IoT-based Smart Home System

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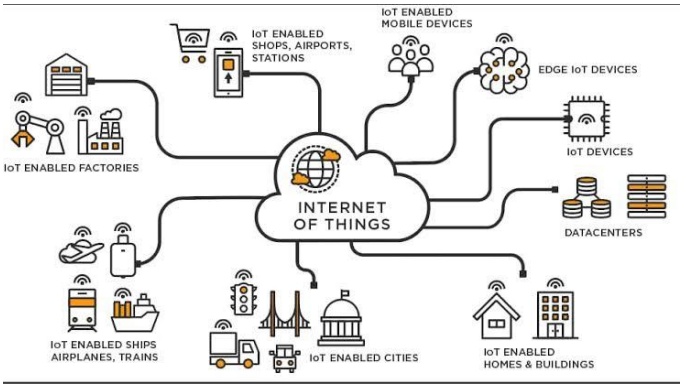
Abstract* — Nowadays, fire incidents have become a critical issue, which must be dealt on time without any unnecessary delay to avoid the loss of lives and belongings. In critical places such as hospitals, schools, and banks, personnel's arrival time to come for help in fire hazards is around 15 minutes. The statistics shows that there are 475,500 structural fires annually in the world, causing 2,950 civilian deaths, 12,775 civilian injuries, and $7.9 billion in property damage. According to the National Fire Protection Association (NFPA), two-third of household fires occurs in premises with no working smoke alarms, alarms with no proper maintenance, or misplaced alarms. The appropriate allocation of fire alarms with a proactive warning could save lives and reduce property losses. This system is a very cost-effective and efficient method for controlling the disaster, and it sends the data to the cloud so that it can be visible anywhere through internet. The Internet of Things (IoT) is the technology used in developing the proposed system, which is an efficient and advanced method for connecting the sensors to the cloud which can store real-time sensor data and connect the entire world of things in a network. The design and development of Smart home system are covered in this paper. With the use of a temperature & humidity sensor we can get to know the real time value of temperature and humidity. With the use of a flame sensor, we can monitor the presence or absence of flame. With the use of a gas sensor, we can detect the real time percentage of gas. This technology will collect all the real time data and it will save into Blynk IoT Cloud where the user can access all the data with mobile application & with web dashboard.

Keywords—IoT, real time, Temperature & humidity Sensor, Flame Sensor, Gas Sensor, Node MCU ESP-8266, Blynk IoT.

I. Introduction

An IoT system contains smart devices which are connected to the internet and uses an embedded processor, sensors and communication hardware to save, transfer and perform an action on the data which they acquire from their surroundings.[1]



IoT devices transfer the sensor data which they receive from connecting the IoT gateway or another edge device where data is transferred to cloud for analysis or being analysed locally. Sometimes, these devices communicate with each other and take action according to the information collected from other devices.[2]

IoT devices can work without the help of people, although people can interact with the devices for performing tasks and getting more straightforward as well as accurate data, give them instructions or access the output.[3]

The Smart home system continuously monitors and measures the Temperature, flame and gas statuses. This data is stored, analysed in the cloud and that stored data can be accessed by using BlynkIoT with Mobile application as well as Web dashboard.[4]

Through the BlynkIoT application user will get to know the real time data. This system is efficient, accurate and simple to implement and use. The project will be beneficial mainly for the people to avoid and take effective measures against fire, gas leakage disasters and to monitor the real time data which occurs in their house or the place at which this system is installed [5]

The following are some of the main advantages of using the smart home system:

- Fire detection and alarming
- Smoke detection and extinction
- Monitoring temperature and humidity
- Easy to use

II. Literature Review

Smart Home System is a system which monitors the humidity, temperature, presence or absence of flame and gas in the home. Effective and cheap methods to monitor the quality of the air and prevent it from a potential hazard. The author collects the data from the app and analyses whether there is a potential disaster in his home or not.[1]

The embedded controller is designed to measure the temperature and humidity, presence of flame and gas in the home. The monitoring station sends the data through a wireless network on a web page. The monitored data is uploaded on the cloud. The sensors used are gas, flame, temperature, and humidity.[2]

