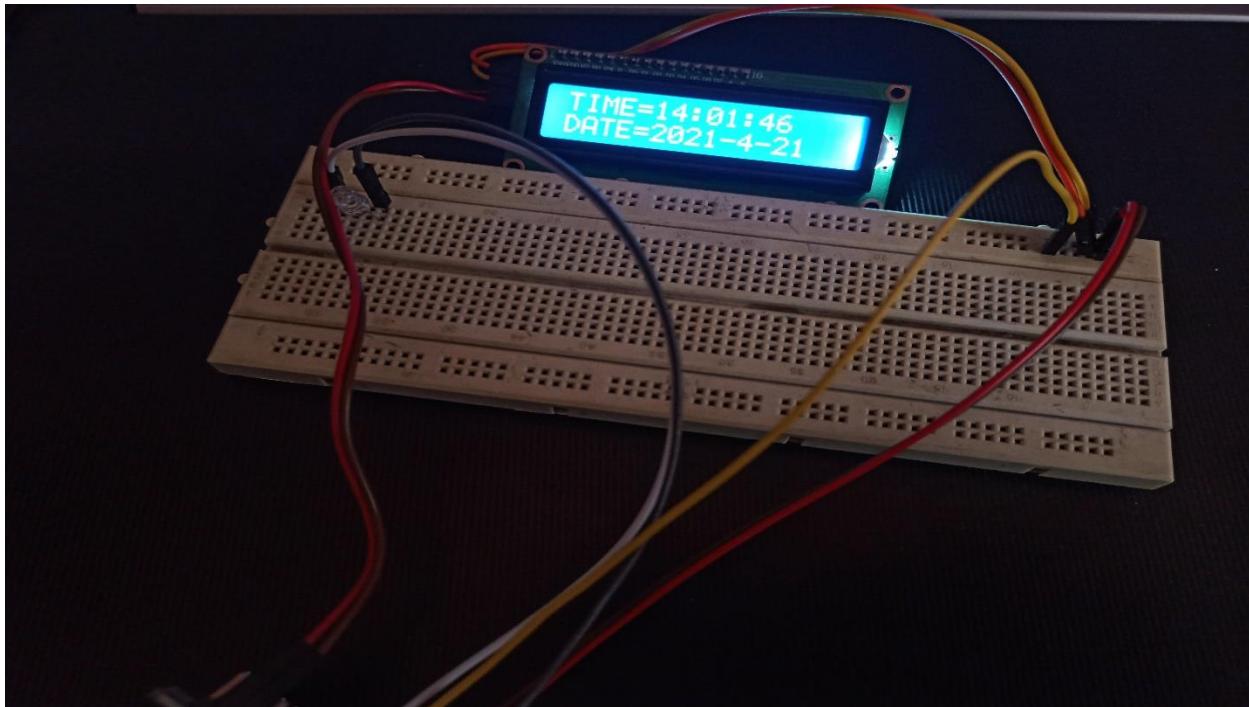


Figure 63 Light off in daytime

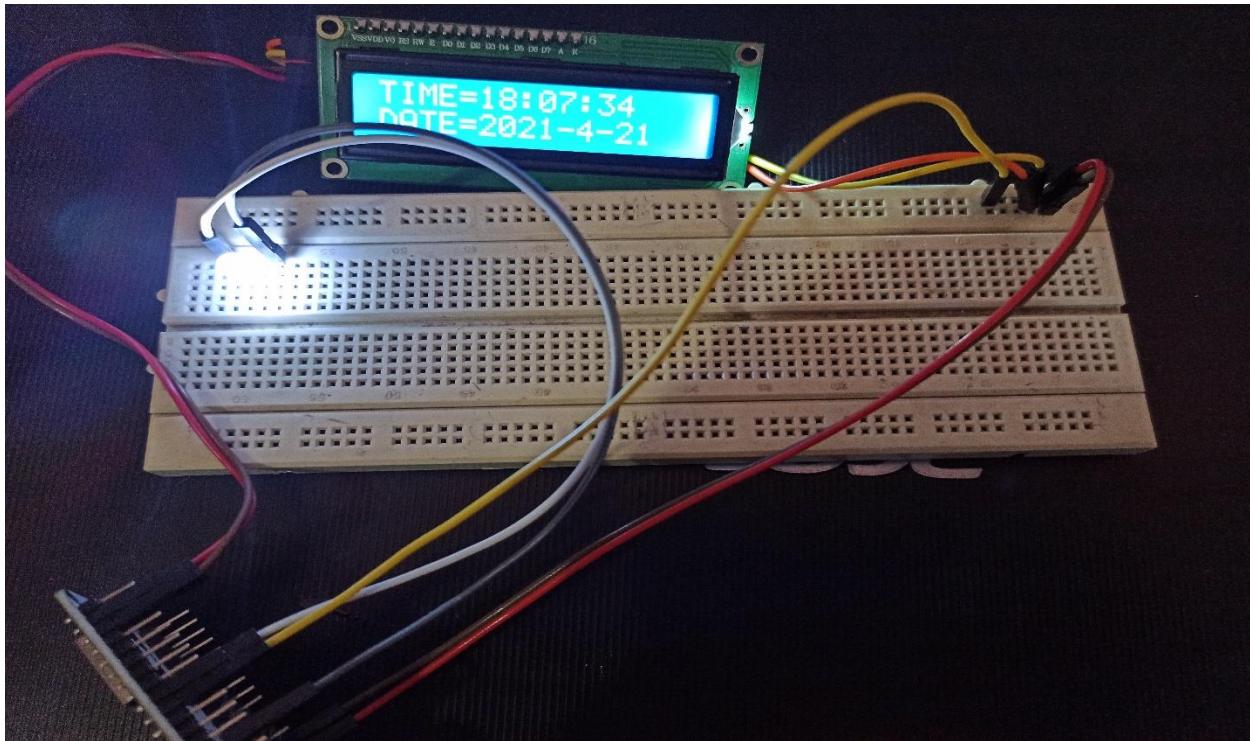


Figure 64 Lights on in nighttime

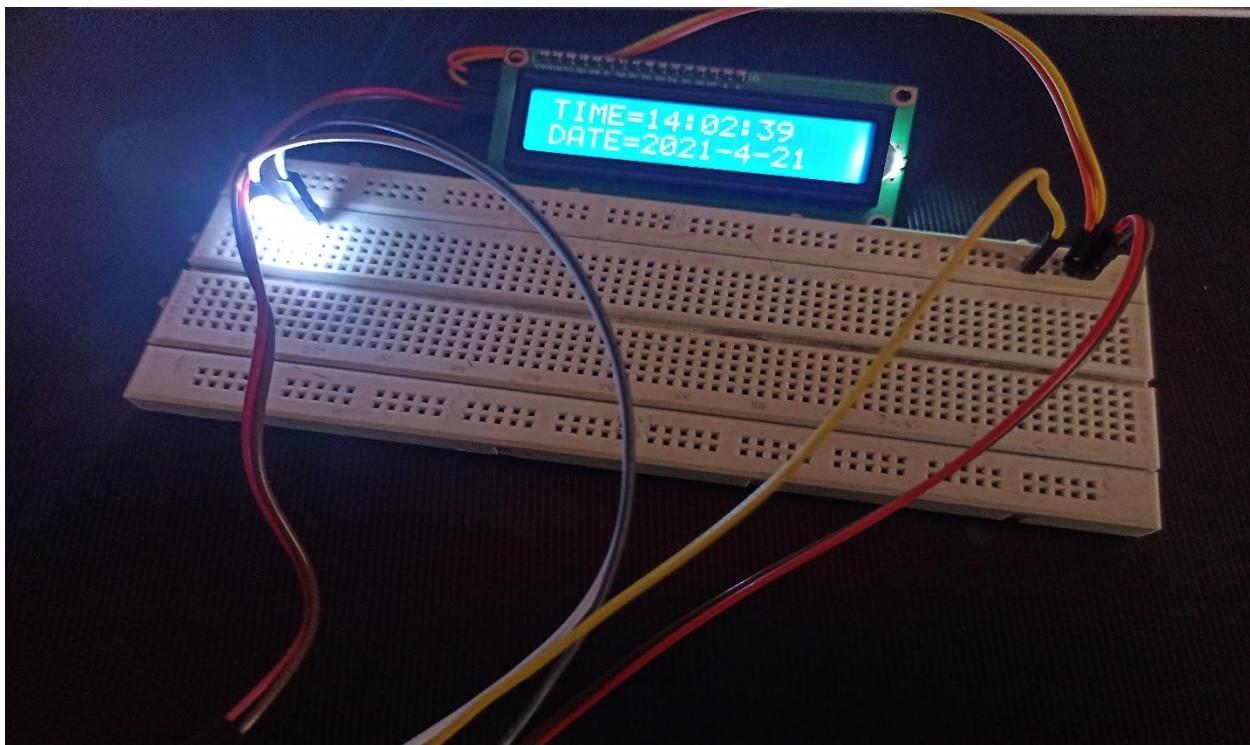


Figure 65 Light on via google assistant

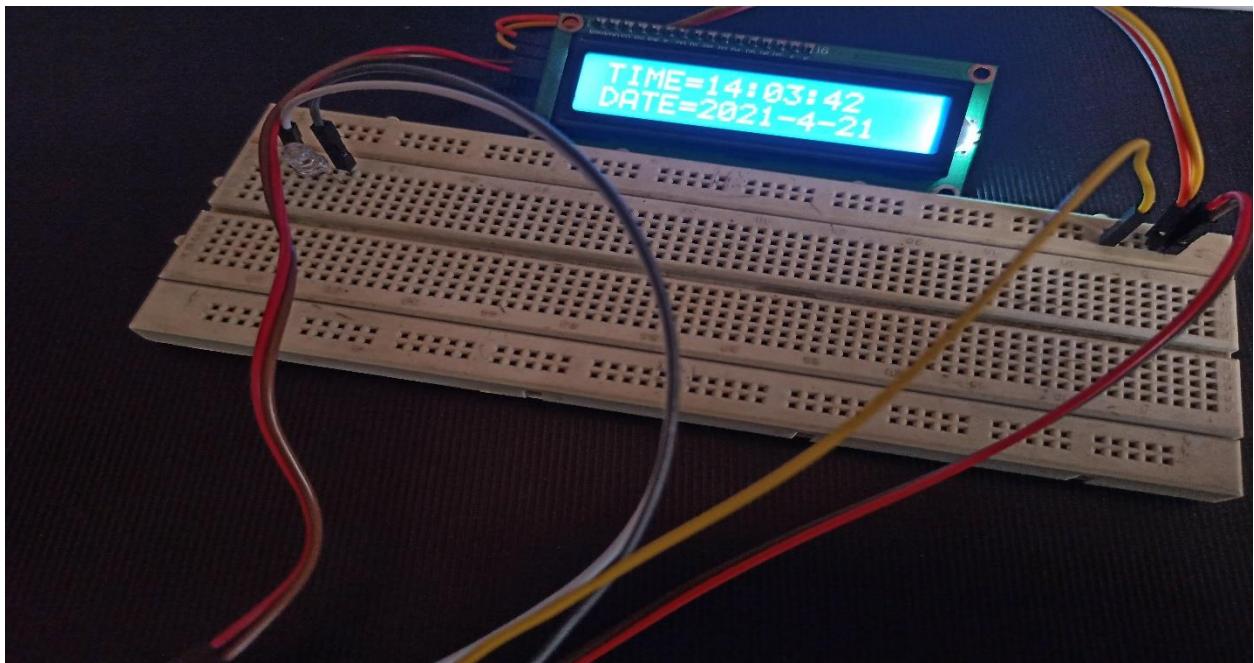


Figure 66 Light off via google assistant

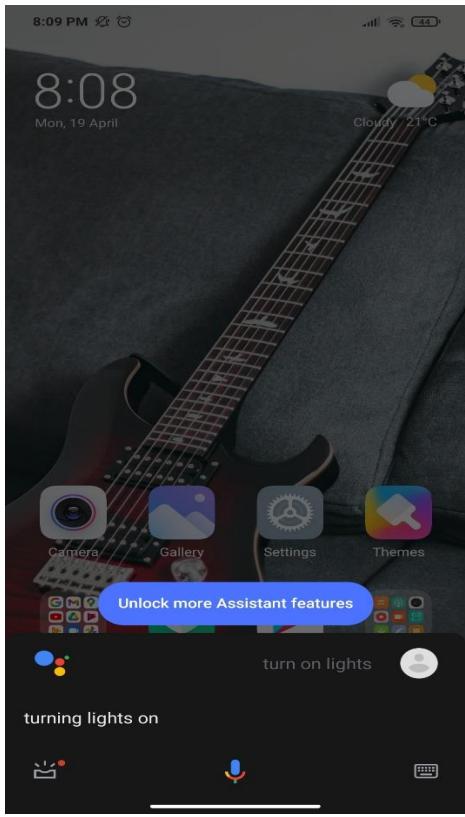


Figure 68 Command for lights on



Figure 67 Command for lights off

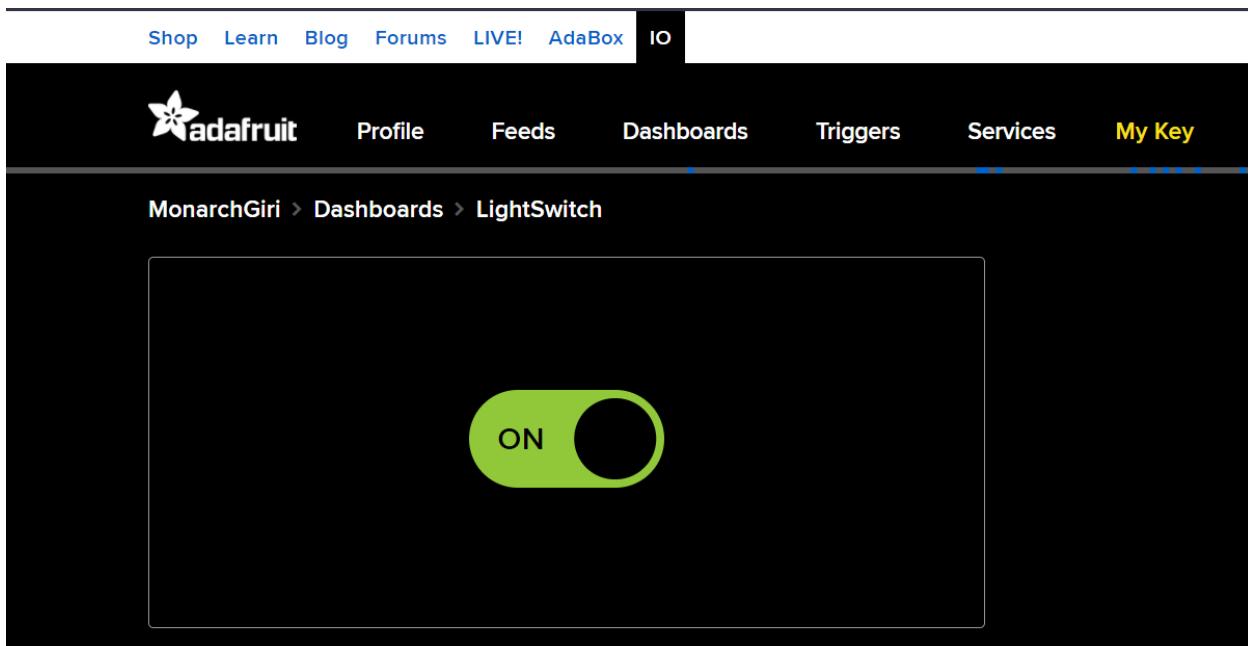


Figure 69 Adafruit dashboard showing light is on

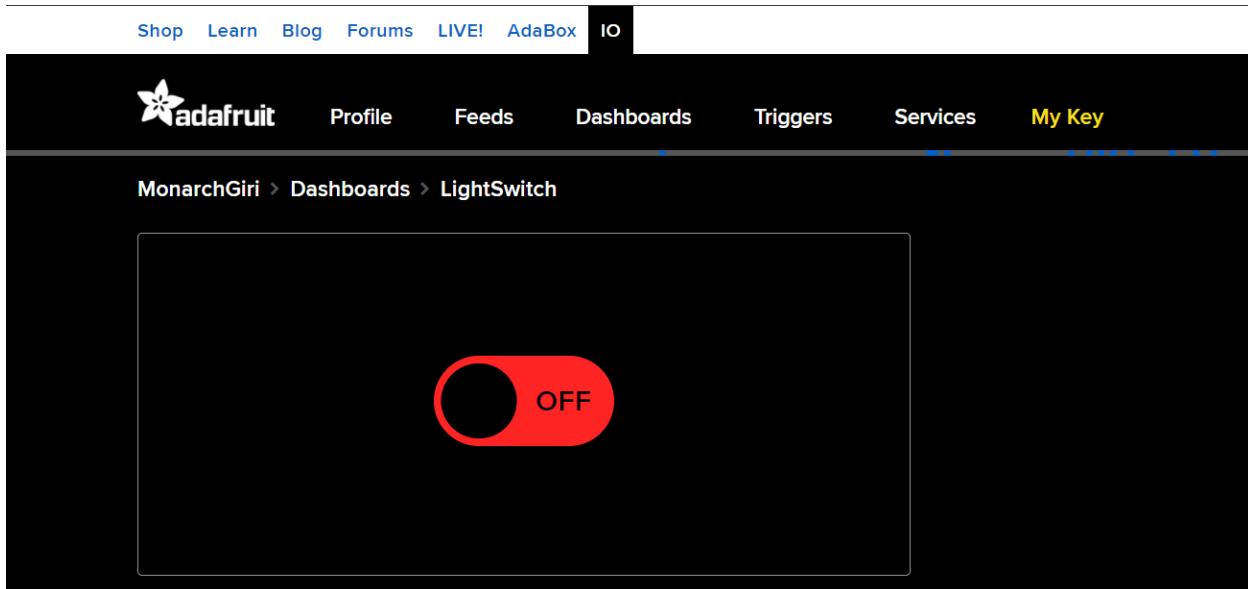


Figure 70 Adafruit dashboard showing light is off

# My Applets

 Filter

All (2)    Created by me (2 of 3)

View archive

You have 1 available Applet. Upgrade to Pro to create unlimited Applets. [Learn more](#)

Upgrade

If You say "turn off lights", then Send data to lightcontrol feed

by monarchgiri818

Connected

1

If You say "turn on lights", then Send data to lightcontrol feed

by monarchgiri818

Connected

1

Figure 71 IFTTT applets

111

#### 4.3.10 Task 10: Final test

This test is the final test where all the above tests were combined and checked if the final output was as expected or not. This is the final test of the working of the system.

##### 4.3.10.1 Program of the final test

The final program of the final system is the combination of the room temperature controller with google assistant which is done in section 4.3.8 and combination of the smart lights with the google assistant which is done in section 4.3.9.

##### 4.3.10.2 Testing the final two systems

Objectives	<ul style="list-style-type: none"> <li>1) To measure the temperature by the DHT11 sensor and automatically control the fan and heater (LED) based on the room temperature and set temperature by the user and control the fan and heater (LED) via google assistant.</li> <li>2) To access the time from NTP server and automatically control the light based on the day and nighttime and control the light via google assistant.</li> </ul>
Expected result	<ul style="list-style-type: none"> <li>1) The fan and heater (LED) would be automatically controlled based on the room temperature and set temperature by the user and fan and heater (LED) can be controlled via google assistant.</li> <li>2) The time would be fetched from the NTP server and the lights would be automatically controlled based on the day and nighttime and control the light via google assistant.</li> </ul>
Final analysis and working of the system	For the final analysis and testing of the system all the tests are done properly as shown above.

	<p>The system is working properly as expected and any error is not found. All the codes and final outputs shown are genuine and the final working is also shown in the section 4.3.8 where there is the combination of the room temperature controller with google assistant which is the testing of the final system of automatic room temperature controller with google assistant. Another final working is shown in the section 4.3.9 where there is the combination of the smart lights with google assistant which is the testing of the final system of smart lights with google assistant. Both the system is working properly.</p>
--	---

*Table 9 Final test of the system*

## 4.4 Securing the IOT devices

Securing the IOT devices are very important for secure data transmission and security of the end users, here physical and device security of IOT devices is explained.

### 4.4.1 Physical security

Physical security is also an important aspect for securing the IOT devices. The hardware components should be properly managed and secured so that the devices perform well and there is minimal chance of the hardware failure. Power supply is very important for the hardware components to perform well. If power supply is higher than need the hardware can explode. NodeMCU is supplied with the 5v power with the help of the power bank, LCD is supplied with 5v which can operate till 5.3v, DHT11 sensor is supplied with 3v from NodeMCU, LED is provided with 3v and the DC is of 12v which is connected with the 12v adapter. The connection for the sensor, LED, LCD and relay module is all connected through the breadboard which helps in safe connection of the devices. All the wiring is done properly so that the devices would not face any problems related to connectivity or circuit failure. The connection of the internet is also done safely and the IP of the NodeMCU cannot be accessed by others and the also Adafruit ID is only known by the user and it cannot be publicly accessed.

### 4.4.2 Device security

According to the report titled as “Securing Your “Internet of Things” Devices” published by U.S. Department of Justice. Here this article talks about the increase in attacks in the IOT devices. Attackers find the vulnerability to gain the unauthorized access, control the devices and damage the devices. If further precautions are not taken, hacker will exploit the system and it can cause a lot of damage. This article also talks about how to secure the devices. First is the strong password protection for the internet connection and the devices. Continue update of the firmware is very necessary, when a new update is available from the manufactures it should be done immediately. The devices which are not in use should be turned off like the camera with microphones which can be compromised by the attackers to invade our privacy. Routers and Wi-Fi also need to be secure as well (justice, 2017).

