ESP-8266 & Sensor Network Based Smart Home Automation

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APPROVAL

This thesis titled on "**IoT sensor network based home automation module development.**", submitted by **Mobinul Islam Riyadh (ID: 172-35-2114s)** to the Department of Software Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Software Engineering and approval as to its style and contents.

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DECLARATION

I hereby declare that this report is my original work for the Bachelor of Software Engineering program, and it is written by me under the supervision of Kaushik Sarker, Associate Professor & Associate Head, Department of Software Engineering, Daffodil International University. I also declare that this report is unique and has not been submitted elsewhere for the award of to any degree.

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Finally, I must acknowledge with due respect the constant support and patience of our parents.

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ABSTRACT

Home automation has gained a lot of popularity in present time. Life is getting more and more convenient with every advancement in this technology. Now almost everything can be digitalized with automation using this technology. Integrating IoT many sensor data can be accessed via internet from anywhere in the world. For safety and security possibilities of this technology is endless. For example, we can connect some sensor such as, smoke sensor, flame sensor, temperature sensor to esp-8266 and connect to the internet. Now we can monitor that environment from anywhere of the world.

Lots of great mind contributing their time and effort for its development. For this there are many open source software and code are available on the internet.

By using image recognition, we can take this to the next level. After that this system will be able to recognize friends and foe.

Keywords: Node MCU ESP-8266, Esp-32 Cam, Raspberry pi, Sensor network, Sensors, Home automation.

CHAPTER 1
INTRODUCTION

1. INTRODUCTION

1.1. Background

Today almost every aspect of our life is inter connected with digital devices. Technologies are evolving rapidly. Most of those technologies evolving for betterment, make safe and secure and easy for a human life. IoT is one of those technologies. Using this technology, we are automating a lot of tasks. One of those automation is home automation system. By creating sensor network and using actuators we can control our appliances. By using sensors, we can get data relating to the room environment from other side of the world. Also, if there any danger in that environment we can get notified. Thus, it provides security.

1.2. Motivation of the Research

- Make contribution to improvement the existing technology.
- Make a cluster of multiple sensors connected in a same network to gather, process and display information's.
- Find a much cheaper but effective way.

1.3. Objective

- Gather multiple sensor data.
- Feed those data into the microcontroller.
- Access those data through internet.
- Make an environment smart to understand its condition.
- Make a human life more safe and secure.

1.4. Scope of this Project

- It has to collect all kinds of sensor data using installed sensors.
- It has to feed those data in to ESP-8266 Node MCU for further processing.
- It has to upload data to the internet server to access it from anywhere from the world.
- User has to see those data real time.
- User could take actions according to and by using actuators Node has to perform respective task.

1.5. Methodology

The method used in designing and constructing that sensor network is based on the operational characteristics and features of the Node MCU ESP-8266 microcontroller, various sensor and modules along with programming the microcontroller.