The data is uploaded on the BlynkIoT. The system used by the author is accurate and precise as it uses the combination of DHT sensor, MQ2 and flame sensor which increases the accurateness at a greater extent and it reduces the chance of false alarm. The author accesses the result in the Blynk web and mobile platform. It uses ESP8226 board which has inbuilt WIFI module.[3]

The sensors used are infrared flame sensor, MQ2(gas sensor) and DHT 11(temperature and humidity sensor). The average accuracy in temperature measurement is +- 1%. The MQ2 sensor detects various gasses like methane, butane, LPG and smoke, The infrared flame sensor detects the light of wavelength between 760nm – 1100nm.[4]

The author works on Nodemcu which is also combined with different sensors like temperature, humidity, flame and gas. The main advantage of this work is that it is low cost and less power consumption. It is installed anywhere to monitor the flame or smoke disasters. The system helps the user take effective measures.[5]

This system automatically displays the temperature, humidity, flame status and gas/smoke levels, on specific webpage of IoT in BlynkIoT as well as in the android application.[6]

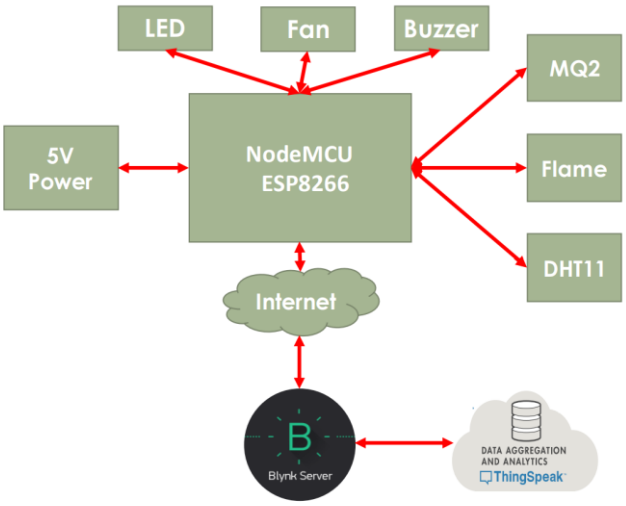
III. METHODOLOGY

This section explains, in detail, the various methods and techniques used to build this system.

A. System Architecture

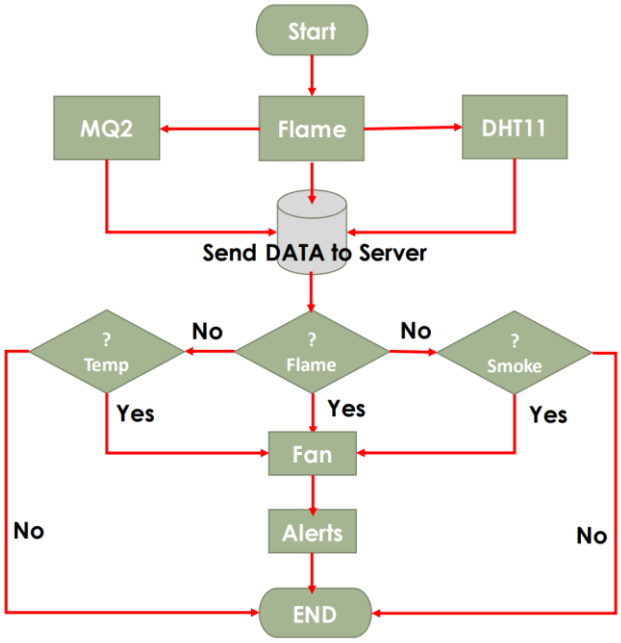
In this model, we use temperature & humidity sensor, flame sensor, gas/smoke sensor.

The sensed data is processed by the Node MCU and published to the cloud service i.e BlynkIoT. The data can be analysed with BlynkIot application by various graphical methods.[1]



B. Control Unit

- This project is proposed to implement the IoT technology as a communication medium in this project. As stated in the previous section. [1]
- The process of the system is start after the microcontroller ESP8266 configured all the sensor and start to read the data from the sensor.[2]
- Then, the data is analysed and sent to the IoT platform that is BlynkIoT via wireless communication by ESP8266 Wi-Fi network.[3]
- The sensors that connect to ESP8266 act as the data collectors of the system where all the data is collected here. [4]
- This system automatically displays the temperature, humidity, flame and gas statuses on specific webpage of IoT in BlynkIoT as well as in android application.[5]



Control unit flowchart.