According to the report titled as IOT SECURITY: CHALLENGES, SOLUTIONS & FUTURE PROSPECTS” written by Mikhail Gloukhovtsev. The writer explains about the different types of attacks that can be faced for example the man-in-the-middle attack, replay attack, denial of service attack. IOT security requirement is also explained where the three main components are described which are the data confidentiality, privacy and trust. The data must be made confidential to make sure that unauthorized people cannot view the data that the writer suggests about the symmetric encryption. Privacy of the data and users must be maintained, data governance and enforcement mechanism should be maintained. There should be trust management system for the IOT deployments which should have the ability to dynamically withdraw the trust of individual devices. There should be trustworthiness of the devices for other nodes that they communicate with (Gloukhovtsev, 2018).

## 5. Chapter 5: Conclusion

The purpose of this project was to research about the problem domain and identify the possible solution to that problem. This project was developed with the purpose to reduce problems related to thermal comfort, energy saving and easy living for the peoples inside the home. Home automation makes our daily life easier and more convenient, implementing home automation is a smart move to automate our home and solve any possible problems related to our daily life. Automatic control of the appliances, voice control, use of sensors to automate devices all fall under the roof of home automation.

Analyzing the problems and identifying the possible solution was the main aim of this project, thermal comfort was the big concern of the problem domain and further analyzing, it is found that thermal comfort is very necessary for everyone living in their homes. Unmanaged and uncomfortable thermal comfort can lead us to many different problems. Without proper thermal comfort it can also affect the human health and living in the environment of unmanaged thermal comfort is very difficult. Especially for children and elderly people thermal comfort is very necessary and it should be managed properly. Energy saving is also very important, and every home should think about that and do their best to make the minimal use of energy and spend only necessary energy for the lights and home appliances. Another big concern was about the disabled people controlling the devices like fan, heater, lights physically. It is difficult for the disabled people to control those devices physically and it is one of the big problems faced by those people.

The proposed problem domain was also discussed through the literature review and the literature review also verifies that the problems domain was valid. It also clarifies that the problems discussed were the actual problems which are being faced in real time. Literature review provides many references about different journals written by different writer who also mentioned that the problems were similar to the problems which is proposed in this project. Analysis of the problem, analysis of the solution and identifying about the main aim and object were done in that section of literature review. While identifying and analyzing about the main aim and objectives about those journals, it was found that developing a system to reduce the possible problems discussed in the problem domain was the main concern. Problems related to thermal comfort, energy saving, controlling the devices physically by the disabled people were mentioned in the reviews by the

writers and for tackling those problems, analysis and implementation of the solution was also discussed in the literature review section.

By identifying the main problems domain, validating the proposed problems domain through the literature review and providing a possible solution to that problem a room temperature controller with smart light and google assistant system was developed in order to manage the thermal comfort, make the minimal use of energy and control the devices via the google assistant. For measuring the temperature of the room DHT11 is used and NodeMCU is used as the main microcontroller with other hardware components as well. Before implementing the hardware and software, detailed theoretical knowledge is necessary which is provided in the background section in this project.

For any project a proper methodology should be followed and according to the selected methodology the entire project is carried out. Evolutionary prototype was the selected methodology and based on that the entire project is completed. From requirement analysis to testing and delivery, this methodology work perfectly for this project. By analyzing the working of the methodology and referencing the use of the methodology by other writers, this methodology was verified. Based on the methodology first task was to design the circuit diagram and with the help of the designing of the circuit the whole hardware components are connected. First task was to develop the circuit diagram then another was to assemble the DHT11 for the measurement of the temperature. Then based on that temperature the development of automatic working of the fan and heater (LED) was done. And same goes for the smart lights, data from the NTP server was fetched and automatic control of the lights were done. For the last part implementation of the google assistant is done so that the devices can be controlled via google assistant. From measuring the temperature by the DHT11 and controlling the devices with google assistant all the test cases and development of the project is shown in the above section.

## 5.1. Legal, Social and Professional issues

### 5.1.1. Legal issues

The idea of this project and development of the system is a freely available and open idea. The concept of this system and home automation is being used widely. The hardware and software are easily available to purchase and to be installed. But according to the Nepal Standards (Certification-mark) Rules, 2040 published in Nepal Gazette the system should be verified with the council for the sale and distribution. And for the council the certificate of application should be submitted and the license or the certificate is valid till 3 years (commission, 1983). Besides that, while the devices are connected to the internet and can be controlled via mobile phone, data privacy can be a huge factor. The Federal Trade Commission (FTC) is concerned that the widespread availability of low-cost IoT products and software would raise security concerns for customers in terms of data collection and use. If security is neglected hackers can attack the system and can have access to the home devices and user's data. But if security is strong and data is encrypted, strong authentication and password are applied, and strong security measures are taken place the devices can be secured and kept safe from others (Chike, 2017).

### 5.1.2. Social issues

Implementation of this system in homes is a good step for automating the homes but when it comes to futuristic homes and homes which has automation included the pricing will rise. The price tag of the home would be high because of the implementation of home automation and real estate agents make the price higher than needed. Another issue can be the reliability of the devices, as it would be based on networks and internet if connection is lost, and network is dropped then the devices will be out of the users control and not work properly. Especially with this temperature control system, if it is not installed properly, it cannot manage the temperature and thermal discomfort is felt and it can lead to higher or lower room temperature than normal range.

### 5.1.3 Professional issues

This system is developed with the purpose of giving more value to the customers and where they can use the system with ease and take as much benefit as they can. One of the challenging tasks is that capturing consumer needs in proposals and satisfying them after handover. And every single consumer is looking for a solution to a particular problem. Customization and incorporation efforts are often underestimated at the outset. It could lead to a delay in project commissioning or a lack of revenue. In professional scenarios keeping customers happy is very important and if the proposed system was verified and if the final system is not satisfying the customers would not buy that system.

## 5.2. Recommendation

*Being the author of this project and working in this project since 1<sup>st</sup> semester, the system is completed properly, and it is working flawlessly. And being the author, limitations and features are known. So, it is recommended that other features can also be added and make the system perform even better. Here are some recommendations and future works that can be considered.*

This system performs efficiently in real time scenarios as well, however more features can be added in this system to make it even better and more usable for the users. As this is the project for the final year, it has to be completed in a limited time frame. The cost analysis was to be done carefully, the resources were to be used wisely and along with the development, the reports and project folders were to be managed thoroughly.

To make the system even better there are few things that can be added. Firstly, this system works well in homes or any other workplaces, this system effectively manages the room temperature. Besides that, remotely monitoring the room temperature and knowing the status of the fan and heater from different place would be more effective. Remotely monitoring the room temperature allows the users to know the current temperature of the room and if there are elderly people and children living in the home the user can know if the room temperature is suitable for them or not. Users can also check which device is active, fan or heater, which gives the user the proper visualization of room temperature and the device which is currently on. Secondly, implementation of remotely controlling the devices makes the use of this system even better. This

allows the user to know the status of the device either it is on or off and also allows to control the device remotely. To be able to control the devices remotely, the user can turn on or off the device before arriving to the home which is even more convenient and work side by side with the automatic control of the temperature. This allows the user to control the devices manually if needed, the user doesn't need the automatic controller during that time. Another addition can be the alert in the user's smartphone when there is sudden change in the temperature of the room. If it becomes too cold or too hot, by sending an alert in users smartphone the user can take a certain measure to manage the temperature or check the cause of the sudden change in the temperature.

### 5.3 Future work

This system is only a prototype which has limited features, to make a full and effective use some of the work can be done and features can be added. Here are some features which can be added and some of the additional work which can be done to the system.

In the journal titled as “Server Room Temperature & Humidity Monitoring Based on Internet of Thing (IoT)” written by Moechammad Alvan Prastoyo Utomo, Abdul Aziz, Winarno, Bambang Harjito. Here a system is designed which can be used to monitor the room temperature and humidity. The data is continuously sent to the cloud and can be monitored from anywhere. Here the continuous monitoring of the temperature is done by DHT22 sensor and via telegram application on android the user gets notified for the current temperature and humidity. After checking the temperature and humidity the data is send to the server and is stored in MongoDB. This allows the user to continuously monitor the temperature and know the condition of the temperature in the room (Moechammad Alvan Prastoyo Utomo, 2019).

In the journal titled as “Application of Wireless Internet in Networking using NodeMCU and Blynk App” written by Nabilah Mazalan. Here a system is developed using the ESP8266 and Blynk app as the main component where the temperature and humidity can be monitored in the mobile phone via Blynk app. The temperature data is also stored in the Blynk server and can be accessed in the obile as well. Besides monitoring the temperature, the devices can also be controlled via the app remotely which is even more convenient (Mazalan, 2019).

In the journal titled as “Remote controlling of home appliances using mobile telephony” written by Rifat Shahriyar, Enamul Hoque, S M Sohan, Iftekhar Naim. This system controls the devices via mobile phone from anywhere. X10 technology is used for the communication of the mobile phone and the devise at home. This system involves two mobile phone, one computer and X10 Active Home Pro system as hardware components. With the help of X10 technology it is easy for the communication between devices and controlling of the devices is easy (Rifat Shahriyar, 2008).

In the journal titled as “Smart Monitoring Temperature and Humidity of the Room Server Using Raspberry Pi and Whatsapp Notifications” written by Dwi Ely Kurniawan, Mohd Iqbal, John Friadi, Rohmat Indra. This proposed system monitors the temperature and humidity of the server room and gives a request to reduce the temperature if there is the increase of temperature in the room. Besides that, the temperature and humidity data are stored in MySQL database and user receives notification on WhatsApp about the condition of the temperature. The data of the temperature and humidity is continuously monitored and would be stored in the database and changes in temperature and current status of the temperature data is send in the WhatsApp so that user can monitor and get alert about the temperature and humidity of the room (by Dwi Ely Kurniawan, 2019).

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## 7. Chapter 7: Appendix

### 7.1 Appendix 1: Survey

#### 7.1.1 Survey form

## Smart room temperature controller and smart light with google assistant.

This is a survey form for my final year project.

In this project a prototype system is designed where sensors collect the temperature data from the room and according to the desired temperature set by the user, if the temperature is above the set temperature the fan would turn on and if the temperature is below the set temperature the heater would turn on automatically in order to maintain the room temperature set by the user.

And for the smart light the data is taken from the internet and if it is daytime the lights would turn off and if it is nighttime the lights would turn on.

The google assistant is also implemented where the user can control the lights, fan and heater via google assistant from their own mobile phones.

Demonstration video of the system.

<https://drive.google.com/file/d/11E9z5NKRcdBKKJKM JL9t9gihaBXKSK7h/view?usp=sharing>

Full Name \*

Short answer text

Age \*

Short answer text

Gender \*

- Male
- Female
- Prefer not to say
- Other...

E-mail address

Short answer text

Have you heard about the term "Internet of things (IoT)"? \*

- Yes
- No
- Maybe

Are you familiar with the term "IoT"?

- Familiar
- Very familiar
- Not familiar

Have you heard about the room temperature control system before? \*

- Yes
- No
- Maybe

Do you think thermal comfort is necessary in home? \*

- Yes
- No
- Maybe

Is smart room temperature controller useful to implement in home or any work places? \*

- Yes
- No
- Maybe

Have you heard about smart lights?

- Yes
- No
- Maybe

Is implementation of smart lights useful in home?

- Yes
- No
- Maybe

Is implementation of google assistant useful to control the electronic appliances?

- Yes
- No
- Maybe

On a scale of 1 to 10, is this system good enough to use in home or any work places?

1      2      3      4      5      6      7      8      9      10

Will you implement this system for your own use?

- Yes
- No
- Maybe

Will this system make your daily life easier and more convenient?

- Yes
- No
- Maybe

Can disable people take the advantage from this system as it manages the temperature on its own, lights would auto turn on and off, and devices can be controlled via google assistant?

- Yes
- No
- Maybe

Any suggestion regarding the improvement for the system?

Long answer text

---

*Figure 72 Survey form*

### 7.1.2 Sample of survey form

20 responses

Accepting responses

Summary Question Individual

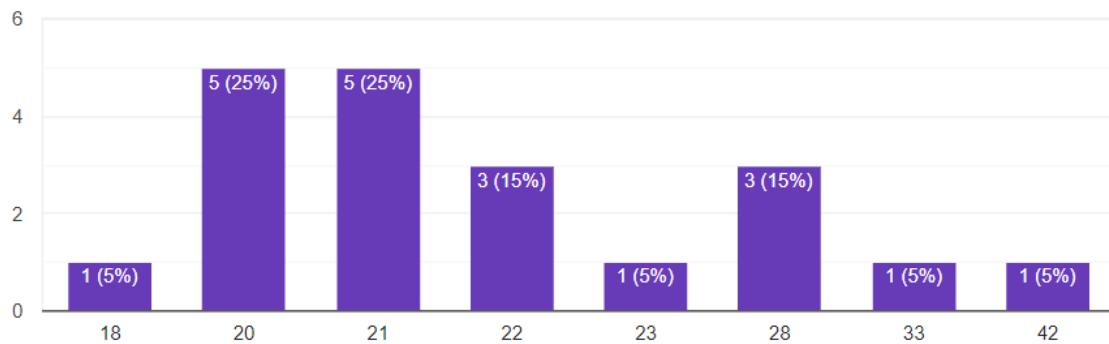
Full Name

20 responses

Dipin Thapa
Yaman Shrestha
Saman Gautam
Swastik Raj Acharya
Sumant yadav
Asbin khadka
Sakshi Acharya
mona giri
Poshan Bhandari

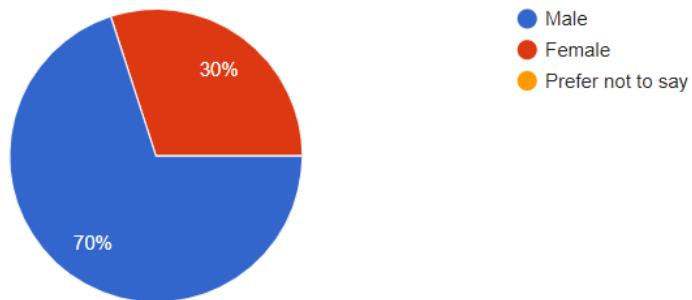
### Age

20 responses



### Gender

20 responses



## E-mail address

17 responses

Hy.dipin@gmail.com

samangautam069@gmail.com

ysumant852432@gmail.com

ashinkhadka5@gmail.com

sakshiacharya43@gmail.com

memonagiri@gmail.com

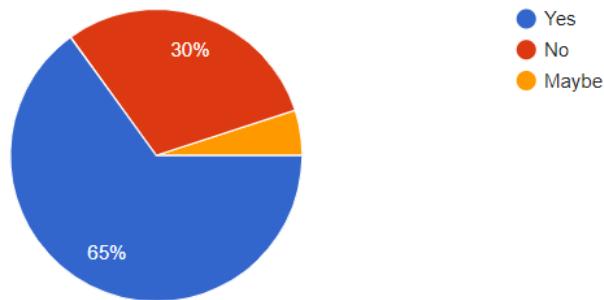
poshanbhandari44@gmail.com

Yudinraut6@gmail.com

roshitimsina25@gmail.com

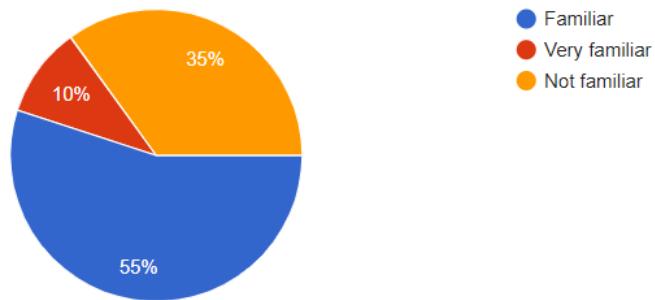
Have you heard about the term "Internet of things (IoT)"?

20 responses



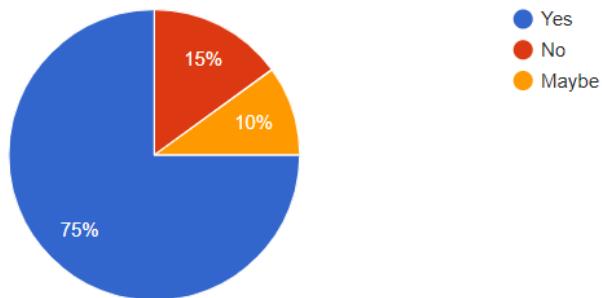
Are you familiar with the term "IoT"?

20 responses



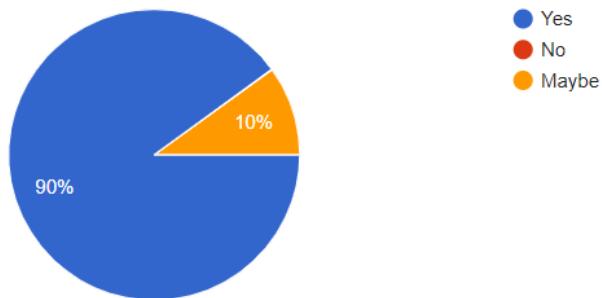
Have you heard about the room temperature control system before?

20 responses



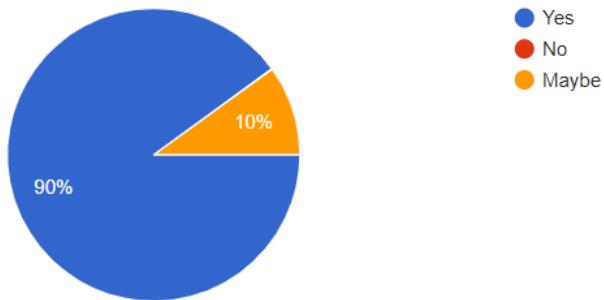
Do you think thermal comfort is necessary in home?

20 responses



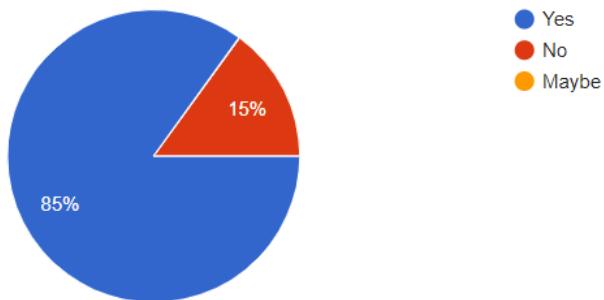
Is smart room temperature controller useful to implement in home or any work places?

20 responses



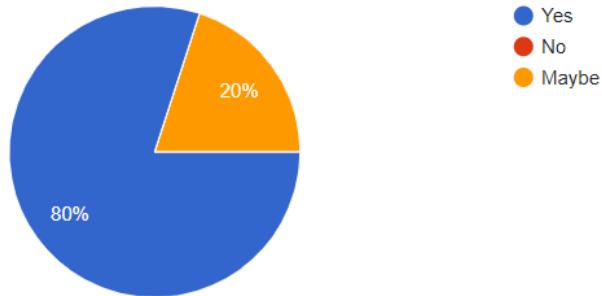
Have you heard about smart lights?

20 responses



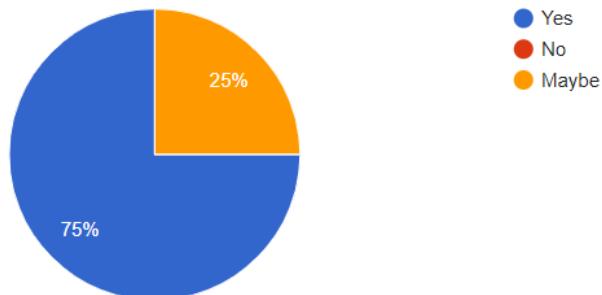
Is implementation of smart lights useful in home?

20 responses



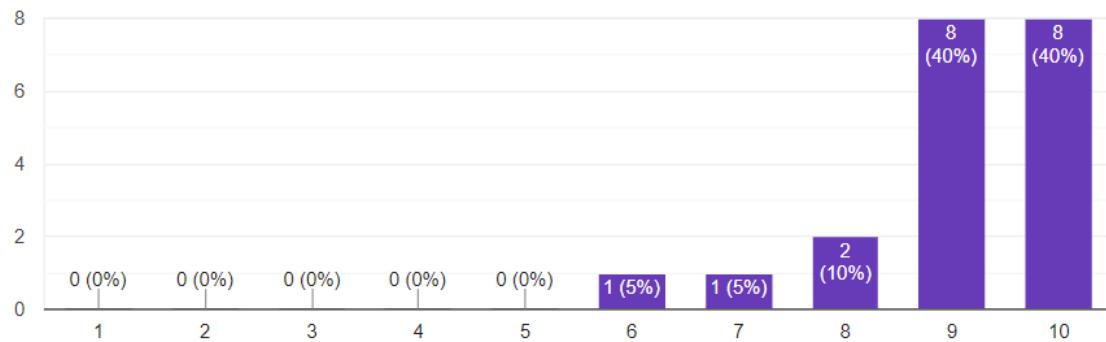
Is implementation of google assistant useful to control the electronic appliances?