1.6. Block Diagram

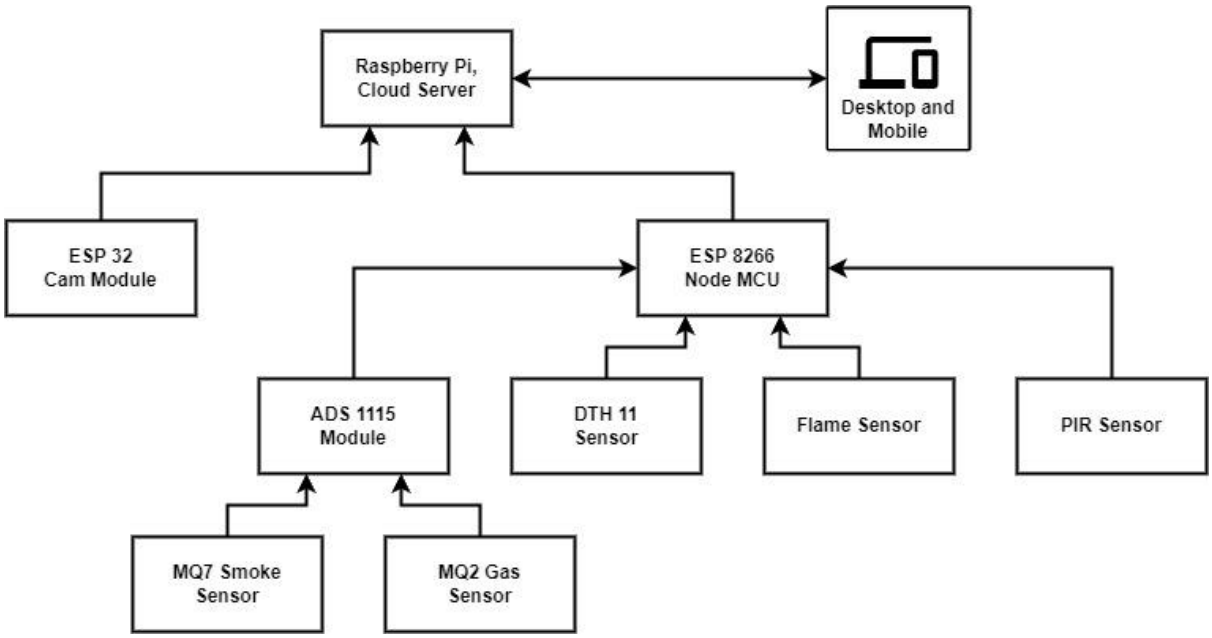


Figure 1: Block Diagram.

CHAPTER 2
LITERATURE REVIEW

2. LITERATURE REVIEW

2.1. Background

In this fast-evolving world a home or office space should also get evolve to its modern form. For this we must integrate technologies to it. It will make a user's life convenient and safe. Lots of great mind of this world are trying to improve this technology thus contributing great researches to the community. Some of that researches are explored in this report and providing below.

2.2. Literature Review

Table 1: Literature Review

sl	Author	Paper	Method	Year	Lacking's
1	G. Joga Rao, A. Vinod, N. Priyanka, Ch. Siva Hari Kumar	IoT Based Web Controlled Home Automation Using Raspberry Pi	Raspberry Pi, Sensors.	2019	Complex to expand.
2	Waheb A. Jabbar, Tee Kok Kian, Roshahliza M. Ramli, Siti Nabila Zubir	Design and Fabrication of Smart Home with Internet of Things Enabled Automation System	ESP Module, Sensors.	2017	Lack of modularity.
3	Padmavathi Kora, Meenakshi Kollati, K. Swaraja, G. Karuna	GSM Based Face Recognition Using Pir Sensor on Raspberry Pi 3	Raspberry Pi, GSM Module.	2019	GSM network bandwidth, signal strength.
4	Surinder Kaur, Rashmi Singh, Neha Khairwal, Pratyk Jain	Home Automation and Security System	GSM, Arduino.	2016	GSM Network Bandwidth, Arduino's processing power.
5	Mayuri Dahake, N. N. Mandaogade	Implementation of Raspberry Pi Human Face Detection & Recognition	Pixel Based Face Recognition, Open CV.	2017	More frames iteration are increase resulting slow System speed.

6	G. Senthilkumar, K. Gopalakrishnan, V. Sathish Kumar	Embedded Image Capturing System Using Raspberry Pi System	Eigen Face Methodology of Face Recognition, Principal Component Analysis	2014	Slow system speed
7	Cristina Stolojescu-Crisan, Calin Crisan, Bogdan-Petru Butunoi	An IoT-Based Smart Home Automation System	Raspberry Pi, ESP Development Board, Bluetooth Technology, Arduino.	2021	Complex Design, Expensive to implement.
8	Mohammed El-hajj, Ahmad Fadlallah, Maroun Chamoun, Ahmed Serhrouchni	A Survey of Internet of Things (IoT) Authentication Schemes	Security, Communication Protocol, Data Encryption.	2019	I Find None.
9	Milo Spadacini, Stefano Savazzi, Monica Nicoli	Wireless home automation network for indoor surveillance: technologies and experiments	Wireless Protocol, Signal Wave & strength.	2014	Old Technologies.
10	Ivan Froiz-Miguez, Taigo M. Fernandez-Carames, Paule Fraga-Lamas, Luis Castedo	Design, Implementation And Practical Evaluation of an IoT Home Automation System	MQTT, ZigBee-WiFi Sensor node.	2018	Expensive to implement, Complex Design.

CHAPTER 3
PARTS & TESTING

3. PARTS

3.1. Approach

I was able to perform detailed research of their capabilities, the microcontroller Node MCU ESP-8266 and sensors (PIR sensor, flame sensor, gas sensor MQ-02 and MQ-07, temperature & humidity sensor DHT11), Modules ADC-1115 and Esp-32 cam module. Microcontroller uses C and C++ programming language. Means by using this language we can develop applications to work on this platform.

ESP-8266 and ESP-32 cam modules has its build in Wi-Fi to connect to a network.

Is has limited number of analog input pins for that we have to use ADC1115 module to increase its analog input pins.

Sensors need separate and regulated voltage source for noise reduction and proper functionalities.

We need multiple voltage range (3.7v, 5v, 6v) for different sensors and modules. Buck converter can be used to achieve those voltage levels.