IV. COMPONENTS USED AND ITS WORKING

Node MCU: The ESP8266 NodeMCU is a small microcontroller that has GPIOs and can connect to the Internet via WLAN. The ESP8266 is a System on a Chip (SoC), manufactured by the Chinese company Espressif. It has 11 GPIO pins* (General Purpose Input/Output pins), and an analogue input as well. It contains a built-in 32-bit low-power CPU, ROM and RAM. It is a complete and self-contained Wi-Fi network solution that can carry software applications as a stand-alone device or connected with a microcontroller (MCU). The module has built-in AT Command firmware to be used with any MCU via COM port. The ESP8266 can be flashed and programmed using the Arduino IDE.[1]

DHT 11: The DHT 11 is a humidity and temperature sensor which is used in weather and environment monitoring of data. This is a very efficient and cost-effective sensor. It is widely used in cheap sensor. Its supply voltage is +5 volt. It senses the temperature which is range from 0_0 C to 50_0 C which has chances of error +-1_0 C. It senses the humidity range from 20% to 90%. It is one of the sensors of DHT series. dht.read is one of the function of DHT and it is used for reading the humidity and temperature from the sensor. Where pin number is the digital pin number from which output of DHT sensor is to be read. [2]

MQ2: Operating Voltage is +5V. Can be used to Measure or detect LPG,Alcohol, Propane, Hydrogen, CO and even Methane. Analog output voltage: 0V to 5V. Digital Output Voltage: 0V or 5V (TTL Logic). Preheat duration 20 seconds. Can be used as a Digital or analog sensor. The Sensitivity of Digital pin can be varied using the potentiometer. [3]

Infrared flame Sensor: A Flame Sensor module or Fire Sensor module is a small size electronics device that can detect a fire source or any other bright light sources. This sensor basically detects IR (Infrared) light wavelength between 760 nm – 1100 nm that is emitted from the fire flame or light source.[4]

BC547 NPN Transistor: BC547 is used as a Switch. A transistor will act as an Open switch during Forward Bias and as a Closed switch during Reverse Bias, this biasing can be achieved by supplying the required amount of current to the base pin. The biasing current should maximum of 5mA. Anything more than 5mA will kill the Transistor; hence a resistor is always added in series with base pin.**[**5]

RGB LED: An RGB LED is a combination of 3 LEDs in just one package. We can produce almost any color by combining those three colors. To produce other colors, we have to can combine the three colors in different intensities. Because the LEDs are very close to each other, our eyes see the result of the combination of colors, rather than the three colors individually.[6]

Buzzer: The buzzer consists of an outside case with two pins to attach it to power and ground. Inside is a piezo element, which consists of a central ceramic disc surrounded by a metal (often bronze) vibration disc. When current is applied to the buzzer it causes the ceramic disk to contract or expand. This then causes the surrounding disc to vibrate. That's the sound that you hear. By changing the frequency of the buzzer, the speed of the vibrations changes, which changes the pitch of the resulting sound.[7]

Resistor: A passive electrical component with two terminals that are used for either limiting or regulating the flow of electric current in electrical circuits. The SI unit of resistoris Ohm.[8]

Rectifier: A rectifier is an electronic device that converts an Alternating Current (AC) into a Direct Current (DC) by using one or more P-N junction diodes.[9]

Exhaust fan: The exhaust fan is turned on based on some conditions and it is used to extinguish fire or smoke.[10]

V. TECHNOLOGIES USED

1. Cloud

The cloud service used in this project is BlynkIoT. BlynkIoT is used to store the depth data that the multiple sensor senses and Node MCU processes. This data can be retrieved or analyzed in the cloud, based on which some control actions can be performed. The collected data is displayed in real time using the dashboard, using which data can be visualized as a chart, graph, text, slider, image, stream, and many more. [1]