20 responses



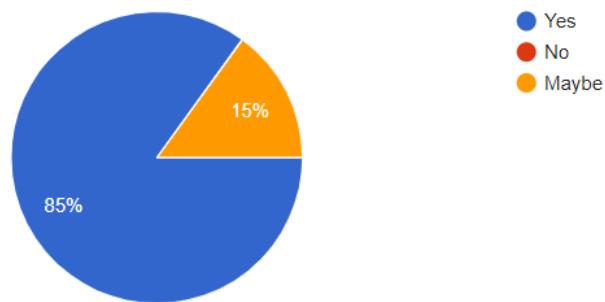
On a scale of 1 to 10, is this system good enough to use in home or any work places?

20 responses



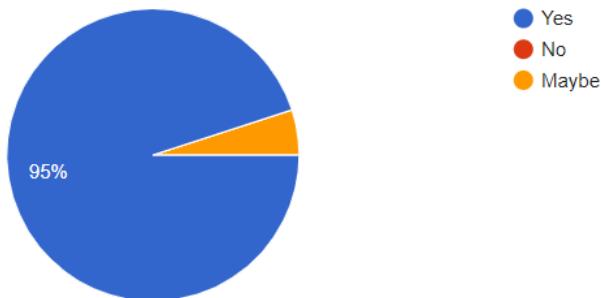
Will you implement this system for your own use?

20 responses



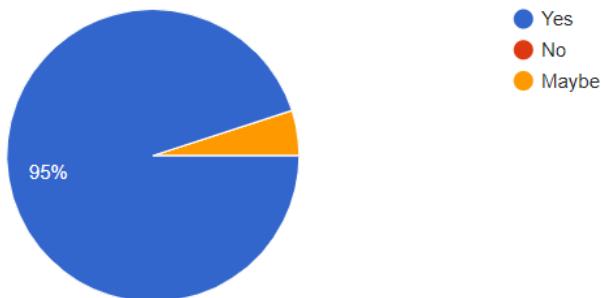
Will this system make your daily life easier and more convenient?

20 responses



Can disable people take the advantage from this system as it manages the temperature on its own, lights would auto turn on and off, and devices can be controlled via google assistant?

20 responses



Any suggestion regarding the improvement for the system?

6 responses

Great

Very effective for all

Excellent

So smart project idea. Very useful for coming generation. (y)

Please ensure manual back up for each system

If we could control the system while we are away from home it would be awesome!! Great work, keep going!!

*Figure 73 Survey responses*

### 7.1.3 Survey result

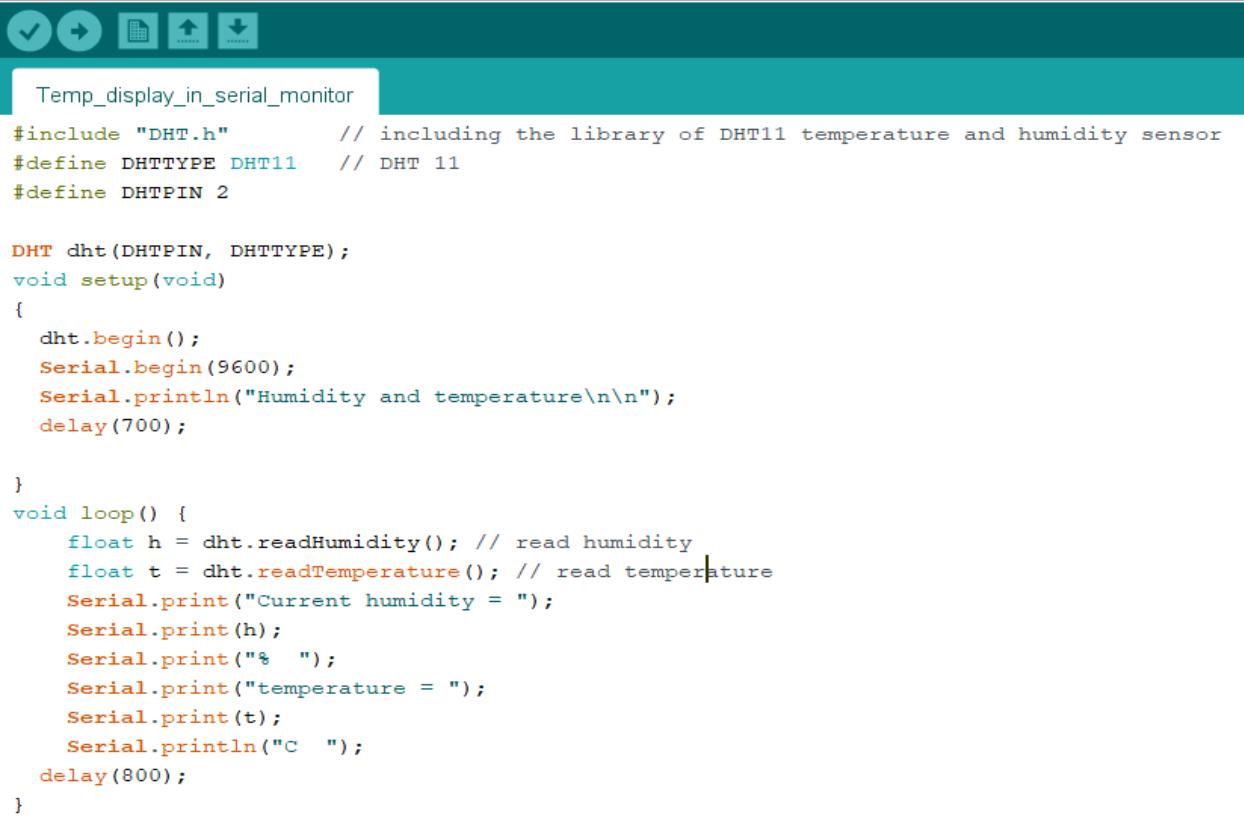
The survey was conducted among the people who can understand the system and 20 responses were recorded. Among them 65% of people were familiar with the term IOT. 75% of people have heard about the room temperature controller system and more than 90% people agreed that thermal comfort is necessary for us. More than 90% people thought that smart room temperature controller useful to implement in home or any workplaces. 85% people have heard about the smart lights and 80% people agreed that smart light is very useful. 75% people were sure that google assistant is helpful but 25% were doubtful. 40% people rated 9 and 40% people rated 10 for the usefulness for this system and 10% is 8 5% is 7 and another 5% is 6. 95% people agreed that this system can help the disabled people and among those responses 6 feedbacks were recorded.

## 7.2 Appendix 2: Sample codes

### 7.2.1 Code for DHT11 for serial monitor

Temp\_display\_in\_serial\_monitor | Arduino 1.8.13

File Edit Sketch Tools Help



```

Temp_display_in_serial_monitor

#include "DHT.h"          // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11      // DHT 11
#define DHTPIN 2

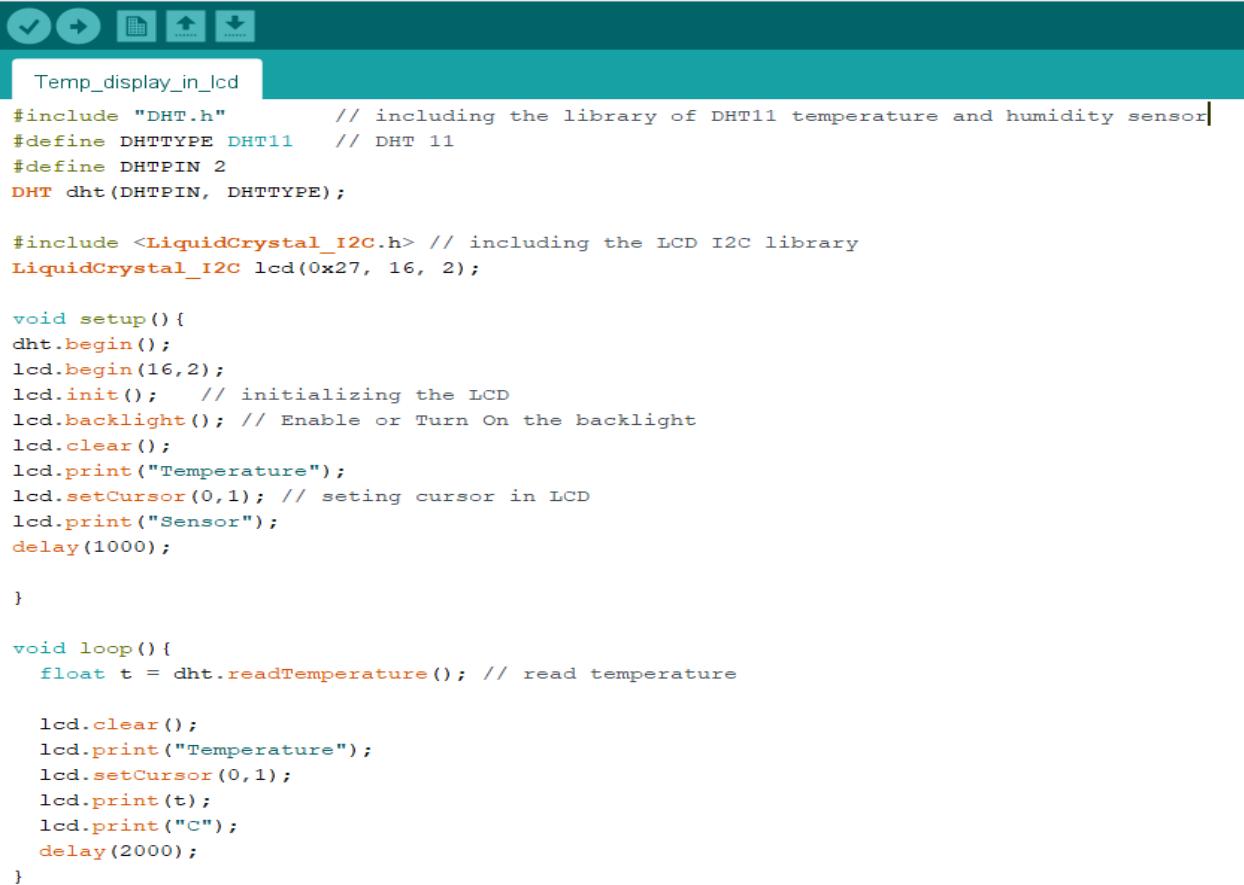
DHT dht(DHTPIN, DHTTYPE);
void setup(void)
{
    dht.begin();
    Serial.begin(9600);
    Serial.println("Humidity and temperature\n\n");
    delay(700);

}
void loop() {
    float h = dht.readHumidity(); // read humidity
    float t = dht.readTemperature(); // read temperature
    Serial.print("Current humidity = ");
    Serial.print(h);
    Serial.print("% ");
    Serial.print("temperature = ");
    Serial.print(t);
    Serial.println("C ");
    delay(800);
}

```

Figure 74 Final code for DHT11 for serial monitor

## 7.2.2 Code for DHT11 for LCD display



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** Temp\_display\_in\_lcd | Arduino 1.8.13
- Menu Bar:** File Edit Sketch Tools Help
- Code Area:**

```
#include "DHT.h"          // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11      // DHT 11
#define DHTPIN 2
DHT dht(DHTPIN, DHTTYPE);

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
dht.begin();
lcd.begin(16,2);
lcd.init();    // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1); // seting cursor in LCD
lcd.print("Sensor");
delay(1000);

}

void loop() {
float t = dht.readTemperature(); // read temperature

lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1);
lcd.print(t);
lcd.print("C");
delay(2000);
}
```

Figure 75 Code for DHT11 for LCD display

### 7.2.3 Code for room temperature controller



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** room\_temp\_controller | Arduino 1.8.13
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for Save, Run, Upload, and Download.
- Sketch Area:**

```
#include "DHT.h"          // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11      // DHT 11
#define DHTPIN 2

DHT dht(DHTPIN, DHTTYPE);

const int Heater_pin = 12, FAN_pin = 14; // declare the IO pins

float SetTemp = 25; // the prefer room temperature is set as 25 degree celsius

#include <LiquidCrystal_I2C.h> //including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

void setup() {
dht.begin();
lcd.begin(16,2);
pinMode(Heater_pin, OUTPUT);
pinMode(FAN_pin, OUTPUT);
lcd.init();    // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1); // setting cursor in LCD display
lcd.print("Sensor");
delay(1000);

}
```

```

void loop() {
    float t = dht.readTemperature(); // read temperature

    lcd.clear();
    lcd.print("Temperature");
    lcd.setCursor(0,1);
    lcd.print(t);
    lcd.print("C");
    delay(2000);

    // condition is applied for the fan and heater
    if(t > SetTemp){
        digitalWrite(FAN_pin, HIGH);
        delay(2000);
    }
    else{
        digitalWrite(FAN_pin, LOW);
    }

    if(t < SetTemp){
        digitalWrite(Heater_pin, HIGH);
        delay(2000);
    }
    else{
        digitalWrite(Heater_pin, LOW);
    }
}

```

Figure 76 Code for room temperature controller

#### 7.2.4 Code for LED light

 led\_blink | Arduino 1.8.13

File Edit Sketch Tools Help



```

int Led = 12; // setting the IO pin for LED

void setup() {
    pinMode(Led, OUTPUT);      // Initialize the LED_BUILTIN pin as an output
}

void loop() {
    digitalWrite(Led, HIGH);   // Turn the LED off by making the voltage HIGH
}

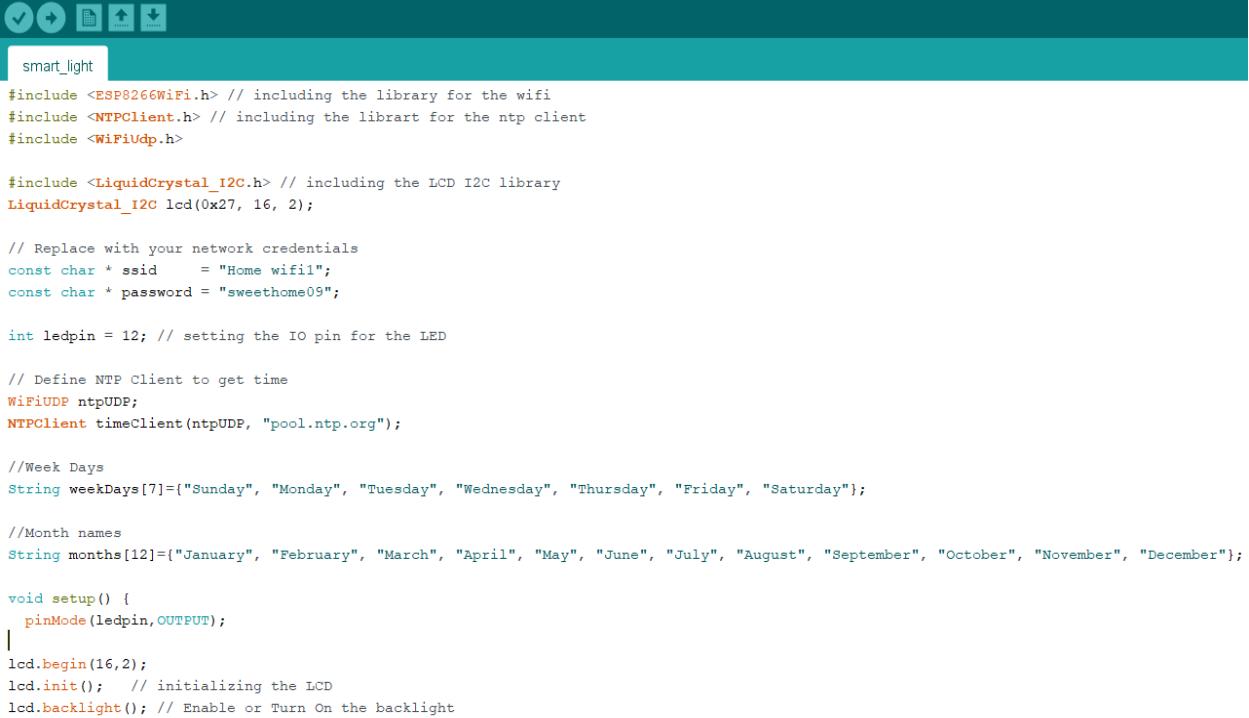
```

Figure 77 Code for LED lights

## 7.2.5 Code for smart lights

smart\_light | Arduino 1.8.13

File Edit Sketch Tools Help



```
#include <ESP8266WiFi.h> // including the library for the wifi
#include <NTPClient.h> // including the librart for the ntp client
#include <WiFiUdp.h>

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Replace with your network credentials
const char * ssid      = "Home wifi1";
const char * password  = "sweethome09";

int ledpin = 12; // setting the IO pin for the LED

// Define NTP Client to get time
WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP, "pool.ntp.org");

//Week Days
String weekDays[7]={"Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"};

//Month names
String months[12]={"January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December"};

void setup() {
  pinMode(ledpin,OUTPUT);
  lcd.begin(16,2);
  lcd.init(); // initializing the LCD
  lcd.backlight(); // Enable or Turn On the backlight
}
```

```
  // Initialize Serial Monitor
  Serial.begin(115200);

  // Connect to Wi-Fi
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }

  // Initialize a NTPClient to get time
  timeClient.begin();
  timeClient.setTimeOffset(20700);
}

void loop() {
  timeClient.update();

  unsigned long epochTime = timeClient.getEpochTime();
  Serial.print("Epoch Time: ");
  Serial.println(epochTime);

  String formattedTime = timeClient.getFormattedTime();
  Serial.print("Formatted Time: ");
  Serial.println(formattedTime);

  int currentHour = timeClient.getHours();
  Serial.print("Hour: ");
  Serial.println(currentHour);

  int currentMinute = timeClient.getMinutes();
  Serial.print("Minutes: ");
  Serial.println(currentMinute);
```

```

int currentSecond = timeClient.getSeconds();
Serial.print("Seconds: ");
Serial.println(currentSecond);

//Get a time structure
struct tm *ptm = gmtime ((time_t *)&epochTime);

int monthDay = ptm->tm_mday;
Serial.print("Month day: ");
Serial.println(monthDay);

int currentMonth = ptm->tm_mon+1;
Serial.print("Month: ");
Serial.println(currentMonth);

int currentYear = ptm->tm_year+1900;
Serial.print("Year: ");
Serial.println(currentYear);

//Print complete date:
String currentDate = String(currentYear) + "-" + String(currentMonth) + "-" + String(monthDay);
Serial.print("Current date: ");
Serial.println(currentDate);

Serial.println("");

lcd.setCursor(0,0); // setting cursor in LCD display
lcd.print("TIME=");
lcd.setCursor(5,0);
lcd.print(formattedTime);

lcd.setCursor(0,1); // setting cursor in LCD display
lcd.print("DATE=");
lcd.setCursor(5,1);
lcd.print(currentDate);

// condition is applied when to turn on and off the light
if(currentHour >= 7 && currentHour <= 17){
    digitalWrite(ledpin,LOW);
}
else{
    digitalWrite(ledpin,HIGH);
}

delay(1000);
}

```

Figure 78 Code for smart lights

## 7.2.6 Code for google assistant

led\_using\_google\_assistant | Arduino 1.8.13

File Edit Sketch Tools Help



```

led_using_google_assistant

#include <ESP8266WiFi.h> // including the library for the wifi
#include "Adafruit_MQTT.h" // adafruit mqtt
#include "Adafruit_MQTT_Client.h" // adafruit mqtt client

#define WLAN_SSID      "Home wifi1"
#define WLAN_PASS      "sweethome09"
#define AIO_SERVER     "io.adafruit.com"
#define AIO_SERVERPORT 1883
#define AIO_USERNAME   "MonarchGiri"
#define AIO_KEY        "aio_VHpo77TWWwUV6IzGjUjUEi71Q1leB"
int output=12;

WiFiClient client;      // Create an ESP8266 WiFiClient class to connect to the MQTT server.

// Setup the MQTT client class by passing in the WiFi client and MQTT server and login details.
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
Adafruit_MQTT_Subscribe lightcontrol = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds/lightcontrol");

void MQTT_connect();

void setup() {
    Serial.begin(115200);
    delay(10);

    pinMode(12,OUTPUT);

    // Connect to WiFi access point.
    Serial.println(); Serial.println();
    Serial.print("Connecting to ");
    Serial.println(WLAN_SSID);

    WiFi.begin(WLAN_SSID, WLAN_PASS);
}