For prototyping I used breadboard and jumper wire to connect all those modules.

For programming the microcontroller, I have used Arduino IDE. But to use Node MCU ESP-8266 first I have to install Adafruit ESP library.

3.2. Components Study

Components used in this prototype are shown below with their functionalities and test codes.

3.2.1. Micro-Processors

Raspberry Pi

Fig-2: Raspberry Pi 3.

3.2.2. Micro-Controllers

a. Node MCU ESP-8266

NodeMCU stands for Node Micro-Controller Unit. It is an open-source hardware and software development platform build around a low-cost System-on-a-chip (SoC) called ESP8266. This chip is designed and manufactured by Espressif Systems. This chip contains key elements of a computer such as CPU, RAM, Networking (Wi-Fi) and also a modern OS and SDK. Which make it an excellent candite for Inter of Things (IoT) projects of every kind.

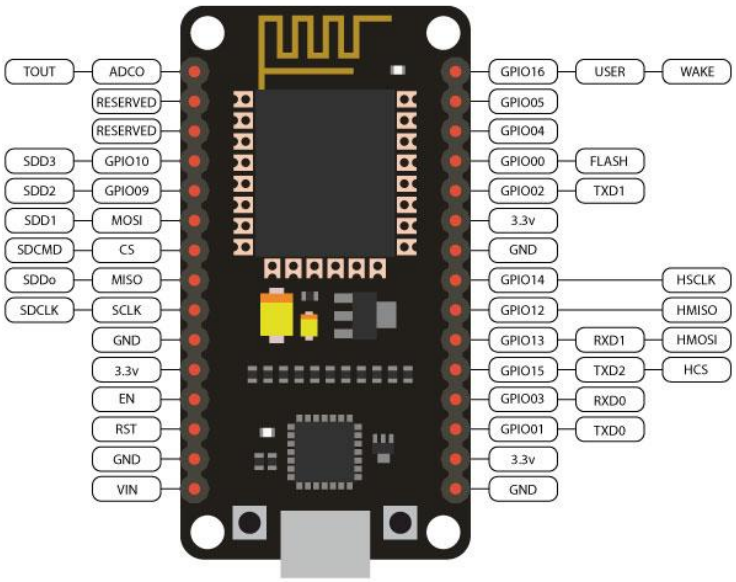


Fig-3: Node MCU ESP-8266

There is two version available for this Node 0.9 which contains ESP-12 and other 1.0 which contains ESP-12E where E stands for 'Enhanced'. For this project I am using 0.9 version. Feature of this version is given below in table.

Table 2: Node MCU ESP8266

Microcontroller	ESP-8266 32-bit
Node MCU Model	Amica
Node MCU Size	49mm * 26mm
Carrier Board Size	102mm * 51mm
Clock Speed	80MHz
USB to Serial	CP2102
USB Connector	Micro USB
Operating Voltage	3.3v
Input Voltage	4.5v to 10v
Flash Memory/SRAM	4MB / 64 KB
Digital I/O Pins	11
Analog I/O Pins	1
ADC Range	0 to 3.3v
Wi-Fi Built in	802. 11 b/g/n
Operating Temperature	-40^0C to 155^0C

Clock Speed: It refers to the operating speed of processor/ microcontrollers expressed in cycles per second. This micro-controller runs at 80MHz.

Flash Memory: This is a non-volatile storage chip that stores data even when the power is off. ESP-8266 has 4 Mega Byte of flash memory.

SRAM: Stands for Static Random Access Memory that retains data in its memory as long as power is on.

Digital I/O Pins: I/O means Input and Output. Digital inputs allow to detect a logic state and output a logic state. This Node has 11 Digital I/O pins.

Analog I/O Pins: This Node has only one Analog I/O pin.

b. ESP-32 CAM

ESP-32-CAM is a development board based on esp-32 chip. It has built in Wi-Fi and Bluetooth. It can process independently as an individual system. It is fully compatible with Wi-Fi 802.11b/g/n/e/I, and Bluetooth 4.0. For its features it is widely used for IoT projects.

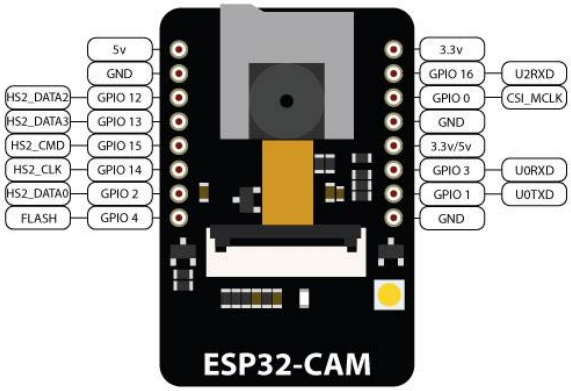


Fig-4: ESP-32 CAM Module.