2. Microcontroller

An MCU is a sophisticated semiconductor integrated circuit (IC) made up of a processor, memory modules, interfaces for communication, and peripherals. A wide variety of devices, such as washing machines, robotics, drones, radios, and game controllers, utilize MCU technology. The microcontroller used in this project is Node MCU ESP8266, which is easier to use due to the in-built wifi chip. [2]

3. MQTT Protocol

The Message Queuing Telemetry Transport (MQTT) protocol is a lightweight messaging protocol used to send and receive data between devices.
It is a simple communication mechanism, where data is published and subscribed with respect to the cloud. [3]

4 . Sensor

A sensor detects and records a physical property like temperature, resistance, capacitance, etc. In our application, infrared flame, gas/smoke, temperature and humidity sensors are used. [4]

VI. SOFTWARE USED

A. Arduino IDE

The Arduino IDE [14] is a software which is act as an interface between the microcontroller board and the computer. The integrated development environment (IDE) is an inter-platform application (for UNIX, Windows, Mac and Linux operating systems) which is coded in language Java. It is widely used in writing & uploading the code in different kind of Arduino UNO boards and microcontrollers like NodeMcu and Wemos board and so forth. It has a set of libraries which is used for connecting various sensors and libraries. It provides the facility of the serial monitor through which we can see the output of the code and it can be dumped in the microcontroller. It compiles the code before it is been uploaded into the microcontroller and checks all the errors which are either of the library error or syntactical error. It is an open source software in which source code is to be written and debug and it is supported by arduino.cc. It saves the file under the .ino extension.[1]

B. BlynkIoT

Blynk is an IoT platform for iOS or Android smartphones that is used to control Arduino, Raspberry Pi and NodeMCU via the Internet. This application is used to create a graphical interface or human machine interface (HMI) by compiling and providing the appropriate address on the available widgets.

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things.

There are three major components in the platform:

- Blynk App: – It allows you to create amazing interfaces for your projects using various widgets which are provided.
- Blynk Server: – It is responsible for all the communications between the smartphone and hardware.
- Blynk Libraries: – It enables communication, for all the popular hardware platforms, with the server and process all the incoming and outcoming commands.[2]

VII. LIBRARIES USED

- **DHT Library:** The DHT11 library is used for connecting the DHT11 sensor to the Arduino IDE or microcontrollers. It contains 4 files DHT.cpp, DHT_U.cpp, DHT.h, DHT_U.h. It is used for connecting all the DHT series sensors to the Arduino IDE. It is created by the BlynkIoT.[1]

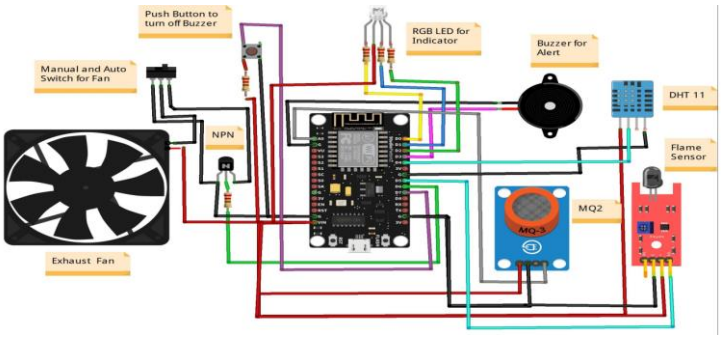
- **Blynk Libraries:** It enables communication, for all the popular hardware platforms, with the server and process all the incoming and outcoming commands.[2]

- **ESP8266Wifi library:** The Wi-Fi library for ESP8266 has been developed based on ESP8266 SDK, using the naming conventions and overall functionality philosophy of the Arduino WiFi library. Over time, the wealth of Wi-Fi features ported from ESP8266 SDK to esp8266 / Arduino outgrew Arduino WiFi library.[3]

VIII. CIRCUIT AND ITS CONNECTIONS

DHT 11	NodeMCU
VCC	Vin / 5V
GND	GND
Data	D4
Flame	
VCC	Vin / 5V
GND	GND
D0	D5
MQ2	
VCC	Vin / 5V
GND	GND
A0	A0
Buzzer	
Red	D5
Black	GND