```

```

while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}

Serial.println();
Serial.println("WiFi connected");
Serial.println("IP address: "); Serial.println(WiFi.localIP());
mqtt.subscribe(&lightcontrol);
}

uint32_t x=0;
void loop() {
    MQTT_connect();

    Adafruit_MQTT_Subscribe *subscription;

    while ((subscription = mqtt.readSubscription(5000))) {
        if (subscription == &lightcontrol) {
            Serial.print(F("Got: "));
            Serial.println((char *)lightcontrol.lastread);
            if (!strcmp((char *) lightcontrol.lastread, "ON"))
            {
                digitalWrite(12, HIGH);
            }
            else
            {
                digitalWrite(12, LOW);
            }
        }
    }
}

void MQTT_connect() {
    int8_t ret;

    // Stop if already connected.
    if (mqtt.connected()) {
        return;
    }

    Serial.print("Connecting to MQTT... ");

    uint8_t retries = 3;

    while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected

        Serial.println(mqtt.connectErrorString(ret));
        Serial.println("Retrying MQTT connection in 5 seconds...");
        mqtt.disconnect();
        delay(5000); // wait 5 seconds
        retries--;
        if (retries == 0) {
            // basically die and wait for WDT to reset me
            while (1);
        }
    }

    Serial.println("MQTT Connected!");
}

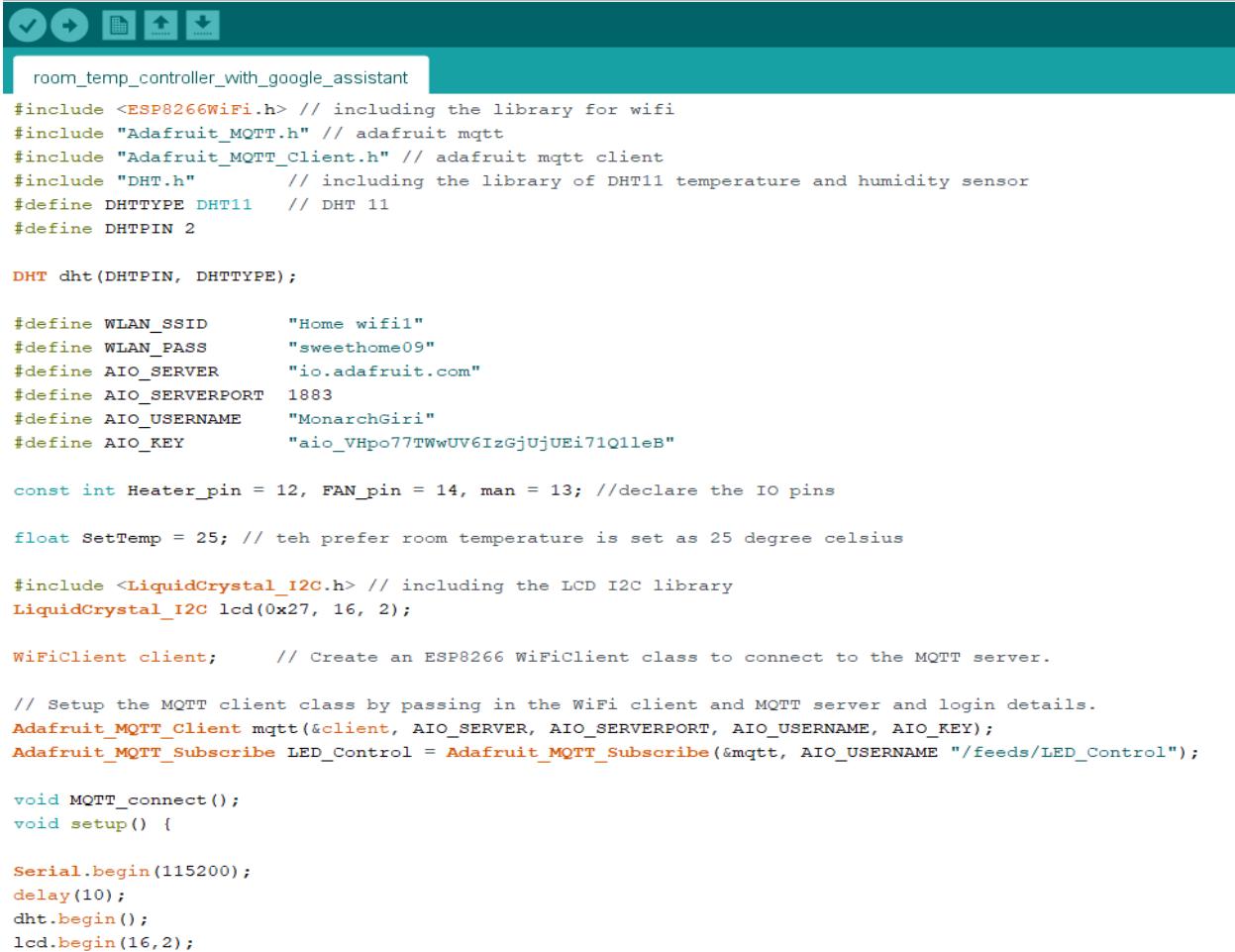
```

Figure 79 Code for google assistant

## 7.2.7 Final code for room temperature controller with google assistant

room\_temp\_controller\_with\_google\_assistant | Arduino 1.8.13

File Edit Sketch Tools Help



```

room_temp_controller_with_google_assistant

#include <ESP8266WiFi.h> // including the library for wifi
#include "Adafruit_MQTT.h" // adafruit mqtt
#include "Adafruit_MQTT_Client.h" // adafruit mqtt client
#include "DHT.h" // including the library of DHT11 temperature and humidity sensor
#define DHTTYPE DHT11 // DHT 11
#define DHTPIN 2

DHT dht(DHTPIN, DHTTYPE);

#define WLAN_SSID      "Home wifi1"
#define WLAN_PASS      "sweethome09"
#define AIO_SERVER     "io.adafruit.com"
#define AIO_SERVERPORT 1883
#define AIO_USERNAME   "MonarchGiri"
#define AIO_KEY        "aio_VHpo77TWwUV6IzGjUjUEi71Q1leB"

const int Heater_pin = 12, FAN_pin = 14, man = 13; //declare the IO pins

float SetTemp = 25; // teh prefer room temperature is set as 25 degree celsius

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

WiFiClient client; // Create an ESP8266 WiFiClient class to connect to the MQTT server.

// Setup the MQTT client class by passing in the WiFi client and MQTT server and login details.
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
Adafruit_MQTT_Subscribe LED_Control = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds/LED_Control");

void MQTT_connect();
void setup() {

Serial.begin(115200);
delay(10);
dht.begin();
lcd.begin(16,2);
}

```

```
pinMode(Heater_pin, OUTPUT);
pinMode(FAN_pin, OUTPUT);
pinMode(man, INPUT);

lcd.init(); // initializing the LCD
lcd.backlight(); // Enable or Turn On the backlight
lcd.clear();
lcd.print("Temperature");
lcd.setCursor(0,1);
lcd.print("Sensor");
delay(1000);

// Connect to WiFi access point.
Serial.println(); Serial.println();
Serial.print("Connecting to ");
Serial.println(WLAN_SSID);

WiFi.begin(WLAN_SSID, WLAN_PASS);
while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
}

Serial.println();
Serial.println("WiFi connected");
Serial.println("IP address: "); Serial.println(WiFi.localIP());
mqtt.subscribe(&LED_Control);

}

uint32_t x=0;
```

```
void loop() {
    MQTT_connect();

    float t = dht.readTemperature();

    lcd.clear();
    lcd.print("Temp.");
    lcd.setCursor(0,1);
    lcd.print(t);
    Serial.print(t);
    lcd.print("C");
    lcd.setCursor(6,0);
    lcd.print("SetTemp=25");
    delay(1000);

    Adafruit_MQTT_Subscribe *subscription;

    if (digitalRead(man) == HIGH) {
        lcd.setCursor(7,1);
        lcd.print("Auto ON");
        if (t > SetTemp) {
            digitalWrite(FAN_pin, HIGH);
            delay(1000);
        }
        else {
            digitalWrite(FAN_pin, LOW);
        }

        if(t < SetTemp){
            digitalWrite(Heater_pin, HIGH);
            delay(1000);
        }
        else{
            digitalWrite(Heater_pin, LOW);
        }
    }
}
```

```
else {
    lcd.setCursor(7,1);
    lcd.print("Auto OFF");
    while ((subscription = mqtt.readSubscription(1000))) {
        if (subscription == &LED_Control) {
            Serial.print(F("Got: "));
            Serial.println((char *)LED_Control.lastread);
            if (!strcmp((char *) LED_Control.lastread, "FAN ON"))
            {
                fanOn();
            }
            if (!strcmp((char *) LED_Control.lastread, "HEATER ON"))
            {
                fanOff();
            }
            if (!strcmp((char *) LED_Control.lastread, "ALL OFF"))
            {
                allOff();
            }
        }
    }
}

void fanOn(){
    digitalWrite(FAN_pin, HIGH);
    digitalWrite(Heater_pin, LOW);
}
void fanOff(){
    digitalWrite(Heater_pin, HIGH);
    digitalWrite(FAN_pin, LOW);
}
void allOff(){
    digitalWrite(FAN_pin, LOW);
    digitalWrite(Heater_pin, LOW);
}
```

```
void MQTT_connect() {
    int8_t ret;

    // Stop if already connected.
    if (mqtt.connected()) {
        return;
    }

    Serial.print("Connecting to MQTT... ");

    uint8_t retries = 3;

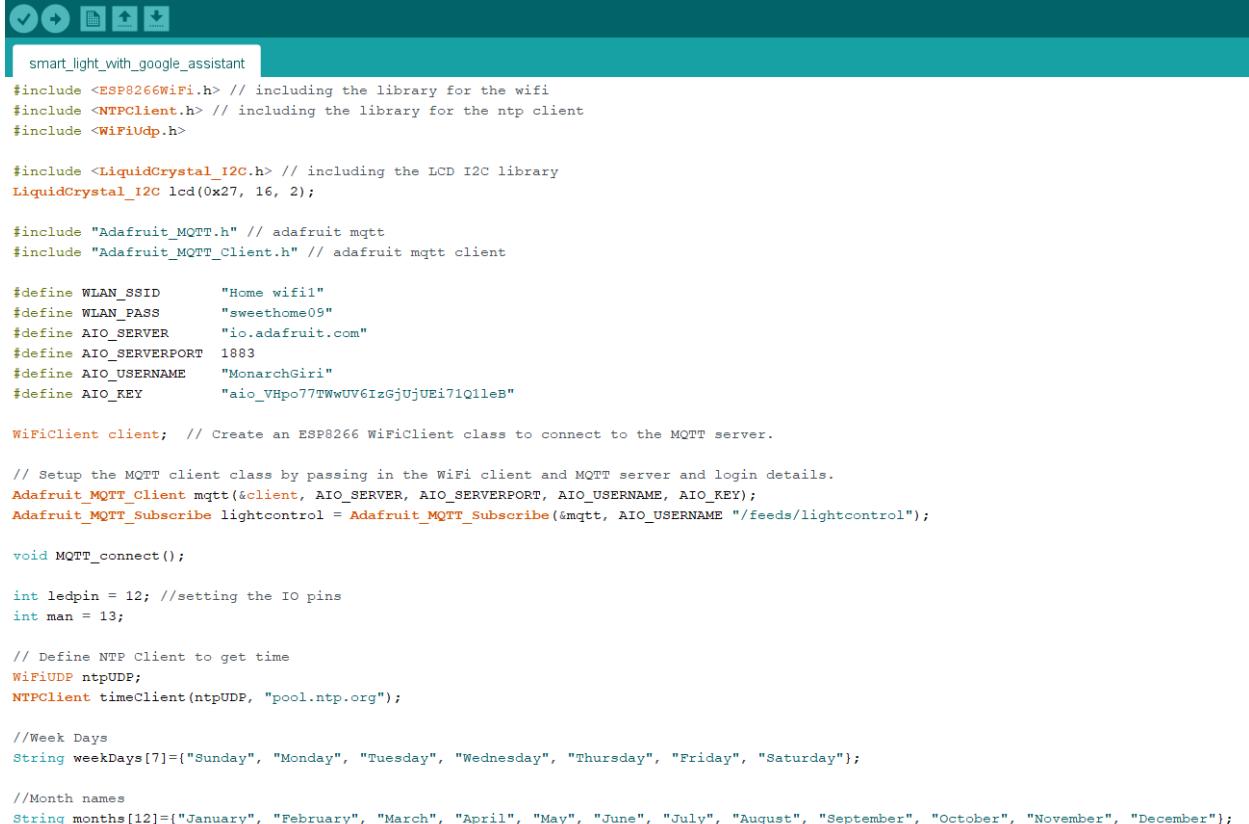
    while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected
        Serial.println(mqtt.connectErrorString(ret));
        Serial.println("Retrying MQTT connection in 5 seconds...");
        mqtt.disconnect();
        delay(5000); // wait 5 seconds
        retries--;
        if (retries == 0) {
            // basically die and wait for WDT to reset me
            while (1);
        }
    }
    Serial.println("MQTT Connected!");
}
```

Figure 80 Final code for room temperature controller with google assistant

## 7.2.8 Final code for smart lights with google assistant

smart\_light\_with\_google\_assistant | Arduino 1.8.13

File Edit Sketch Tools Help



```
#include <ESP8266WiFi.h> // including the library for the wifi
#include <NTPClient.h> // including the library for the ntp client
#include <WiFiUdp.h>

#include <LiquidCrystal_I2C.h> // including the LCD I2C library
LiquidCrystal_I2C lcd(0x27, 16, 2);

#include "Adafruit_MQTT.h" // adafruit mqtt
#include "Adafruit_MQTT_Client.h" // adafruit mqtt client

#define WLAN_SSID      "Home wifi1"
#define WLAN_PASS      "sweethome09"
#define AIO_SERVER     "io.adafruit.com"
#define AIO_SERVERPORT 1883
#define AIO_USERNAME   "MonarchGiri"
#define AIO_KEY        "aio_Vhp077FWwUV6izGjUjUEi7iQl1eB"

WiFiClient client; // Create an ESP8266 WiFiClient class to connect to the MQTT server.

// Setup the MQTT client class by passing in the WiFi client and MQTT server and login details.
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER, AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
Adafruit_MQTT_Subscribe lightcontrol = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds/lightcontrol");

void MQTT_connect();

int ledpin = 12; //setting the IO pins
int man = 13;

// Define NTP Client to get time
WiFiUDP ntpUDP;
NTPClient timeClient(ntpUDP, "pool.ntp.org");

//Week Days
String weekDays[7]={"Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"};

//Month names
String months[12]={"January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December"};
```

```
void setup() {
    pinMode(ledpin,OUTPUT);

    lcd.begin(16,2);
    lcd.init(); // initializing the LCD
    lcd.backlight(); // Enable or Turn On the backlight

    // Initialize Serial Monitor
    Serial.begin(115200);

    // Connect to WiFi access point.

    Serial.println(); Serial.println();
    Serial.print("Connecting to ");
    Serial.println(WLAN_SSID);

    WiFi.begin(WLAN_SSID, WLAN_PASS);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }

    Serial.println();
    Serial.println("WiFi connected");
    Serial.println("IP address: "); Serial.println(WiFi.localIP());
    mqtt.subscribe(&lightcontrol);

    // Initialize a NTPClient to get time
    timeClient.begin();
    timeClient.setTimeOffset(20700);

}
```

```
uint32_t x=0;

void loop() {
    MQTT_connect();
    timeClient.update();

    unsigned long epochTime = timeClient.getEpochTime();
    Serial.print("Epoch Time: ");
    Serial.println(epochTime);

    String formattedTime = timeClient.getFormattedTime();
    Serial.print("Formatted Time: ");
    Serial.println(formattedTime);

    int currentHour = timeClient.getHours();
    Serial.print("Hour: ");
    Serial.println(currentHour);

    int currentMinute = timeClient.getMinutes();
    Serial.print("Minutes: ");
    Serial.println(currentMinute);

    int currentSecond = timeClient.getSeconds();
    Serial.print("Seconds: ");
    Serial.println(currentSecond);

    //Get a time structure
    struct tm *ptm = gmtime ((time_t *)&epochTime);

    int monthDay = ptm->tm_mday;
    Serial.print("Month day: ");
    Serial.println(monthDay);

    int currentMonth = ptm->tm_mon+1;
    Serial.print("Month: ");
    Serial.println(currentMonth);
```

```

int currentYear = ptm->tm_year+1900;
Serial.print("Year: ");
Serial.println(currentYear);

//Print complete date:
String currentDate = String(currentYear) + "-" + String(currentMonth) + "-" + String(monthDay);
Serial.print("Current date: ");
Serial.println(currentDate);

Serial.println("");

lcd.setCursor(0,0);
lcd.print("TIME=");
lcd.setCursor(5,0);
lcd.print(formattedTime);

lcd.setCursor(0,1);
lcd.print("DATE=");
lcd.setCursor(5,1);
lcd.print(currentDate);

Adafruit_MQTT_Subscribe *subscription;

if (digitalRead(man) == HIGH) {
    if(currentHour >= 7 && currentHour <= 17){
        digitalWrite(ledpin,LOW);
    }
    else{
        digitalWrite(ledpin,HIGH);
    }
    delay(1000);
}

```

```

else{
    while ((subscription = mqtt.readSubscription(1000))) {
        if (subscription == &lightcontrol) {
            Serial.print(F("Got: "));
            Serial.println((char *)lightcontrol.lastread);
            if (!strcmp((char*) lightcontrol.lastread, "ON"))
            {
                digitalWrite(ledpin, HIGH);
            }
            else
            {
                digitalWrite(ledpin, LOW);
            }
        }
    }
}

void MQTT_connect() {
    int8_t ret;

    // Stop if already connected.
    if (mqtt.connected()) {
        return;
    }
    Serial.print("Connecting to MQTT... ");

    uint8_t retries = 3;
    while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected
        Serial.println(mqtt.connectErrorString(ret));
        Serial.println("Retrying MQTT connection in 5 seconds...");
        mqtt.disconnect();
        delay(5000); // wait 5 seconds
        retries--;
    }

    if (retries == 0) {
        // basically die and wait for WDT to reset me
        while (1);
    }
}
Serial.println("MQTT Connected!");
}