Table 3: ESP32 Cam

Microcontroller	ESP-32
SPI Flash	32Mbit
RAM	Internal 520KB + External 4M PSRAM
Bluetooth	4.0
Image Output Format	JPEG, BMP, GRAYSCALE
Serial Port Rate	115200 bps
Antenna	PCB Antenna
Operating Voltage	3.3v
Input Voltage	3.3v to 5v
Spectrum Range	2412 ~ 2484 MHz
I/O Port	9
Operating Temperature	-20^0C to 85^0C

Features: It has many features such as,

- Low power dual-core 32-bit CPU.
- Support for image Wi-Fi uploads.
- Supports TF card.
- Support secondary development.
- Support serial and remote firmware update.
- Built in 520KB SRAM.
- Supports STA/AP/STA+AP working mode.

c. ADS-1115

It is use for those micro-controllers which has no analog-to-digital converter such as raspberry pi or need extra ADC I/O such as in case of ESP-8266 or need higher-precision ADC. It supports both python library for raspberry pi and Arduino library for Arduino.

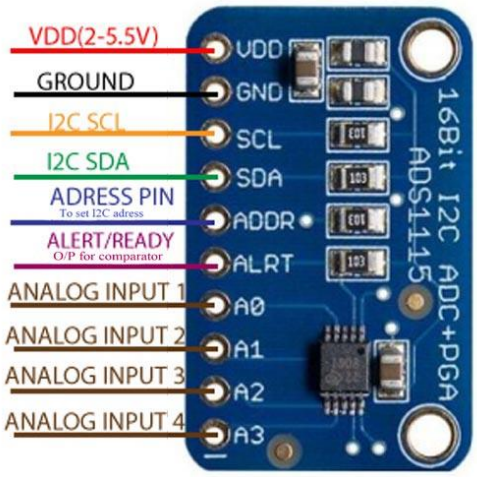


Fig-5: ADC 1115 Module.

Specifications:

- Wide power supply range: 2.0v to 5.5v.
- Low current consumption.
- Auto shutdown.
- Programmable data rate: 8-SPS to 860-SPS.
- Internal oscillator.
- I2C interface.
- 4 channel ADC.

3.2.3. Sensors

a. DHT 11

DHT11 sensor module is widely used as temperature and humidity sensor.it has a dedicated NTC t measure temperature. It has an 8-bit microcontroller that outputs the value of temperature and humidity as serial data.

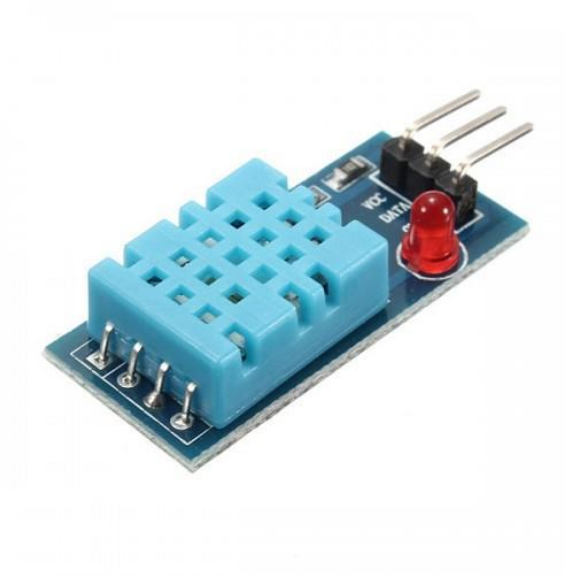


Fig-6: DHT11 Sensor Module.

Table 4: DHT11

1	VCC	Power supply 3.5v to 5.5v
2	Data	I/O
3	Ground	Connect to the ground

DHT11 Specifications:

- Temperature range 0°C to 50°C.
- Humidity range 20% to 90%.
- Temperature and humidity are both 16-bit
- Outputs serial data.
- Accuracy ±1oC and ±1%.

[

b. Flame Sensor

This module is sensitive to the flame and radiation. It also can detect ordinary light source in the range of a wavelength of 760nm to 1100nm. This module can output both analog and digital signal as output. It is widely used in fire alarm

This module is sensitive to the flame and radiation. It also can detect ordinary light source in the range of a wavelength of 760nm to 1100nm. This module can output both analog and digital signal as output. It is widely used in fire alarm.