```

Figure 81 Final code for smart lights with google assistant

## 7.3 Appendix 3: System design

### 7.3.1 Work breakdown structure

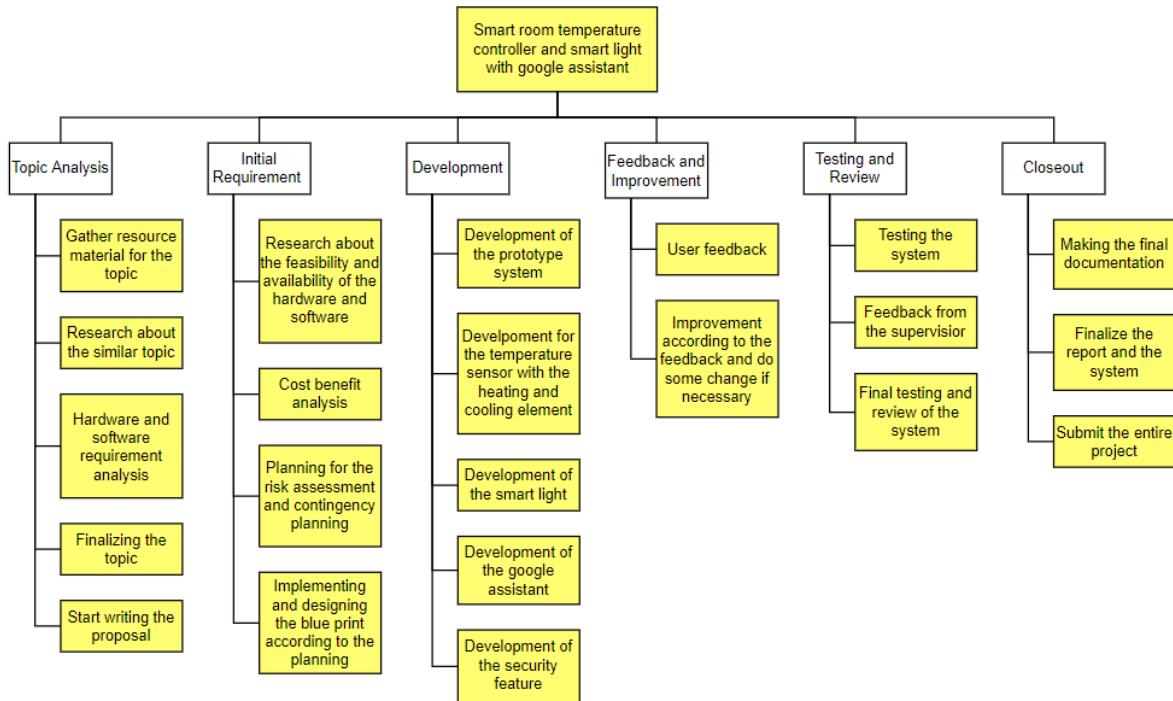


Figure 82 Work breakdown structure

### 7.3.2 Gantt chart

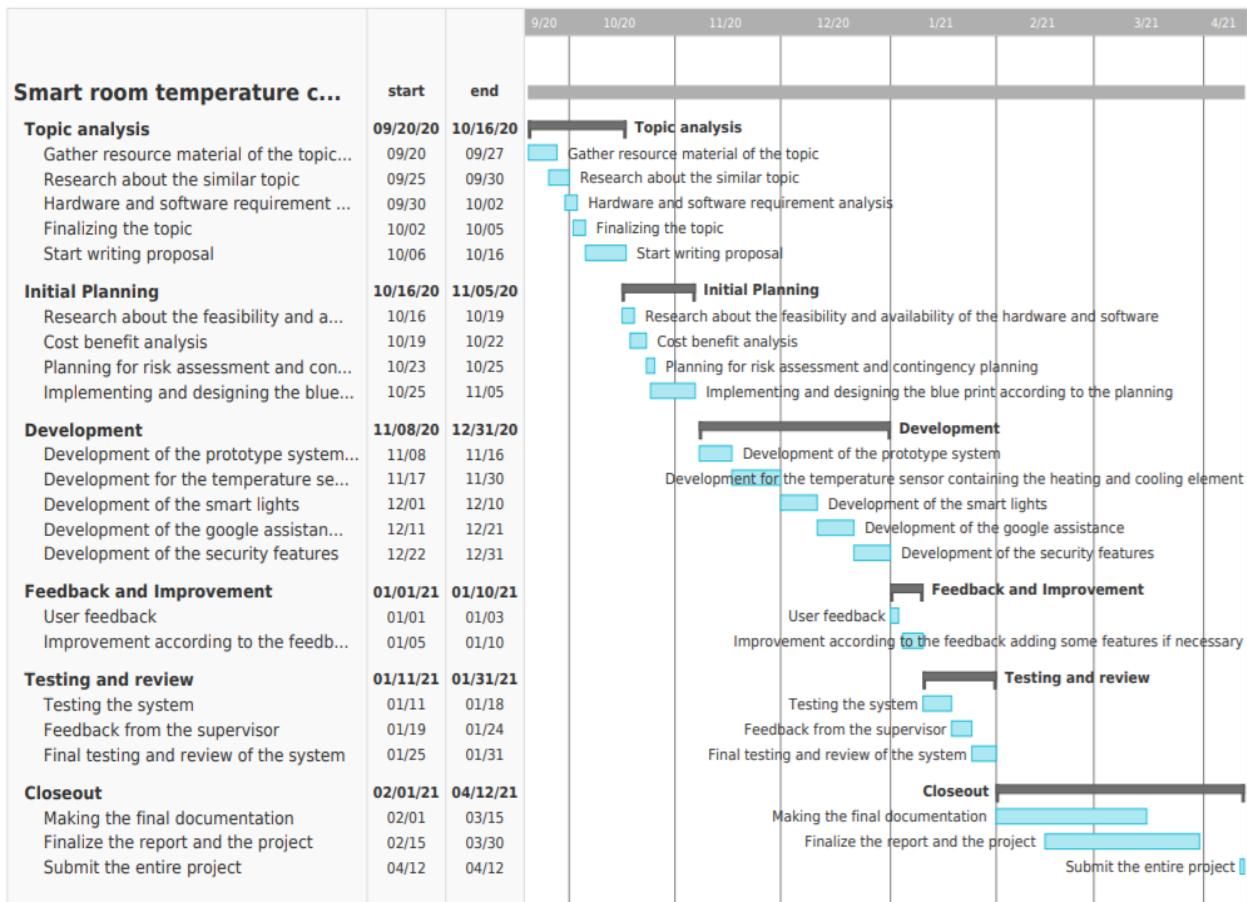


Figure 83 Gantt chart

### 7.3.3 Flowchart of the system architecture

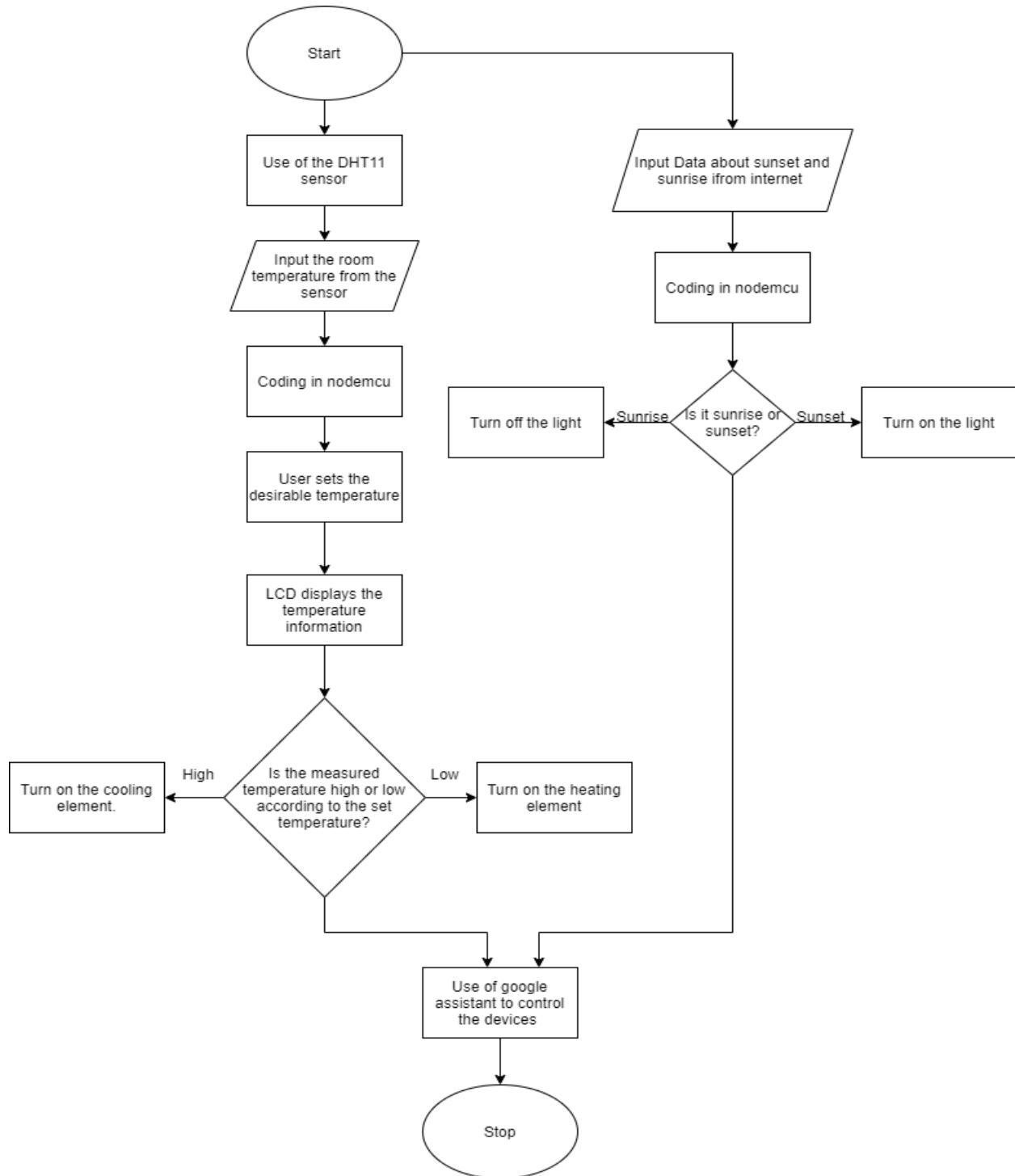


Figure 84 Flow chart of the system architecture

#### 7.3.4 Use case diagram

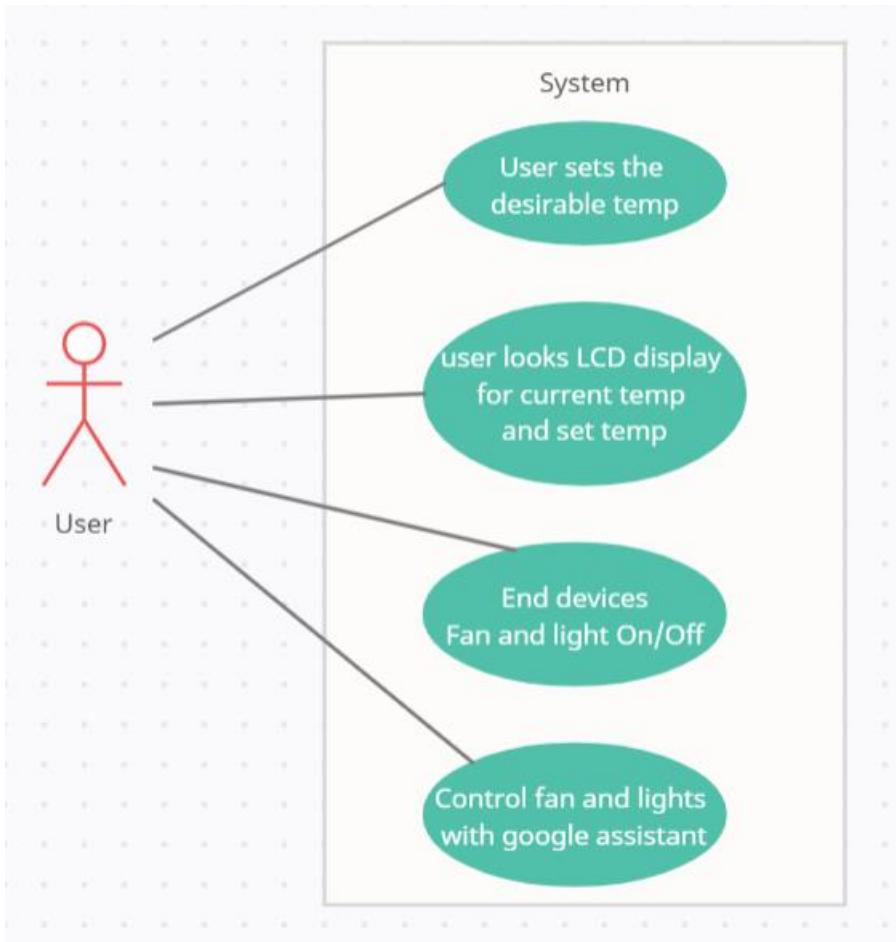
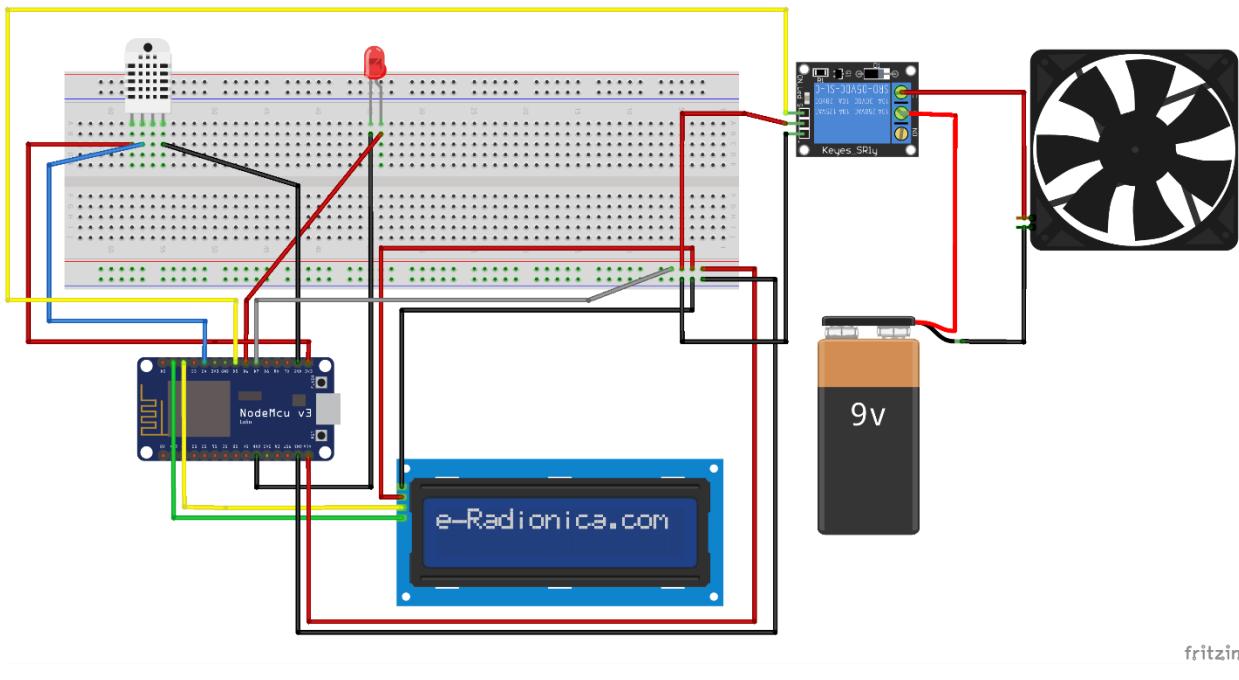


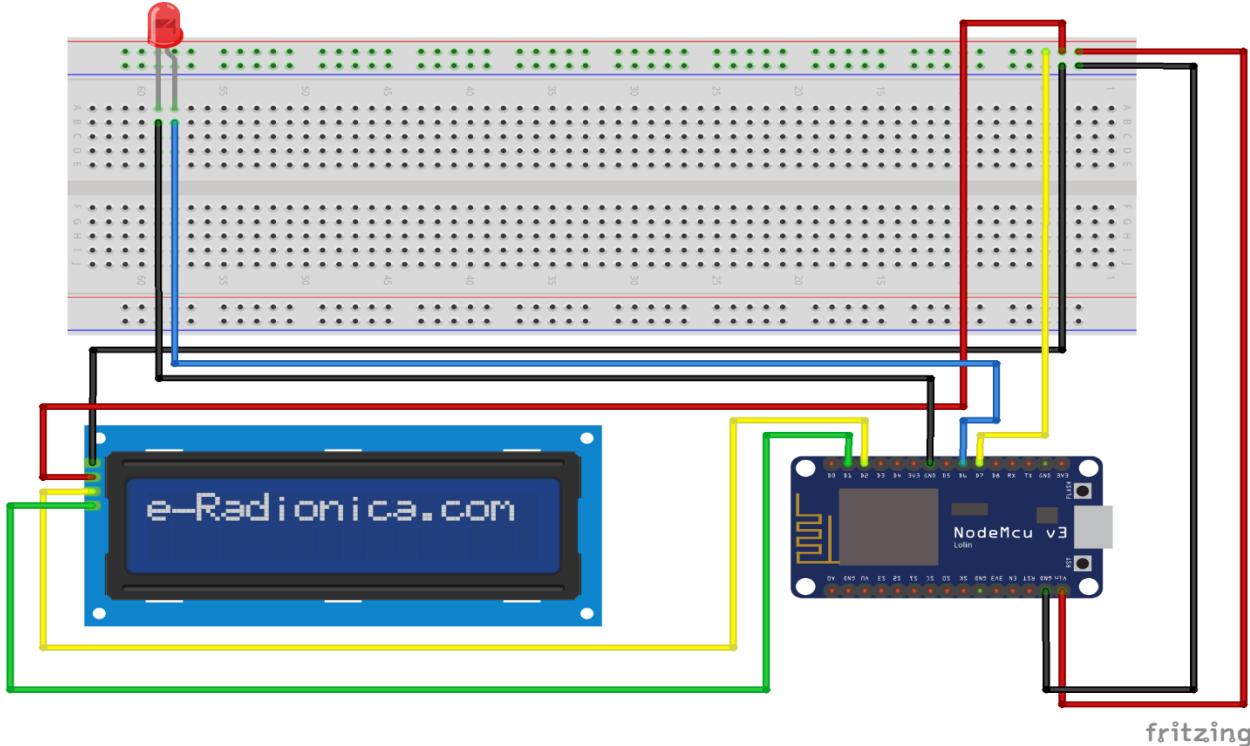
Figure 85 Use case diagram

### 7.3.5 Circuit diagram



fritzing

Figure 86 Circuit diagram of room temperature controller



fritzing

Figure 87 Circuit diagram of smart light

### 7.3.6 Hardware architecture

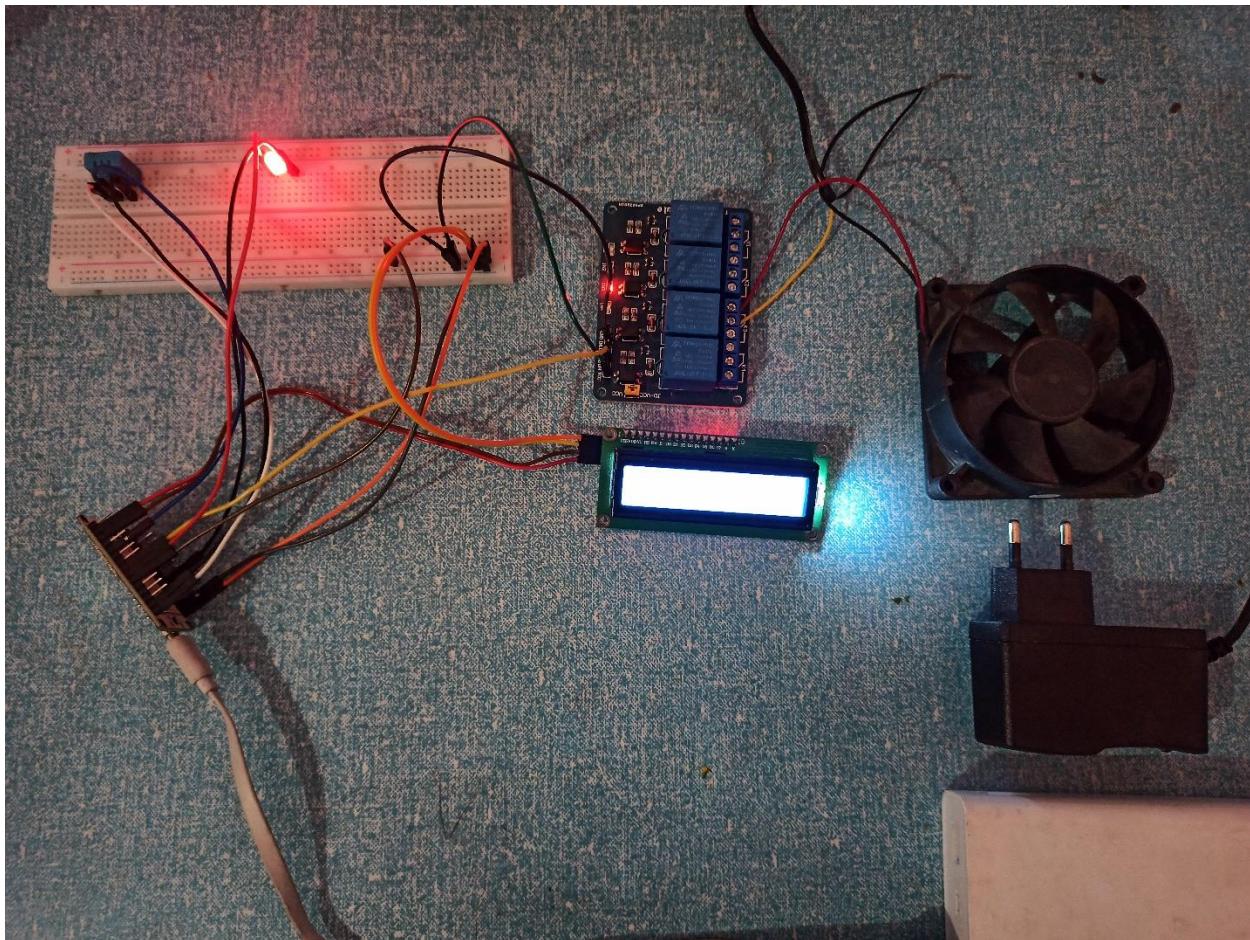


Figure 88 Hardware architecture of room temperature controller

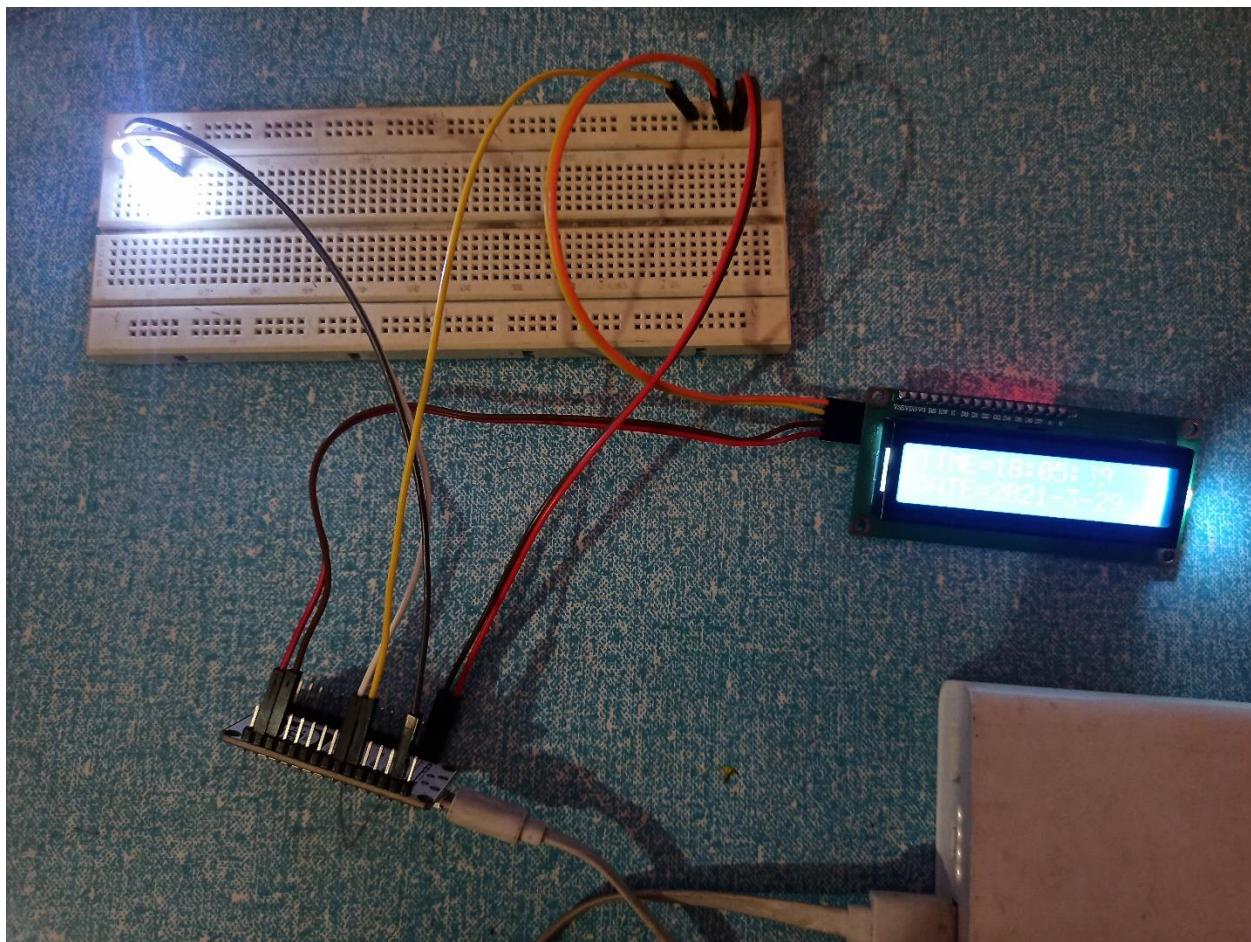


Figure 89 Hardware architecture of smart light

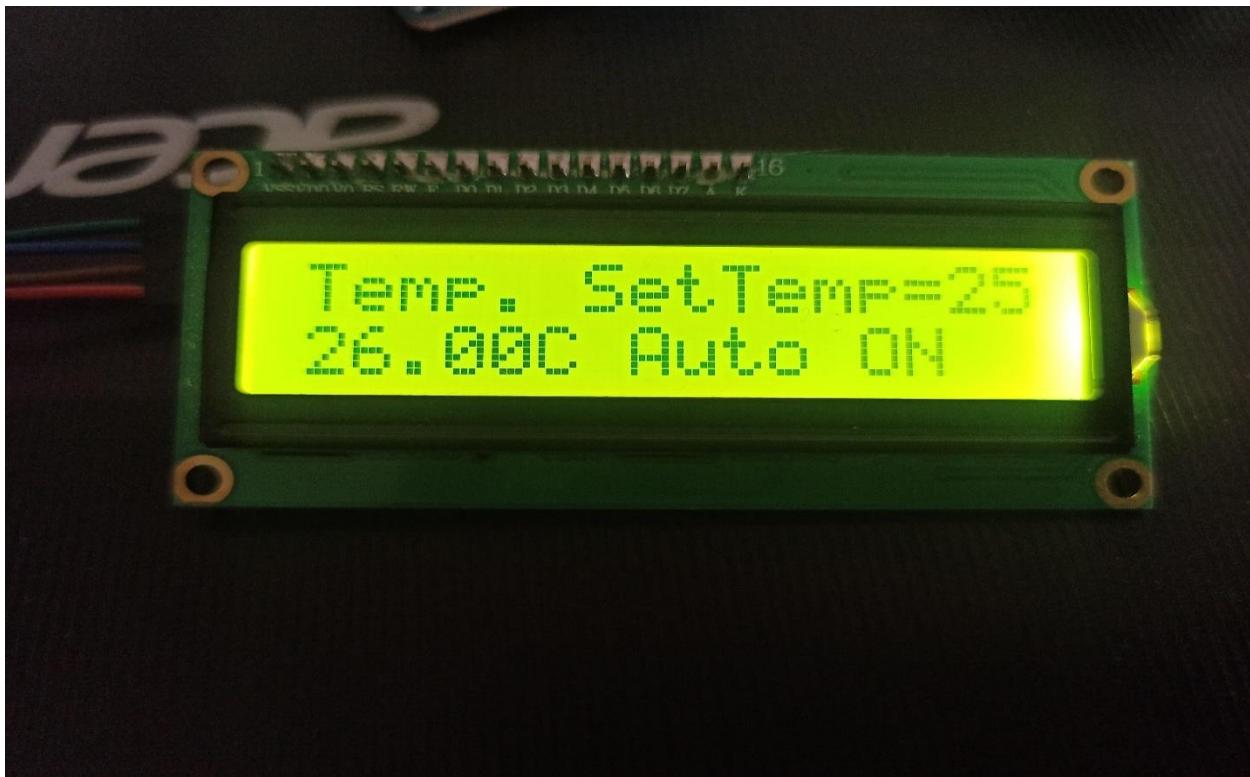


Figure 90 LCD display of room temperature controller

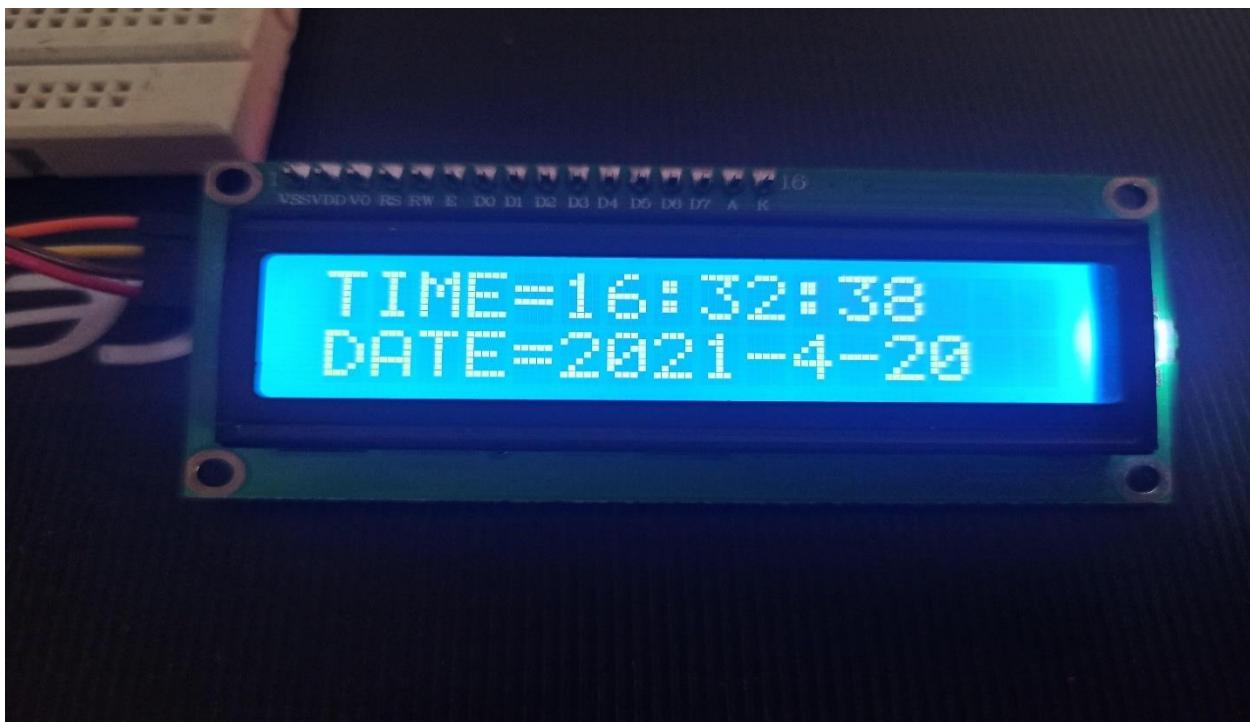


Figure 91 LCD display of smart light

# Originality report

## Originality report

---

**COURSE NAME**  
CS6P05 - FYP - Abiral Shrestha and Akchayat Bikram Joshi

**STUDENT NAME**  
Monarch Giri BSc. (Hons) Computer Networking & IT Security

**FILE NAME**  
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**REPORT CREATED**  
25 Apr 2021

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The user set the desired room temperature and by measuring the temperature from the sensor the system manages the temperature of the room by turning on the heater (LED) if the temperature is below the...

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This system allows the user to set a desired temperature which is then compared to the room temperature measured by a temperature sensor. ... the help of a microcontroller, the system responds by...

Design and simulation of an automatic room heater control system <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6025698/>

2 of 112 passages

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...electronic devices in our home or in our workplaces. The concept of home automation has been around from a very long period of time. From the period of 1940s to 1960s in the...

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The concept of home automation has been around for a long time, especially in science-fiction that imagined future homes being completely automated and robots helping us with household chores.

A Quick History of Home Automation - Somfy <https://www.somfy.com.au/discover-somfy/blog/post/2018-03-07-a-quick-history-of-home-automation>

3 of 112 passages

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IOT refers to the physical devices that are interconnected with each other to perform certain tasks and which are connected to the internet for sharing and collecting the data

Top web match

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. ... be filled with many smaller IoT...

What is the IoT? Everything you need to know about the Internet of ... <https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/>

4 of 112 passages

Student passage FLAGGED

...some result and present them with the final outcome. IOT makes devices smarter by letting it to connect through the internet and communicate with people and other

Top web match

It's when physical devices connect and share data one other "things" and people. ... IoT makes once "dumb" devices "smarter" by giving them the ability to send data over the internet, allowing the...

What Is The Internet of Things? A Complete Guide To IoT. | Built In <https://builtin.com/internet-things>

5 of 112 passages

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...platform perform well. IOT has been growing rapidly since the past few years and it has become one of the most important and useful technology ever developed. By connecting the devices...

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Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we ... Access to low-cost, low-power sensor technology. Affordable and ... A host of...

What Is the Internet of Things (IoT)? - Oracle <https://www.oracle.com/internet-of-things/what-is-iot/>

6 of 112 passages

Student passage CITED

...desire. IOT allows use to maximize performance, look past the sensor data and understand how the data is collected and transmitted, such as timestamps and error

Top web match

The Internet of Things (IoT) is the network of physical objects ('Things') that use sensors to capture data and embedded connectivity to exchange ... Go beyond the sensor data and look at how that ...

7 Real Benefits that IoT Brings - Heller Search Associates <https://www.hellerssearch.com/blog/7-real-benefits-iot-brings>

7 of 112 passages

Student passage FLAGGED

IOT provides better quality of life increasing the comfort, convenience, and better management, which improves the quality of life.

Top web match

Improving the quality of life by increasing comfort, convenience, and better management. IoT also brings to the world many other ... Manufacturing: IoT production-line monitor system allows proactive...

What is the IoT and its applications - ITC Group [https://itcgroup.io/blog/detail/what-is-the-iot-and-its-applications\\_b310](https://itcgroup.io/blog/detail/what-is-the-iot-and-its-applications_b310)

8 of 112 passages

Student passage FLAGGED

the NodeMCU, if the temperature of the room is below the set temperature, then the heater (LED) would turn on automatically and if the room temperature is above the set temperature, then the fan would...

Top web match

The Fan is triggered ON when the room temperature is higher than the set temperature and the heater is triggered ON when the room temperature is ... value, then the heater will be automatically...

Design and simulation of an automatic room heater control system <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6025698/>

9 of 112 passages

Student passage FLAGGED

...shows that people need more facility in home. Implementing smart home systems with remote display controls and health care capabilities would reduce the cost of home personal assistance

Top web match

In fact, from economic point of view, the cost of living at home with monitoring devices and intelligent appliances is less expensive and more beneficial than attending medical centers and being...

Smart Home Automation System for Elderly, and Handicapped <https://studylib.net/doc/18481034/smart-home-automation-system-for-elderly--and-handicapped>

10 of 112 passages

Student passage FLAGGED

...excitation signal or a power signal to operate and passive sensors do not need any external power and it can deliver output response directly. Another is analog and digital sensors; analog sensors...

Top web match

**Passive Sensors**, on the other hand, do not require any external power signal and directly generates output response. The other type of ...

What is a Sensor? Different Types of Sensors, Applications <https://www.electronicshub.org/different-types-sensors/>

11 of 112 passages

Student passage FLAGGED

Adafruit IO is a cloud service which provides us the service to connect our devices to the internet, it is platform for storing data, viewing data, and controlling devices

Top web match

**Adafruit IO** is an easy-to-use IoT platform that is useful for storing data, viewing data, and controlling devices. Adafruit IO uses several different protocols, including REST and MQTT, but using...

Sending and Receiving data with Adafruit IO and Python - Digikey <https://www.digikey.com/en/maker/blogs/2018/sending-and-receiving-data-with-adafruit-io-and-python>

12 of 112 passages

Student passage FLAGGED

...internet. It helps us in different way like, it can display the real time data, helps to maintain connected to the internet, it helps to connect the projects to other internet enabled devices

Top web match

With Adafruit IO, you can use graphs and charts to display your data as well as buttons and switches to trigger particular features on your device. ... real-time visualization of your data online;...

How to Make a Web Based IoT Control Dashboard - Circuit Basics <https://www.circuitbasics.com/how-to-make-a-web-based-iot-control-dashboard/>

13 of 112 passages

Student passage CITED

...applications, services, networking, and devices, reached \$130bn. Global Data, according to the data and analytics firm, is expected to hit \$318 billion by 2023, at a 20 percent compound annual growth

Top web match

By Michelle Froese The global market for Internet of Things (IoT) technology, which consists of software, services, connectivity, and devices, reached \$130bn in 2018. According to data and analytics...

Renewable Energy News / Global IoT market to reach \$318 billion ... <http://www.renewenews.com/global-iot-market-to-reach-318-billion-by-2023-says-globaldata/>

14 of 112 passages

Student passage FLAGGED

...automation is a topic which is familiar with everybody. The worldwide smart home mechanization market is expected to cross 21 billion US dollars

Top web match

Smart automation can also do more than that; it has displayed the future of our true life. For 2020, the global smart home mechanization market is forecasted to touch 21 billion U.S. dollars. The...

IoT Development Solutions for Home Automation | by Priyanka Bhatt ... <https://medium.com/@piabhatt420/iot-development-solutions-for-home-automation-46f947afc39c>

15 of 112 passages

Student passage CITED

According to Statista report, more than 45 million smart home devices will be connected in U.S. homes by the end of the 2018 year, giving an average income per house of approximately \$490

Top web match

According to research from Statista forecasts that by the end of the 2018 year, higher than 45 million smart home devices will be connected in U.S. homes, giving the average revenue per home ...

IoT Development Solutions for Home Automation | by Priyanka Bhatt ... <https://medium.com/@piabhatt420/iot-development-solutions-for-home-automation-46f947afc39c>

16 of 112 passages

Student passage FLAGGED

The total number of devices connected worldwide is more than 17 billion whereas the no of devices is more than 7 billion excluding the mobile phones, laptops, tv or

Top web match

The number of connected devices that are in use worldwide now exceeds 17 billion, with the number of IoT devices at 7 billion (that number does not include smartphones, tablets, laptops or fixed line...

State of the IoT 2018: Number of IoT devices now at 7B – Market ... <https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/>

17 of 112 passages

Student passage CITED

...it would be comfortable for us to live in. According to the Committee on Climate Change in UK, around 19% of the UK's carbon emissions come from heating the homes and workplaces

## Top web match

And there's an impact on the climate too. According to the Committee on Climate Change, 19% of the UK's carbon emissions come from heating our homes and workplaces. So it's definitely wise to keep on...

What's the ideal room temperature for your home? | OVO Energy <https://www.ovogeny.com/guides/energy-guides/average-room-temperature.html>

---

18 of 112 passages

Student passage FLAGGED

...in work-related accidents. Six studies showed an uptick in **trauma hospital admissions during hot weather**, while one study found no connection. The evidence for the effects of subgroups including...

## Top web match

For **trauma hospital admissions**, 6 studies reported an increase during hot weather, whereas 1 study found no association. The evidence for impacts on injuries by subgroups such as children, the elderly...

Impact of high ambient temperature on unintentional injuries in high ... <https://pubmed.ncbi.nlm.nih.gov/26868947/>

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19 of 112 passages

Student passage CITED

...use thermostats to manage their heating and/or cooling systems. In 2005, over 97% of households in the United States had a heating system and over 75% had air

## Top web match

Heating and cooling homes consumes a substantial portion of energy. Most households in the U.S.1 use thermostats to control the heating and/or cooling system in their home; in 2005, approximately 97%...

How people use thermostats in homes: A review - Faculty Washington [https://faculty.washington.edu/aragon/pubs/how\\_people\\_use\\_thermostats\\_in\\_homes.pdf](https://faculty.washington.edu/aragon/pubs/how_people_use_thermostats_in_homes.pdf)

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20 of 112 passages

Student passage FLAGGED

the thermostat is helpful but until the set temp is not reached it continuously heats the room and until the temperature drops it would continue to heat the room and by setting the thermostat higher...

## Top web match

It allows the heating to be fully on until the set temperature is reached, at which point the thermostat will turn the heating off until the temperature drops again. ... higher than your comfort level...

8 Mistakes People Make With Their Programmable Thermostat | Blog <https://www.warmup.com/blog/5-mistakes-people-make-with-their-thermostat>

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21 of 112 passages

Student passage ATTN

...available in android mobiles and in google home device. Google has said that there is more than 500 million people who are using google assistant in their mobile phones, TVs and

## Top web match

Google has today announced in an official blog post that over half a billion people in more than 90 countries are now using the Google Assistant to get things done each month across their smart...

Google Assistant is Now Used By Over 500 Million People Every ... <https://www.iphoneincanada.ca/news/google-assistant-500-million-monthly-users/>

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22 of 112 passages

Student passage FLAGGED

...basis. Google Assistant can understand two commands at once if you have a Google Home speaker, which is an improvement over Amazon Alexa's Follow-Up Mode

## Top web match

During the test of more than 4,000 questions led by Stone Temple, Google Assistant consistently outperformed other industry leaders including Alexa, Siri, and Cortana when recognizing and responding...

Useful ArticlesWhich voice assistant is best? - Smarter Home ... <https://www.smarterhomeelectronics.co.uk/20/useful-articles/which-voice-assistant-is-best>

---

23 of 112 passages

Student passage FLAGGED

**Heat stress, heat cramps, heat stroke, and mortality** may both result from prolonged exposure to excessive heat, as well as intensify preexisting chronic disorders like lung, **cerebral**, and...

Top web match

Prolonged exposure to extreme heat can cause **heat exhaustion, heat cramps, heat stroke, and death**, as well as exacerbate preexisting chronic conditions, such as various respiratory, **cerebral**, and...

Effects of Heat - Climate and Human Health [https://www.niehs.nih.gov/research/programs/geh/climatechange/health\\_impacts/heat/index.cfm](https://www.niehs.nih.gov/research/programs/geh/climatechange/health_impacts/heat/index.cfm)

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24 of 112 passages

Student passage CITED

**urban heat island effect is caused by** high concentrations of **buildings** in urban centers, which generate and absorb heat, leaving the city center several degrees hotter than the surrounding

Top web match

**Urban heat islands** are frequently cited as a reason to install a cool roof, but the **heat island effect** is actually caused by a number of other factors in ... **buildings and paved surfaces that absorb...**

6 Causes of Urban Heat Islands and 4 Ways to Offset Them | Buildings <https://www.buildings.com/articles/27532/6-causes-urban-heat-islands-and-4-ways-offset-them>

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25 of 112 passages

Student passage FLAGGED

**the sleep of the humans, increased wakefulness and reduced rapid eye movement sleep and slow wave sleep** are the stereotypical symptoms of hot or cold exposure. **Heat exposure** while in sleep can...

Top web match

**The stereotypical effects of heat or cold exposure are increased wakefulness and decreased rapid eye movement sleep and slow wave sleep...** In real-life situations where bedding and clothing are used, ...

Effects of thermal environment on sleep and circadian rhythm <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3427038/>

---

26 of 112 passages

Student passage FLAGGED

...can be harmful, it also creates sleep disorder as **increased wakefulness and reduced rapid eye movement sleep and slow wave sleep** are the some of the symptoms that can be...

Top web match

**The stereotypical effects of heat or cold exposure are increased wakefulness and decreased rapid eye movement sleep and slow wave sleep.** These effects of the thermal environment on sleep stages are...

Effects of thermal environment on sleep and circadian rhythm <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3427038/>

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27 of 112 passages

Student passage QUOTED

In the journal title as "**Design and simulation of an automatic room heater control system**" written by Adamu Murtala Zungeru, Mmoloki Mangwala, Joseph Chuma...

Top web match

This paper presents the **design and simulation of an Automatic Room Heater Control system**. This system allows the user to set a desired temperature which is then compared to the room temperature...

Design and simulation of an automatic room heater control system ... <https://www.sciencedirect.com/science/article/pii/S2405844018304602>

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28 of 112 passages

Student passage FLAGGED

**dedicated room temperature regulation** is no longer just a key problem in ensuring **employee satisfaction** and, as a result, improved job output; it's also a **health and safety issue**

Top web match

Design and implementation of a room temperature control system: Microcontroller-based. Abstract: **Dedicated control over room temperature** is not only a key issue in providing work conditions that...

Design and implementation of a room temperature control system ... <https://ieeexplore.ieee.org/document/7072989/>

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29 of 112 passages

Student passage FLAGGED

...System for Smart Electric Fan Using PIC" written by **Zairi Ismael Rizman, Kim Ho Yeap, Nuraliza Ismail, Norizan Mohamad, Nur Hafizah Rabi'ah Husin**. They stated that in this current world of changing...

Top web match

Design an Automatic Temperature Control System for Smart Electric Fan Using PIC. **Zairi Ismael Rizman; Kim Ho Yeap; Nuraliza Ismail; Norizan Mohamad; Nur Hafizah Rabi'ah Husin.** Abstract.

Search Results: International Journal of Science and Research (IJSR) [https://www.ijsr.net/search\\_index\\_results\\_paperid.php?id=21081301](https://www.ijsr.net/search_index_results_paperid.php?id=21081301)

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30 of 112 passages  
Student passage FLAGGED

**This is to ensure that the cooling process runs more efficiently and effectively**, particularly in large spaces and during hot weather caused by global warming

Top web match

It also has a unique double feature designs, such as using 2 fans, 2 Light Emitting Diodes (LED) and 2 sensors. **This is to ensure the cooling process operates more efficiently and effectively....**

Design an Automatic Temperature Control System for Smart Electric ... [https://www.ijsr.net/get\\_abstract.php?paper\\_id=21081301](https://www.ijsr.net/get_abstract.php?paper_id=21081301)

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31 of 112 passages  
Student passage QUOTED

In the journal titled as "Literature Review on Home Automation system for Physically disabled Peoples" written by Saeed Faroom, Muhammad Nauman Ali, Sheraz Yousa...