Specifications:

- Detects flame or a light source of a wavelength in the range or 760nm to1100nm.
- Adjustable detection range.
- Operating distance 20cm (4.8v).
- Has both analog and digital I/O.
- Operating voltage 3.3v to 5v.
- Chip used LM393.

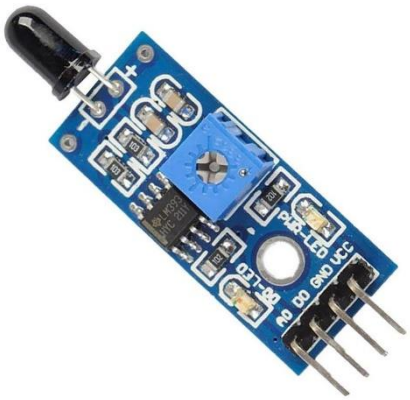


Fig-7: Flame sensor.

c. MQ-02

MQ-02 sensor is highly sensitive to Hydrogen, LPG, Methane and other combustible gases. For its cheap cost and simple drive circuit and effectiveness it is widely used in Domestic, industrial and portable gas detection applications.

Fig-8: MQ-02 sensor.

Specifications:

- Detects LPG, Methane, Hydrogen.
- Adjustable detection range.
- Has both analog and digital I/O.
- Operating voltage 3.3v to 5v.
- Chip used LM393.

d. MQ-07

MQ-07 sensor is highly sensitive to Carbon Monoxide (CO) and has fast response time. It can sense approximate 100ppm to 10000ppm in the air.

Fig-9: MQ-07 sensor.

Specifications:

- Detects CO gas.
- Adjustable detection parameter.
- Has both analog and digital I/O.
- Operating voltage 5v.
- Detecting range 100ppm to 10000ppm.

e. PIR Sensor

Everything emits some level of radiation and the hot things emits more radiation. PIR sensor can detect levels of infrared radiation. Full form is Passive Infrared Sensor.

Fig-10: PIR sensor.

Specifications:

- Detection Angle <140°.
- Distance 3m to 7m.
- I/O Digital.

f. Breadboard

This Board has holes connected internally row and column wise. This is used for prototyping test circuits. Here I used this board to insert all the modules and sensors for wiring.

Fig-11: Breadboard.

g. Jumper wire

This is called jumper wires. It is used to connect multiple electronic parts together to mimic the wiring. For prototyping circuits, it is widely used. Here I used them in a breadboard to wire all the modules and sensors.

Fig-12: Jumper Wire.

h. Power Supply

This is an external power supply for powering electronics. It converts mains AC 220v to DC 12v. There are many versions available for power supply. I used this type of power supply because for my prototype I need 12v voltage source.

Fig-13: Power Supply.

CHAPTER 4
ASSEMBLING

4. PROCEUDRE

4.1. Circuit Diagram

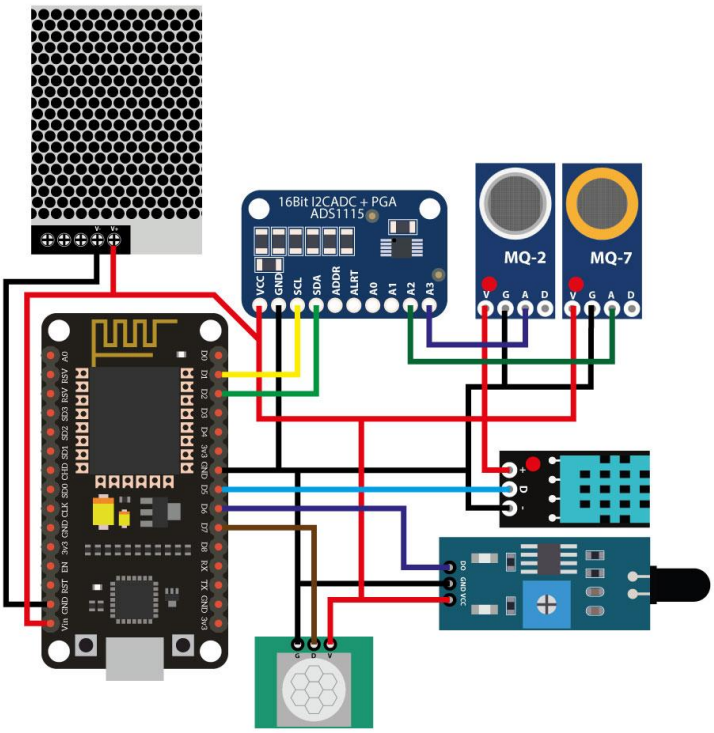
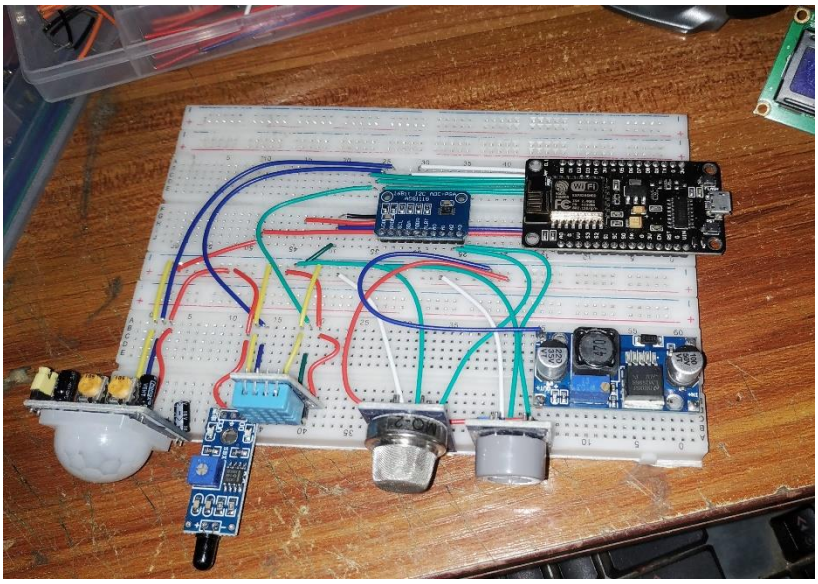