Top web match

**Literature review on home automation system for physically disabled peoples.** Abstract: Generally the Art of controlling the home appliances automatically & sometimes remotely is called home automation...

Literature review on home automation system for ... - IEEE Xplore <https://ieeexplore.ieee.org/document/8346397>

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32 of 112 passages  
Student passage FLAGGED

...can lead to a huge wastage of the energy. **The International Energy Agency predicts that by 2050 the energy demand of buildings will increase by 50**

Top web match

**The International Energy Agency predicts that the energy demand of buildings will increase by 50%** by 2050 if certain measures are not conducted to improve building energy efficiency (2). In buildings,...

Design and Application of a Smart Lighting System Based on ... - MDPI <https://www.mdpi.com/2076-3417/10/23/8545/pdf>

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33 of 112 passages  
Student passage QUOTED

In the journal "Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant" written by M. Poongothai, K. Sundar, B. Vinayak Prabhu.

Top web match

**Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant.** September 2016; International Journal of Computer Applications 182(16):6-10.

(PDF) Implementation of IoT based Intelligent Voice Controlled ... [https://www.researchgate.net/publication/327722894\\_Implementation\\_of\\_IoT\\_based\\_Intelligent\\_Voice\\_Controlled\\_Laboratory\\_using\\_Google\\_Assistant](https://www.researchgate.net/publication/327722894_Implementation_of_IoT_based_Intelligent_Voice_Controlled_Laboratory_using_Google_Assistant)

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34 of 112 passages  
Student passage FLAGGED

...and managed over a network infrastructure. In human absence **controlling** and monitoring the devices which consume power is a major inability. For better comfort, better utilization of the devices and...

Top web match

As an organization grows every year, new management problems and energy issues appear. Monitoring and **controlling** the unused devices that consume power during human absence is a major inability. In...

Implementation of IoT based Intelligent Voice Controlled ... - IJCA <https://www.ijcaonline.org/archives/volume182/number16/29944-2018917808>

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35 of 112 passages  
Student passage CITED

...devices and monitor them google assistant can be used. **The introduction of Google Assistant not only makes it more accessible to users, but it also makes the process more social with its**

Top web match

The aim is to control and monitor the things such as lights, fans, projector and air-conditioner of IoT lab in CIT campus using Google assistant or chat bot. **The instigation of Google assistant not...**

Implementation of IoT based Intelligent Voice Controlled ... - IJCA <https://www.ijcaonline.org/archives/volume182/number16/29944-2018917808>

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36 of 112 passages

Student passage FLAGGED

...System for Smart Electric Fan Using PIC" written by **Zairi Ismael Rizman, Kim Ho Yeap, Nuraliza Ismail, Norizan Mohamad, Nur Hafizah Rabl'ah Husin**

Top web match

Design an Automatic Temperature Control System for Smart Electric Fan Using PIC. **Zairi Ismael Rizman; Kim Ho Yeap; Nuraliza Ismail; Norizan Mohamad; Nur Hafizah Rabl'ah Husin.** Abstract.

Search Results: International Journal of Science and Research (IJSR) [https://www.ijsr.net/search\\_index\\_results\\_paperid.php?id=21081301](https://www.ijsr.net/search_index_results_paperid.php?id=21081301)

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37 of 112 passages

Student passage FLAGGED

...to temperature variations, the circuit uses a microcontroller. **The device tests the temperature of the integrated circuit**, where the fan is regulated in accordance with the

Top web match

An integrated circuit provides self-heating in order to assist an externally ... integrated circuit that is thermally coupled to a heat dissipating **device**, ... and the **temperature of the integrated...**

US6163161A - Directed self-heating for reduction of system test time ... <http://www.google.com/patents/US6163161>

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38 of 112 passages

Student passage QUOTED

...In the journal titled as "Literature Review on Home Automation system for Physically disabled Peoples" written by Saeed Faroom, Muhammad Nauman Ali, Sheraz Yousaf.

Top web match

**Literature review on home automation system for physically disabled peoples.** Abstract: Generally the Art of controlling the home appliances automatically & sometimes remotely is called home automation....

Literature review on home automation system for ... - IEEE Xplore <https://ieeexplore.ieee.org/document/8346397>

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39 of 112 passages

Student passage QUOTED

In the journal titled as "Development and Implementation of Smart Street Lighting System based on Lora Technology" written by Ngo Thanh Tung, Le Minh Phuong, Nguyen...

Top web match

**Development and Implementation of Smart Street Lighting System based on Lora Technology.** Abstract: This paper concerned with the development and implementation of smart street lighting control system...

Development and Implementation of Smart Street ... - IEEE Xplore <https://ieeexplore.ieee.org/document/8921028>

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40 of 112 passages

Student passage FLAGGED

...Street Lighting System based on Lora Technology" written by **Ngo Thanh Tung, Le Minh Phuong, Nguyen Minh Huy, Nguyen Hoai Phong, Ta Le Dinh Huy, Nguyen Dinh Tuyen**

Top web match

**PDF Ngo Thanh Tung; Le Minh Phuong; Nguyen Minh Huy; Nguyen Hoai Phong; Ta Le Dinh Huy; Nguyen Dinh Tuyen All Authors**

Development and Implementation of Smart Street ... - IEEE Xplore <https://ieeexplore.ieee.org/document/8921028>

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41 of 112 passages

Student passage FLAGGED

**When attached to the center, the automatic mode is maintained:** Monitor the light according to the control center's preset scenario or time control, and the sensor

Top web match

10) . The proposed smart street public lighting provides some advantages features such as: -Automatic mode, **when connected to the center is maintained:** Control the light according to the predetermined...

LoRa model IV. SYSTEM STRUCTURE FOR INTELLIGENT ... [https://www.researchgate.net/figure/LoRa-model-IV-SYSTEM-STRUCTURE-FOR-INTELLIGENT-STREET-LIGHTING-SERVICE\\_fig1\\_323863173](https://www.researchgate.net/figure/LoRa-model-IV-SYSTEM-STRUCTURE-FOR-INTELLIGENT-STREET-LIGHTING-SERVICE_fig1_323863173)

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42 of 112 passages

Student passage FLAGGED

**The proposed lighting scheme used ZigBee and Wi-Fi connectivity to monitor the lights in commercial/residential buildings** based on available natural daylight, occupancy, or the needs of the building's...

Top web match

**The proposed lighting system uses ZigBee and Wi-Fi communication protocols to control the lights of commercial/residential buildings** according to natural daylight, occupancy or as per the requirements...

(PDF) Implementation of Smart LED Lighting and Efficient Data  
... [https://www.researchgate.net/publication/322283703\\_Implementation\\_of\\_Smart\\_LED\\_Lighting\\_and\\_Efficient\\_Data\\_Management\\_System\\_for\\_Buildings](https://www.researchgate.net/publication/322283703_Implementation_of_Smart_LED_Lighting_and_Efficient_Data_Management_System_for_Buildings)

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43 of 112 passages

Student passage FLAGGED

certain technologies in automobiles, as well as in retail, education, healthcare, and telecommunications settings. Voice assistants help us to perform a number of tasks without having to use our...

Top web match

Additionally, certain technology in cars, as well as in retail, education, healthcare, and telecommunications environments, can be operated by voices...Voice assistants allow us to do a variety of tasks...

How Voice Assistants Are Changing Our Lives | Smartsheet <https://www.smartsheet.com/voice-assistants-artificial-intelligence>

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44 of 112 passages

Student passage FLAGGED

...calculated value of temperature and humidity is shown. The relay in this system is used as the switching factor to activate the devices according to changes

Top web match

The measured value of the temperature and humidity is displayed in the Liquid Crystal Display. In this system relay is using as the switching element to activate the devices according to the...

Automatic Room Temperature and Monitoring System ... - IJIRSET [https://www.ijirset.com/upload/2019/april/128\\_Automatic\\_N.pdf](https://www.ijirset.com/upload/2019/april/128_Automatic_N.pdf)

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45 of 112 passages

Student passage QUOTED

In the journal title as "Design and simulation of an automatic room heater control system" written by Adamu Murtala Zungeru, Mmoloki Mangwala, Joseph Chuma...

Top web match

This paper presents the design and simulation of an Automatic Room Heater Control system. This system allows the user to set a desired temperature which is then compared to the room temperature...

Design and simulation of an automatic room heater control system ... <https://www.sciencedirect.com/science/article/pii/S2405844018304602>

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46 of 112 passages

Student passage FLAGGED

Luminaires, switches, a distributed wireless sensor network (WSN), and a rule base for lighting control are all part of the proposed scheme. Each luminaire includes a sensing module that regulates the...

Top web match

The proposed system includes luminaires, sensors, a distributed wireless sensor network (WSN), and a rule base for lighting control. Each luminaire is equipped with a sensing module that controls the...

Design and Application of a Smart Lighting System Based on ... - MDPI <https://www.mdpi.com/2076-3417/10/23/8545/pdf>

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47 of 112 passages

Student passage QUOTED

In the journal "Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant" written by M. Poongothai, K. Sundar, B. Vinayak Prabhu.

Top web match

**Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant.** September 2018; International Journal of Computer Applications 182(16):6-10.

(PDF) Implementation of IoT based Intelligent Voice Controlled ... [https://www.researchgate.net/publication/327722894\\_Implementation\\_of\\_IoT\\_based\\_Intelligent\\_Voice\\_Controlled\\_Laboratory\\_using\\_Google\\_Assistant](https://www.researchgate.net/publication/327722894_Implementation_of_IoT_based_Intelligent_Voice_Controlled_Laboratory_using_Google_Assistant)

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48 of 112 passages

Student passage QUOTED

In the journal titled as "Design and Implementation of IoT-Based Smart Home Voice Commands for disabled people using Google Assistant

Top web match

**Design and implementation of IoT-based smart home voice commands for disabled people using Google Assistant** ieee conference publication ieee xplore  
Design and implementation of IoT-based smart home...

Design and Implementation of IoT-Based Smart Home Voice ... <https://ieeexplore.ieee.org/abstract/document/9079344/>

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49 of 112 passages

Student passage QUOTED

In the journal titled as "Monitoring environmental parameters: humidity and temperature using Arduino based microcontroller and sensors" written by Nagendra Dangi. The author has used the....

Top web match

**Monitoring environmental parameters: humidity and temperature using Arduino based microcontroller and sensors** : Microcontroller based building monitoring system.

Monitoring environmental parameters: humidity and ... - Theseus <https://www.theseus.fi/handle/10024/142235>

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50 of 112 passages

Student passage QUOTED

In the article titled as "Globally controlled multiple relays using NODE MCU" written by Kundan Ghosh, Monidip Bhownick, Dipanwita Joddar. They...

Top web match

**"Globally controlled multiple relays using NODE MCU."** PhD diss., University of Technology, 2018. ThingSpeak-an API and Web Service for the Internet of Things.

Design and implementation of monitoring and warning (IOT) system ... [https://www.researchgate.net/publication/342610000\\_Design\\_and\\_implementation\\_of\\_monitoring\\_and\\_warning\\_IOT\\_system\\_for\\_electricity\\_coles](https://www.researchgate.net/publication/342610000_Design_and_implementation_of_monitoring_and_warning_IOT_system_for_electricity_coles)

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51 of 112 passages

Student passage FLAGGED

...developed by IBM and first released in 1999. It is a publish and subscribe network protocol which transports messages between devices. MQTT is mainly used for machine-to-machine communication or for...

Top web match

The Message Queuing Telemetry Transport (MQTT) is a lightweight, publish-subscribe network protocol that transports messages between devices. The protocol usually runs over TCP/IP; however, any...

MQTT - Wikipedia <https://en.wikipedia.org/wiki/MQTT>

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52 of 112 passages

Student passage FLAGGED

the purpose to allow monitoring the devices used in oil and gas industry to send the data to the remote servers. These tracking systems were mostly used in remote areas where establishing a landline,...

Top web match

The original purpose of the communication method was to allow monitoring devices used in the oil and gas industry to send their data to remote servers. In many cases, such monitoring devices were used...

What is MQTT? Definition and Details - Paessler <https://www.paessler.com/it-explained/mqtt>

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53 of 112 passages

Student passage FINISH

...the broker rather than communicating individually with one another. **Each client may be either a publisher, a subscriber, or both** (Spofford, 2019).

Top web match

Clients do not communicate directly with each other, but rather connect to the broker. **Each client may be either a publisher, a subscriber, or both**. MQTT is an event-driven protocol.

What is MQTT? Definition and Details - Paessler <https://www.paessler.com/it-explained/mqtt>

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54 of 112 passages

Student passage FLAGGED

**The broker is in charge of processing all messages, filtering them, deciding who has subscribed to each message, and then delivering it to others who have subscribed**

Top web match

Depending on the implementation, a broker can handle up to millions of concurrently connected MQTT clients. **The broker is responsible for receiving all messages, filtering the messages, determining ...**

MQTT Client and Broker and MQTT Server and Connection ... <https://www.hivemq.com/blog/mqtt-essentials-part-3-client-broker-connection-establishment/>

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55 of 112 passages

Student passage FLAGGED

**MQTT client**Any device that runs a MQTT library and connects to a MQTT broker over a network is a MQTT client. The MQTT client, for example, may be a very...

Top web match

The MQTT broker is much more passive, acting more like a signpost for where the data should go. **MQTT client Any Thing** (from a microcontroller to a massive server) that runs an MQTT library and...

MQTT beginner's guide | u-blox <https://www.u-blox.com/en/blogs/insights/mqtt-beginners-guide>

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56 of 112 passages

Student passage FLAGGED

...MQTT broker over a network is a MQTT client. The MQTT client, for example, may be a very small, resource-constrained device that connects via wireless and has a bare-minimum library

Top web match

An MQTT client is any device (from a micro controller up to a full-fledged server) that runs an MQTT library and connects to an MQTT broker over a network. For example, **the MQTT client can be a very...**

MQTT Client and Broker and MQTT Server and Connection ... <https://www.hivemq.com/blog/mqtt-essentials-part-3-client-broker-connection-establishment/>

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57 of 112 passages

Student passage FLAGGED

...is its simplicity of implementation. Server libraries for MQTT are available in a wide range of programming languages. Android, Arduino, C, C++, C#, Go, iOS, Java, JavaScript...

Top web match

MQTT is a standard for moving data between an IoT device and a server. ... There are many open source clients available in a wide range of programming languages. ... Overview · MQTT 5 Essentials ...

Getting Started with MQTT - HiveMQ <https://www.hivemq.com/blog/how-to-get-started-with-mqtt/>

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58 of 112 passages

Student passage FLAGGED

**A UTF-8 string that the broker uses to filter messages for each linked client** is referred to as a Subject. One or two...

Top web match

Communication in MQTT is based on the topic principle. An MQTT topic is a **UTF-8 string that the broker uses to filter messages for each connected client**. To receive messages, the client must subscribe...

15 Frequently Asked MQTT Questions - HiveMQ <https://www.hivemq.com/blog/15-frequently-asked-mqtt-questions/>

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59 of 112 passages

Student passage CITED

If a broker receives data that needs to be released to a subject that doesn't exist yet, the topic is automatically generated, and clients will subscribe to it (Yuan, 2020).

## Top web match

Topics are not explicitly created in MQTT. If a broker receives data published to a topic that does not currently exist, the topic is simply created, and clients may subscribe to the new topic....

What is MQTT? Definition and Details - Paessler <https://www.paessler.com/it-explained/mqtt>

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60 of 112 passages

Student passage CITED

A rogue **ESP8266** transmitting **MQTT SUBSCRIBE packets** within an Arduino sketch's **main loop()** function can send up to **500 packets** every minute. If we didn't apply rate caps on any action, it wouldn't...

## Top web match

Most of the systems connecting to Adafruit IO are simple, automated devices and MQTT client scripts. A runaway **ESP8266** sending **MQTT SUBSCRIBE packets** inside the **main loop()** function of an Arduino...

Adafruit IO MQTT API – Adafruit IO API Reference <https://io.adafruit.com/api/docs/mqtt.html>

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61 of 112 passages

Student passage CITED

Host: io.adafruit.com Port: 1883 or 8883 (for SSL encrypted connection) Username: Personal Adafruit account username Password: Personal Adafruit IO key...

## Top web match

Host: io.adafruit.com Port: 1883 or 8883 (for SSL encrypted connection) Username: your Adafruit account username (see the accounts.adafruit.com page here to find yours)

MQTT API | Adafruit IO | Adafruit Learning System <https://learn.adafruit.com/adafruit-io/mqtt-api>

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62 of 112 passages

Student passage FLAGGED

...Adafruit IO exposes feed data via special topics. People can subscribe to a feed's topic to be updated anytime the feed has a new value, or they can post a new value for a...

## Top web match

Adafruit IO's MQTT API exposes feed data using special topics. You can publish a new value for a feed to its topic, or you can subscribe to a feed's topic to be notified when the feed has a new value....

MQTT API | Adafruit IO | Adafruit Learning System <https://learn.adafruit.com/adafruit-io/mqtt-api>

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63 of 112 passages

Student passage FLAGGED

If there is a controlled **5V voltage source**, the **VIN** pin can be used directly to supply the **ESP8266** and its peripherals. The **3.3V** pins are the output of a voltage regulator

## Top web match

Alternatively, if you have a regulated **5V voltage source**, the **VIN** pin can be used to directly supply the **ESP8266** and its peripherals...The **3.3V** pins are the output of an on-board **voltage regulator**

Insight Into ESP8266 NodeMCU Features & Using It With Arduino ... <https://lastminuteengineers.com/esp8266-nodemcu-arduino-tutorial/>

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64 of 112 passages

Student passage PUBLISHED

**GND** – It is a ground pin of **ESP8266 NodeMCU development board**.

## Top web match

**GND** is a ground pin of **ESP8266 NodeMCU development board**. I2C Pins are used to hook up all sorts of I2C sensors and peripherals in your project. Both I2C ...

Insight Into ESP8266 NodeMCU Features & Using It With Arduino ... <https://lastminuteengineers.com/esp8266-nodemcu-arduino-tutorial/>

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65 of 112 passages

Student passage CITED

...programmatically, with a maximum clock frequency of 100 kHz. It should be remembered that the I2C clock frequency should be higher than the slave device's **SLOWEST CLOCK** frequency (engineers, 2021).

## Top web match

I2C interface functionality can be realized programmatically, and the clock frequency is 100 kHz at a maximum. It should be noted that I2C clock frequency should be higher than the slowest clock...

Insight Into ESP8266 NodeMCU Features & Using It With Arduino ... <https://lastminuteengineers.com/esp8266-nodemcu-arduino-tutorial/>

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66 of 112 passages  
Student passage FLAGGED

**GPIO pins** – The **ESP8266 NodeMCU has 17 GPIO pins** that can be programmatically allocated to different functions including I2C, I2S, UART, PWM, IR Remote Control, LED Light, and Button

Top web match

It should be noted that the frequency of I2C clocks should be higher than the slowest hour frequency of slave devices. **GPIO Pins ESP8266 NodeMCU has 17 GPIO pins** that can be assigned to various ...

Esp0200 esp- 12e ch340g datasheet - Weebly <https://palenugemin.weebly.com/uploads/1/3/4/0/134077610/4d4e0200c095ea3.pdf>

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67 of 112 passages  
Student passage FLAGGED

...set to high impedance or internal pull-up or pull-down. It can also be set to edge-trigger or level-trigger to produce CPU interrupts when programmed as an input.

Top web match

Each digital enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU...

Insight Into ESP8266 NodeMCU Features & Using It With Arduino ... <https://lastminuteengineers.com/esp8266-nodemcu-arduino-tutorial/>

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68 of 112 passages  
Student passage CITED

**UART pins** – The **ESP8266 NodeMCU has two UART interfaces, UART0 and UART1**, which can communicate at up to 4.5 Mbps and have asynchronous connectivity (RS232 and RS485). For connectivity...

Top web match

**UART Pins NodeMCU/ESP8266 has 2 UART interfaces (UART0 and UART1)** which provide asynchronous communication (RS232 and RS485), and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0...

NodeMCU ESP8266 Specifications, Overview and Setting Up <https://www.make-it.ca/nodemcu-arduino/nodemcu-details-specifications/>

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69 of 112 passages  
Student passage FLAGGED

...pulled LOW, it uses the least amount of power possible. **RST pin** – RST pin is used to reset the **ESP8266 chip**. **WAKE pin** – Wake pin is used to wake the...

Top web match

When pulled LOW the chip works at minimum power. **RST pin** -- RST pin is used to reset the **ESP8266 chip**. **WAKE pin** -- Wake pin is used to wake the chip from deep-sleep.

Insight Into ESP8266 NodeMCU Features & Using It With Arduino ... <https://lastminuteengineers.com/esp8266-nodemcu-arduino-tutorial/>

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70 of 112 passages  
Student passage CITED

...– RST pin is used to reset the **ESP8266 chip**. **WAKE pin** – Wake pin is used to wake the chip from deep-sleep (engineers, 2021).