Fig-14: Circuit Diagram.

4.2. Assembled Prototype



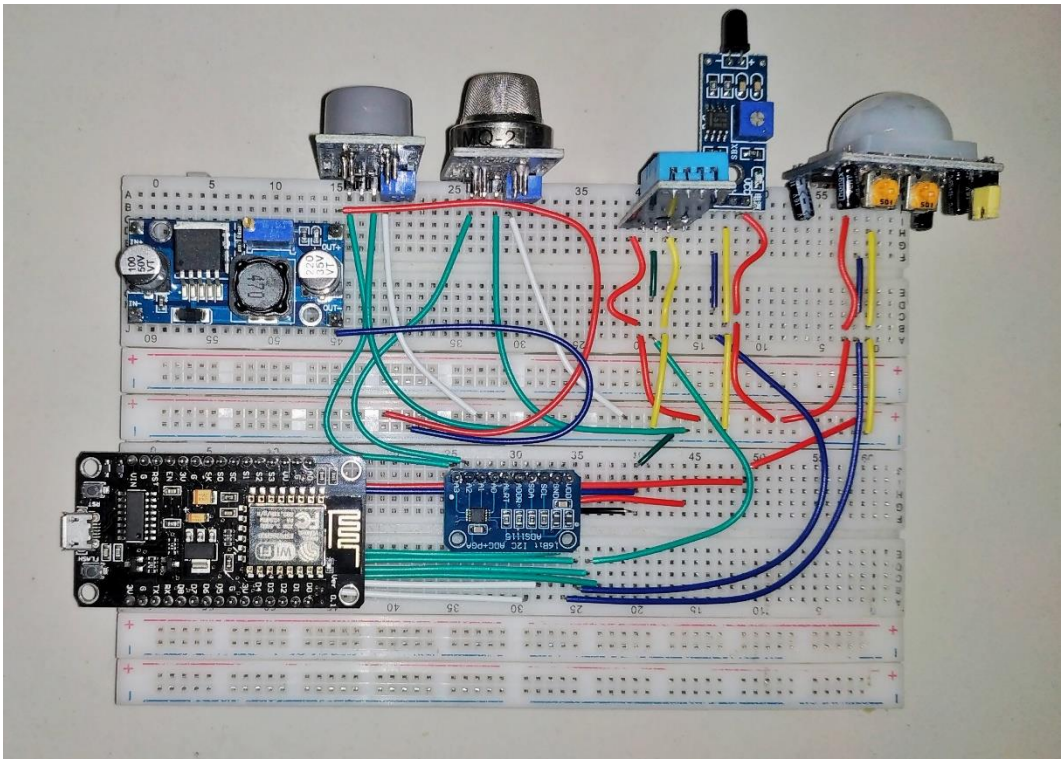


Fig-15: Prototype.

4.3. Learning Experience

In this prototype building process I have learned a lot of things. A lot of problem arises, for that I had to redesign the wiring. Found some components is not compatible with Node MCU ESP-8266. Learned some new trouble shooting technique and many more things.

CHAPTER 5
RESULT AND DISCUSSION

5. RESULT & DISCUSSION

5.1. Result and Discussion

This is the blynk app installed in my phone receiving sensor data from the esp8266 sensor network. Here we can see multiple segments shows multiple sensor data. Currently 1 sensor showing 27 degrees and PIR sensor sowing present but other sensor shows no data because there isn't any harmful gas or flame present in my environment.

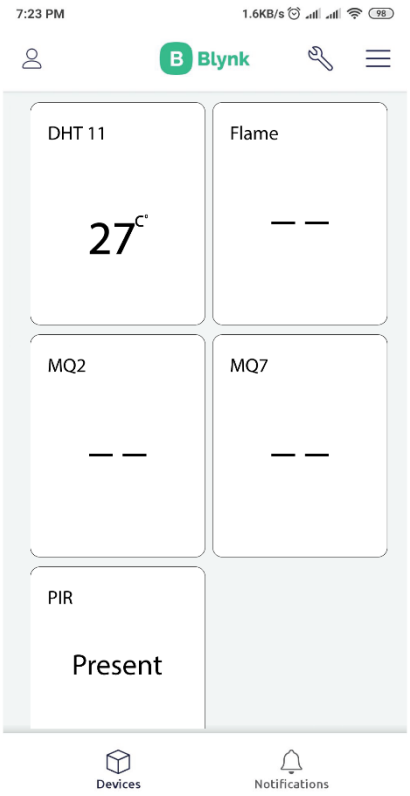


Fig-16: Output from blynk app.

CHAPTER 6
CONCLUSION

6. CONCLUSIONS & COMMENDTINS

6.1. Conclusion

- By using this sensor network a user can collect all the data of his/her home from anywhere of the world.
- User can maintain security of his home.
- Safety factor increased.
- user can control some aspect of his home remotely and much more.

6.2. Future Works

This is just a prototype so it could be modified and improved in many ways. We use multiple modules to create this but in future we can create a single circuit board (PCB) where all the components can be soldered. It will reduce its cost. More sensors can be added. Network topology is now star topology but we can try different topologies like hybrid. It will increase its reliability.

6.3. References

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6.4. Comment

Some of this document's photo is collected from the internet for better resolution. And the test code is from Arduino IDEs built-in libraries.

Appendix A

Test code for ESP8266 to display all the available networks

```
#include "ESP8266WiFi.h"
void setup() {
  Serial.begin(115200);
  WiFi.mode(WIFI_STA);
  WiFi.disconnect();
  delay(100);
  Serial.println("Setup Complete");
}
void loop() {
  Serial.println("Scan Started");
  int n = WiFi.scanNetworks();
  Serial.println("Scan Complete");
  if (n == 0)
    Serial.println("No Networks Found");
  else{
    Serial.print(n);
    Serial.println(" Networks Found");
    for (int i = 0; i < n; ++i) {
      Serial.print(i + 1);
      Serial.print(": ");
      Serial.print(WiFi.SSID(i));
      Serial.print(" (");
      Serial.print(WiFi.RSSI(i));
      Serial.print(")");
      Serial.println((WiFi.encryptionType(i) == ENC_TYPE_NONE)?" ":"*");
      delay(10);
    }
  }
```

```
 Serial.println("");
 delay(5000);
}
```

Appendix B

Test code for DHT11

```
#include "DHT.h"
 DHT dht2(2,DHT11);
 void setup(){
  Serial.begin(9600);
 }
 void loop(){
   Serial.println("Temperature in C:");
   Serial.println((dht2.readTemperature( )));
   Serial.println("Humidity in C:");
   Serial.println((dht2.readHumidity()));
   delay(1000);
 }
```

Appendix C

Test code for Flame sensor

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
int LED = D2;
int RELAY = D4;
int Flame_sensor = D1;
int Flame_detected;
BlynkTimer timer;
char auth[] = "jovd0wly3APhqOwX6XJzwN4j0m6wpTwR"; //Auth code sent via Email
char ssid[] = "Alsan";
char pass[] = "12345678";
```

```
void notifyOnFire(){
  Flame_detected = digitalRead(Flame_sensor);
  Serial.println(Flame_detected);
  if (Flame_detected == 0) {
    Serial.println("Flame detected...! take action immediately.");
    Blynk.notify("Alert : Fire detected...! take action immediately.");
    digitalWrite(LED, HIGH);
    digitalWrite(RELAY, LOW);
    delay(500);
  }
  else{
    Serial.println("No Fire detected. stay cool");
    digitalWrite(LED, LOW);
    digitalWrite(RELAY, HIGH);
  }
}
void setup(){
  Serial.begin(115200);
  Blynk.begin(auth, ssid, pass);
  pinMode(LED, OUTPUT);
  pinMode(RELAY, OUTPUT);
  digitalWrite(RELAY, HIGH);
  pinMode(Flame_sensor, INPUT_PULLUP);
  timer.setInterval(1000L, notifyOnFire);
}
void loop(){
  Blynk.run();
  timer.run();
}
```

Appendix D

Test code for MQ02 and MQ07 sensor