Top web match

**RST pin** -- RST pin is used to reset the **ESP8266 chip**. **WAKE pin** -- Wake pin is used to wake the chip from deep-sleep. ESP8266 development platforms

Insight Into ESP8266 NodeMCU Features & Using It With Arduino ... <https://lastminuteengineers.com/esp8266-nodemcu-arduino-tutorial/>

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71 of 112 passages  
Student passage FLAGGED

...temperature and humidity of that place. Its temperature ranges from 0 to 50 degree Celsius with +/- 2 degree accuracy and from 20 to 80 percentage of humidity with 5 percentage **accuracy**

Top web match

Introduction to DHT11 DHT11 is a low cost embedded sensor, which is used to measure temperature (in a range from 0 to 50 degree Celsius with an accuracy of +/- 2 C) and moisture (in a range from 20% to...

Introduction to DHT11 - The Engineering Projects <https://www.theengineeringprojects.com/2019/09/introduction-to-dht11.html>

72 of 112 passages

Student passage FLAGGED

...of stability. It's lightweight, inexpensive, and simple to use. **This sensor is also used** to measure air temperature and humidity in our weather stations

[Top web match](#)

It is small, low cost and easy to use. **This sensor is also used in our weather stations** to measure atmospheric temperature and humidity. On the basis of this information, experts can make rain...

Introduction to DHT11 - The Engineering Projects <https://www.theengineeringprojects.com/2019/03/introduction-to-dht11.html>

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73 of 112 passages

Student passage CITED

For measuring the humidity, it consists of capacitive humidity sensor and **it has a thermistor** inserted in it for temperature control, which is a resistive and wet NTC temperature measuring...

[Top web match](#)

It consists of a capacitive humidity sensor which measures humidity in the air. For temperature measurement, **it has a thermistor** embedded in it, which is a resistive and wet NTC temperature measuring...

Introduction to DHT11 - The Engineering Projects <https://www.theengineeringprojects.com/2019/03/introduction-to-dht11.html>

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74 of 112 passages

Student passage CITED

...3.5 to 5.5vOperating current: 0.3 to 5.5mASampling rate: 0.5 HzDimensions: 27mm x 59mm x 13.5mm (1.05" x 2.32" x 0.53").Weight: 2.4g (Ali, 2019)

[Top web match](#)

Its sampling rate is 0.5 Hz. Its dimensions are 27mm x 59mm x 13.5mm (1.05" x 2.32" x 0.53"). It has four pins with 0.1" spacing.

Introduction to DHT11 - The Engineering Projects <https://www.theengineeringprojects.com/2019/03/introduction-to-dht11.html>

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75 of 112 passages

Student passage FLAGGED

...for soldering or permanent connections to create circuits quickly. **Breadboards almost always have common rows** where the holes in a row are electrically

[Top web match](#)

Leaded components (i.e. through-hole parts), are inserted into holes containing metal grips that gently clamp onto the lead and **breadboards almost always have common rows** whereby the holes in a row...

What are Breadboards and Their Uses | Breadboard | Maker Pro <https://maker.pro/breadboard/tutorial/an-introduction-to-breadboards-and-their-uses>

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76 of 112 passages

Student passage FLAGGED

**Leaded parts are placed into holes containing metal grips that softly lock onto the lead**, and breadboards almost always have common rows where the holes in a row are electrically connected

[Top web match](#)

**Leaded components** (i.e. through-hole parts), are inserted into holes containing metal grips that gently clamp onto the lead and breadboards almost always have common rows whereby the holes in a row...

What are Breadboards and Their Uses | Breadboard | Maker Pro <https://maker.pro/breadboard/tutorial/an-introduction-to-breadboards-and-their-uses>

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77 of 112 passages

Student passage FLAGGED

...control rails on either side of the key rows. **Most breadboards have clips on the front, back, and sides** that can be used to attach them to other breadboards to create more complicated circuits

[Top web match](#)

Some breadboards have power rails on either side of the main rows and breadboards are able to house large parts, including DIP 40 ICs. **Most breadboards will have clips on the front, back, and sides**...

What are Breadboards and Their Uses | Breadboard | Maker Pro <https://maker.pro/breadboard/tutorial/an-introduction-to-breadboards-and-their-uses>

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78 of 112 passages

Student passage FLAGGED

LCD stands for liquid crystal display and is often used to display various values in various electronic projects and equipment. Liquid crystal displays (LCDs) use liquid crystals to...

Top web match

In today's tutorial, we will have a look at Introduction to 16x2 LCD Module. LCD stands for liquid crystal display it mostly used in different electronic projects and devices to display different...

Introduction to 16x2 LCD Module - The Engineering Projects <https://www.theengineeringprojects.com/2019/11/introduction-to-16x2-lcd-module.html>

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79 of 112 passages

Student passage FLAGGED

A standard LCD module used in DIY electronic projects and circuits is a 16 x 2 liquid crystal display. LCDs come in a variety of configurations, including (8 x 1), (10 x 2), and (16 x 1), but the 16 x...

Top web match

16 x 2 liquid crystal display is a basic LCD module used in DIY electronic projects and circuits...LCD also available in different arrangements like (8 x 1), (10 x 2), (16 x 1), but the 16 x 2 liquid...

Introduction to 16x2 LCD Module - The Engineering Projects <https://www.theengineeringprojects.com/2019/11/introduction-to-16x2-lcd-module.html>

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80 of 112 passages

Student passage CITED

The word "solid-state lighting," which includes organic LEDs (OLEDs), separates this type of lighting from those that use heated filaments (incandescent and tungsten halogen lamps) or gas discharge...

Top web match

Since light is generated within the solid semiconductors materials, LED's are described as solid -- state devices. The term solid -- state lighting, which also encompasses organic LEDs, distinguishes ...

OFFONN ELECTRICALS <https://offonn.in/whyled.php>

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81 of 112 passages

Student passage FLAGGED

It is official Arduino program that makes code compilation so simple that even a non-technical person can get their feet wet with the learning process. It runs on the Java Platform and is compatible...

Top web match

Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module. It is an official Arduino software, making code compilation too easy that even a...

Introduction to Arduino IDE - The Engineering Projects <https://www.theengineeringprojects.com/2018/10/introduction-to-arduino-ide.html>

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82 of 112 passages

Student passage FLAGGED

...with operating systems such as MAC, Windows, and Linux. It has built-in functions and commands that are useful for debugging, writing, and compiling code in the environment

Top web match

It is easily available for operating systems like MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and...

Introduction to Arduino IDE - The Engineering Projects <https://www.theengineeringprojects.com/2018/10/introduction-to-arduino-ide.html>

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83 of 112 passages

Student passage FLAGGED

The key code, also known as a sketch, generated on the IDE platform will eventually produce a Hex File, which will be transferred and uploaded to the board's controller

Top web match

Basically, it is used for uploading the code in the Arduino Device. The main code created on the IDE platform, also known as a sketch, will eventually generate a Hex File that is then transferred and...

EEEE Stand-alone Solar Monitoring System using Internet of Things ... <https://publisher.uthm.edu.my/periodicals/index.php/eeee/article/download/374/2>

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84 of 112 passages

Student passage FLAGGED

**It enables you to create a schematic, and thus a component, that can then be applied to professional-looking wiring diagrams.** Three components of fritzing are

Top web match

Fritzing is a great open source tool for anyone to teach, share, and prototype their electronic projects! It allows you to design a **schematic**, and thus a part, which **can then be added to** very ...

Make Your Own Fritzing Parts - learn.sparkfun.com <https://learn.sparkfun.com/tutorials/make-your-own-fritzing-parts/what-is-fritzing>

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85 of 112 passages

Student passage FLAGGED

**Breadboard view – Fritzing will show the circuit in breadboard view, making it simple to see how components** can connect **and be wired**. In the Breadboard view, Fritzing has a large library of parts to...

Top web match

To understand Fritzing, it is important to know something about Breadboard View, Schematics View, and Printed Circuit Boards View. **Breadboard View -- Fritzing** can present your **circuit in breadboard**...

All about Fritzing - West Florida Components <https://www.westfloridacomponents.com/blog/all-about-fritzing/>

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86 of 112 passages

Student passage CITED

**Printed circuit board view – Electronic** modules are **electrically wired on copper tracks laminated on a non-conducting substrate** on a printed circuit board (PCB). This view is...

Top web match

Fritzing has a large library of schematic parts to build up the Schematic View. **Printed Circuit Board View -- A** printed circuit board (PCB) consists of **electronic components connected electrically on...**

All about Fritzing - West Florida Components <https://www.westfloridacomponents.com/blog/all-about-fritzing/>

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87 of 112 passages

Student passage FLAGGED

**Evolutionary prototyping is a software development process** in which a prototype is built first by the developer or development team

Top web match

**Evolutionary prototyping is a software development method** where the developer or development team first constructs a prototype. After receiving initial feedback from the customer, subsequent...

Evolutionary Prototyping | SpringerLink [https://link.springer.com/10.1007/978-1-4020-8265-8\\_201039](https://link.springer.com/10.1007/978-1-4020-8265-8_201039)

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88 of 112 passages

Student passage FLAGGED

**The evolutionary development model** breaks down the development cycle into simpler, incremental waterfall models, with consumers gaining access to the product at the completion of each cycle

Top web match

It is better for software products that have their feature sets redefined during development because of user feedback and other factors. **The Evolutionary development model divides the development...**

Software Engineering | Evolutionary Model - GeeksforGeeks <https://www.geeksforgeeks.org/software-engineering-evolutionary-model/>

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89 of 112 passages

Student passage FLAGGED

...team responds by modifying the product, schedule, or operation. **Breaking down job into smaller chunks, prioritizing them, and then bringing those chunks to the consumer one by one**

Top web match

The Evolutionary development model divides the development cycle into smaller, incremental waterfall models in which users are able to get access to ... Evolutionary model suggests **breaking down** of...

Software Engineering | Evolutionary Model - GeeksforGeeks <https://www.geeksforgeeks.org/software-engineering-evolutionary-model/>

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90 of 112 passages

Student passage FLAGGED

...the consumer and can be introduced and distributed in stages. It can be difficult to break down a problem into several iterations that satisfy the customer and can be implemented and delivered

Top web match

Disadvantages: Sometimes it is hard to divide the problem into several versions that would be acceptable to the customer which can be incrementally implemented and delivered. Attention reader!

Software Engineering | Evolutionary Model - GeeksforGeeks <https://www.geeksforgeeks.org/software-engineering-evolutionary-model/>

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91 of 112 passages

Student passage FLAGGED

...and enforcement mechanism should be maintained. There should be trust management system for the IoT deployments which should have the ability to dynamically withdraw the trust of individual devices

Top web match

As a result of this, any trust management system for IoT deployments must have the ability to dynamically withdraw trust of individual devices. Likewise, individual devices must be dynamically able to...

Security and Privacy in Internet of Things (IoTs): Models, ... [https://books.google.com/books?id=kr\\_1CwAACBAJ&pg=PA239&dq=trust+management+system+iot+deployments+ability+dynamically+withdraw+trust+individual+devices&source=bl&ots=pTj](https://books.google.com/books?id=kr_1CwAACBAJ&pg=PA239&dq=trust+management+system+iot+deployments+ability+dynamically+withdraw+trust+individual+devices&source=bl&ots=pTj)

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92 of 112 passages

Student passage QUOTED

In the journal titled as "Remote controlling of home appliances using mobile telephony" written by Rifat Shahriyar, Enamul Hoque, S M Sohan...

Top web match

**Remote controlling of home appliances using mobile telephony.** August 2008; International Journal of Smart Home 2(3). Authors: Rifat Shahriyar at Bangladesh University of Engineering and Technology.

(PDF) Remote controlling of home appliances using mobile telephony [https://www.researchgate.net/publication/228847978\\_Remote\\_controlling\\_of\\_home\\_appliances\\_using\\_mobile\\_telephony](https://www.researchgate.net/publication/228847978_Remote_controlling_of_home_appliances_using_mobile_telephony)

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93 of 112 passages

Student passage FLAGGED

...devise at home. This system involves two mobile phone, one computer and X10 Active Home Pro system as hardware components. With the help of X10 technology it is easy...

Top web match

Description of the Prototype: The prototype implementation involves two mobile phones, one computer and X10 Active Home Pro system as hardware components. The

(PDF) Remote controlling of home appliances using mobile telephony [https://www.researchgate.net/publication/228847978\\_Remote\\_controlling\\_of\\_home\\_appliances\\_using\\_mobile\\_telephony](https://www.researchgate.net/publication/228847978_Remote_controlling_of_home_appliances_using_mobile_telephony)

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94 of 112 passages

Student passage FLAGGED

...M. M. J. C. B. G. B. B., 2020. Design and simulation of an automatic room heater control system. *Heliyon*, 6(9).

Top web match

This paper presents the design and simulation of an Automatic Room Heater Control system. This system allows the user to set a desired temperature which is then compared to the room temperature...

Design and simulation of an automatic room heater control system ... <https://www.sciencedirect.com/science/article/pii/S2405844018304602>

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95 of 112 passages

Student passage FLAGGED

Bilal Ghazal, K. A.-K., 2015. Smart Home Automation System for Elderly, and Handicapped People using XBee. s.l., International Journal of Smart Home.

Top web match

**Smart Home Automation System for Elderly, and Handicapped People using XBee.**

[PDF] Smart Home Automation System for Elderly, and Handicapped ... <https://www.semanticscholar.org/paper/5fca301fffa35a15d337ba10a3c9f8870264b>

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96 of 112 passages

Student passage FLAGGED

by M. Poongothai, K. S. B. V. P., 2018. **Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant.** International Journal of Computer Applications, Volume 182.

[Top web match](#)

**Implementation of IoT based Intelligent Voice Controlled Laboratory using Google Assistant.** September 2018; International Journal of Computer Applications 182(16):6-10.

(PDF) Implementation of IoT based Intelligent Voice Controlled ... [https://www.researchgate.net/publication/327722894\\_Implementation\\_of\\_IoT\\_based\\_Intelligent\\_Voice\\_Controlled\\_Laboratory\\_using\\_Google\\_Assistant](https://www.researchgate.net/publication/327722894_Implementation_of_IoT_based_Intelligent_Voice_Controlled_Laboratory_using_Google_Assistant)

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97 of 112 passages

Student passage FLAGGED

crist, 2019. **7 things to know about smart lights before you buy a boatload of them.** cnet, 15 9.

[Top web match](#)

**7 things to know about smart lights before you buy a boatload of them.** BSD Research Team. November 27, 2019. Views 0. SaveSavedRemoved 0. From light bulbs and sticks to light switches and wall panels,...

7 things to know about smart lights before you buy a boatload of them <https://bestshoppingdiscounts.com/7-things-to-know-about-smart-lights-before-you-buy-a-boatload-of-them/>

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98 of 112 passages

Student passage FLAGGED

Dangi, N., 2017. **Monitoring environmental parameters: humidity and temperature using Arduino based microcontroller and sensors.** Helsinki Metropolia University of Applied Sciences.

[Top web match](#)

**Monitoring environmental parameters: humidity and temperature using Arduino based microcontroller and sensors** : Microcontroller based building monitoring system.

Monitoring environmental parameters: humidity and ... - Theseus <https://www.theseus.fi/handle/10024/142235>

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99 of 112 passages

Student passage FLAGGED

Eveline Otte im Kampe, S. K. S. H., 2015. **Impact of high ambient temperature on unintentional injuries in high-income countries.** BMJ, 6(2).

[Top web match](#)

**Impact of high ambient temperature on unintentional injuries in high-income countries:** a narrative systematic literature review Impact of high ambient temperature on unintentional injuries in...

Impact of high ambient temperature on unintentional injuries in high ... <https://pubmed.ncbi.nlm.nih.gov/26868947/>

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100 of 112 passages

Student passage FLAGGED

Froese, M., 2018. **Global IoT market to reach \$318 billion by 2023, says GlobalData.** windpower engineering, 19 11.

[Top web match](#)

**Global IoT market to reach \$318 billion by 2023, says GlobalData.** November 19, 2018. By Michelle Froese The global market for Internet of Things (IoT) technology, which consists of software, services,...

Renewable Energy News / Global IoT market to reach \$318 billion ... <http://www.renewanews.com/global-iot-market-to-reach-318-billion-by-2023-says-globaldata/>

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101 of 112 passages

Student passage FLAGGED

Haris Isyanto, A. S. A. M. S., 2020. **Design and Implementation of IoT-Based Smart Home Voice Commands for disabled people using Google Assistant.** s.l., IEEE.

[Top web match](#)

**Design and implementation of IoT-based smart home voice commands for disabled people using Google Assistant** ieee conference publication ieee xplore Design and implementation of IoT-based smart home...

Design and Implementation of IoT-Based Smart Home Voice ... <https://ieeexplore.ieee.org/abstract/document/9070344/>

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102 of 112 passages  
 Student passage FLAGGED

Kundan Ghosh, M. B. D. J., 2018. **Globally controlled multiple relays using NODE MCU.** s.l., RCC INSTITUTE OF INFORMATION TECHNOLOGY.

Top web match

"**Globally controlled multiple relays using NODE MCU.**" PhD diss., University of Technology, 2018. ThingSpeak-an API and Web Service for the Internet of Things.

Design and implementation of monitoring and warning (IOT) system

... [https://www.researchgate.net/publication/342610000\\_Design\\_and\\_implementation\\_of\\_monitoring\\_and\\_warning\\_IOT\\_system\\_for\\_electricity\\_poles](https://www.researchgate.net/publication/342610000_Design_and_implementation_of_monitoring_and_warning_IOT_system_for_electricity_poles)

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103 of 112 passages  
 Student passage FLAGGED

Lueth, K. L., 2018. **State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating.** IOT analytics, 8 8.

Top web match

**State of the IoT 2018: number of IoT devices now at 7B -- market accelerating** Log In

State of the IoT 2018: Number of IoT devices now at 7B – Market ... <https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/>

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104 of 112 passages  
 Student passage FLAGGED

Marcus, S., 2020. **What's the ideal room temperature for your home?** ovoenergy, 23 12.

Top web match

**What's the ideal room temperature for your home? OVO energy OVO Beyond**

What's the ideal room temperature for your home? | OVO Energy <https://www.ovovenergy.com/guides/energy-guides/average-room-temperature.html>

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105 of 112 passages  
 Student passage FLAGGED

Mizuno, K. O.-M. & K., 2012. **Effects of thermal environment on sleep and circadian rhythm.** BMC.

Top web match

**Effects of thermal environment on sleep and circadian rhythm Resources**

Effects of thermal environment on sleep and circadian rhythm <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3427038/>

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106 of 112 passages  
 Student passage FLAGGED

news, i. b., 2020. **The Installed base of smart street lights to surpass 30 million worldwide by 2023.** IoT business news, 3 1.

Top web match

**IoT news - the installed base of smart street lights to surpass 30 million worldwide by 2023 - IoT business news General IoT News**

IoT News - The installed base of smart street lights to surpass 30 ... <https://iotbusinessnews.com/2020/01/03/19747-the-installed-base-of-smart-street-lights-to-surpass-30-million-worldwide-by-2023/>

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107 of 112 passages  
 Student passage FLAGGED

...P. T. L. D. H. N. D. T., 2019. **Development and implementation of Smart Street Lighting System based on Lora Technology.** s.l., IEEE.

Top web match

**Development and implementation of Smart Street Lighting System based on Lora Technology.** Abstract: This paper concerned with the development and implementation of smart street lighting control system...

Development and implementation of Smart Street ... - IEEE Xplore <https://ieeexplore.ieee.org/document/8921028>

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108 of 112 passages  
 Student passage FLAGGED

...R. A. , M. N. , A. B., 2016. **A literature review on the improvement strategies of passive design for the roofing system of the modern house in a hot and humid climate region.** scipedia, Volume 5.

Top web match

**A literature review on the improvement strategies of passive design for the roofing system of the modern house in a hot and humid climate region.**

(PDF) A literature review on the improvement strategies of passive ... <https://www.researchgate.net/publication/284806515> A literature review on the improvement strategies of passive design for the roofing system of the modern

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109 of 112 passages  
Student passage FLAGGED

Ranger, S., 2020. **What is the IoT? Everything you need to know about the Internet of Things right now.** zdnet, 3 2.

Top web match

**What is the IoT? Everything you need to know about the Internet of Things right now** ZDNet Search

What is the IoT? Everything you need to know about the Internet of ... <https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/>

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110 of 112 passages  
Student passage FLAGGED

...Shahriyar, E. H. S. M. S. I. N., 2008. **Remote controlling of home appliances using mobile telephony.** International Journal of Smart Home, Volume 2.

Top web match

**Remote controlling of home appliances using mobile telephony.** August 2008; International Journal of Smart Home 2(3). Authors: Rifat Shahriyar at Bangladesh University of Engineering and Technology.

(PDF) Remote controlling of home appliances using mobile telephony <https://www.researchgate.net/publication/228847978> Remote controlling of home appliances using mobile telephony

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111 of 112 passages  
Student passage FLAGGED

Seed Faroom, M. N. A. S. Y., 2018. **Literature Review on Home Automation system for Physically disabled Peoples.** s.l., IEEE.

Top web match

**Literature review on home automation system for physically disabled peoples.** Abstract: Generally the Art of controlling the home appliances automatically & sometimes remotely is called home automation...

Literature review on home automation system for ... - IEEE Xplore <https://ieeexplore.ieee.org/document/8346397>

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112 of 112 passages  
Student passage FLAGGED

...Syazanna Raf', M. S. L. N. A. Z., 2018. **Thermal Insulation of Residential Construction through the Study of Temperature Difference of bricks.** MATEC Web of Conferences.

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**Thermal Insulation of Residential Construction through the Study of Temperature Difference of Bricks.** ... Comparing the temperature differences of IB1 and Clay brick, IB1 provide a better performance...

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