```
int Buzzer = D2;
int Gas_analog = A0;
int Gas_digital = D1;
void setup() {
  Serial.begin(115200);
  pinMode(Buzzer, OUTPUT);
  pinMode(Gas_digital, INPUT);
}
void loop() {
  int gassensorAnalog = analogRead(Gas_analog);
  int gassensorDigital = digitalRead(Gas_digital);
  Serial.print("Gas Sensor: ");
  Serial.print(gassensorAnalog);
  Serial.print("\t");
  Serial.print("Gas Class: ");
  Serial.print(gassensorDigital);
  Serial.print("\t");
  if (gassensorAnalog > 1000) {
    Serial.println("Gas");
    digitalWrite (Buzzer, HIGH) ; //send tone
    delay(1000);
    digitalWrite (Buzzer, LOW) ;  //no tone
  }
  else {
    Serial.println("No Gas");
  }
  delay(100);
}
```

Appendix E

Test code for PIR sensor

```
int Status = 12;
int sensor = 13;
void setup() {
  pinMode(sensor, INPUT);
  pinMode(Status, OUTPUT);
}
void loop() {
  long state = digitalRead(sensor);
    if(state == HIGH) {
      digitalWrite (Status, HIGH);
      Serial.println("Motion detected!");
      delay(1000);
    }
    else {
      digitalWrite (Status, LOW);
      Serial.println("Motion absent!");
      delay(1000);
      }
}
```

Appendix F

Version 1 code for the prototype

```
#include "ESP8266WiFi.h"
#include "DHT.h"
DHT dht2(2,DHT11);
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
```

```
void setup() {
pinMode(sensor, INPUT);
  pinMode(Status, OUTPUT);
  Serial.begin(115200);
  Blynk.begin(auth, ssid, pass);
  pinMode(LED, OUTPUT);
  pinMode(RELAY, OUTPUT);
  digitalWrite(RELAY, HIGH);
  pinMode(Flame_sensor, INPUT_PULLUP);
  timer.setInterval(1000L, notifyOnFire);
  Serial.begin(115200);
  WiFi.mode(WIFI_STA);
  WiFi.disconnect();
  delay(100);
  Serial.println("Setup Complete");
}

void loop() {
long state = digitalRead(sensor);
    if(state == HIGH) {
      digitalWrite (Status, HIGH);
      Serial.println("Motion detected!");
      delay(1000);
    }
    else {
      digitalWrite (Status, LOW);
      Serial.println("Motion absent!");
      delay(1000);
  int gassensorAnalog = analogRead(Gas_analog);
  int gassensorDigital = digitalRead(Gas_digital);
  Serial.print("Gas Sensor: ");
```

```
  Serial.print(gassensorAnalog);
  Serial.print("\t");
  Serial.print("Gas Class: ");
  Serial.print(gassensorDigital);
  Serial.print("\t");
  if (gassensorAnalog > 1000) {
    Serial.println("Gas");
    digitalWrite (Buzzer, HIGH) ; //send tone
    delay(1000);
    digitalWrite (Buzzer, LOW) ;  //no tone
  }
  else {
    Serial.println("No Gas");
  }
  delay(100);
Serial.println("Temperature in C:");
   Serial.println((dht2.readTemperature( )));
   Serial.println("Humidity in C:");
   Serial.println((dht2.readHumidity()));
   delay(1000);
  Serial.println("Scan Started");
  int n = WiFi.scanNetworks();
  Serial.println("Scan Complete");
  if (n == 0)
    Serial.println("No Networks Found");
  else{
    Serial.print(n);
    Serial.println(" Networks Found");
    for (int i = 0; i < n; ++i) {
      Serial.print(i + 1);
      Serial.print(": ");
```

```
    Serial.print(WiFi.SSID(i));
    Serial.print(" (");
    Serial.print(WiFi.RSSI(i));
    Serial.print(")");
    Serial.println((WiFi.encryptionType(i) == ENC_TYPE_NONE)?" ":"*");
    delay(10);
   }
  }
  Serial.println("");
  delay(5000);
}
```

N.B: This code has some bugs. Those will be fixed in the later versions.

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