RGB	NodeMCU
Red	D0
Green	D1
Blue	D2
+	Vin / 5V
Button	
A1	Vin / 5V
B1	GND
A2	D7
Transistor	
Emitter	GND
Base	D6
	Exhaust Fan
5V	Red
Collector	Black



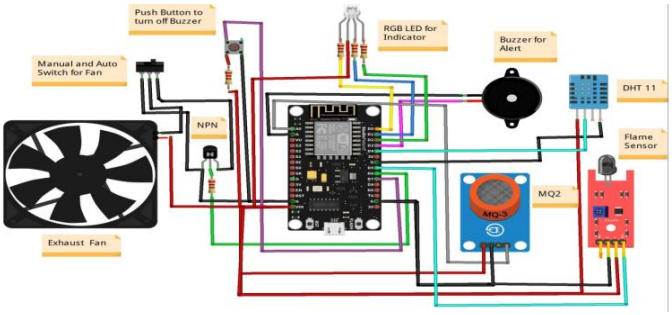
IX. PROJECT DESCRIPTION

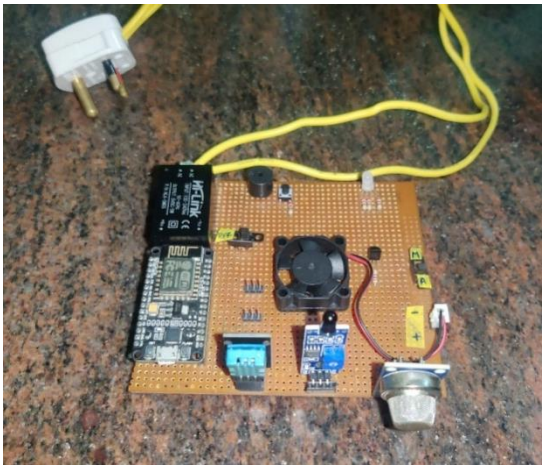
In this phase, the temperature & humidity, flame ,gas sensor, Node MCU, exhaust fan, RGB LED, buzzer and the remaining hardware are assembled.

This hardware is integrated with the software tools used i.e. BlynkIoT cloud application. The system prototype is then tested and the outcomes are documented and described.[1]

A. System Prototype

The hardware unit consists of the the temperature & humidity, flame and gas sensor which is connected to the Node MCU via cables as shown in the circuit diagram.[2]





B. Result

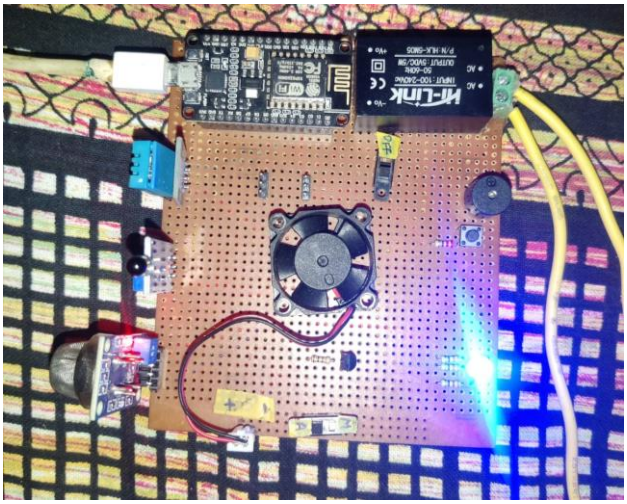
```
Executable segment sizes:
ICACHE : 32768           - flash instruction cache
IROM   : 254776          - code in flash         (default or ICACHE_FLASH_ATTR)
IRAM   : 29093   / 32768 - code in IRAM          (IRAM_ATTR, ISRs...)
DATA   : 1592  )         - initialized variables (global, static) in RAM/HEAP
RODATA : 2436  ) / 81920 - constants             (global, static) in RAM/HEAP
BSS    : 26728 )         - zeroed variables      (global, static) in RAM/HEAP
Sketch uses 287897 bytes (27%) of program storage space. Maximum is 1044464 bytes.
Global variables use 30756 bytes (37%) of dynamic memory, leaving 51164 bytes for local variables. Maximum is 81920 bytes.
```

1. Successful compilation of code

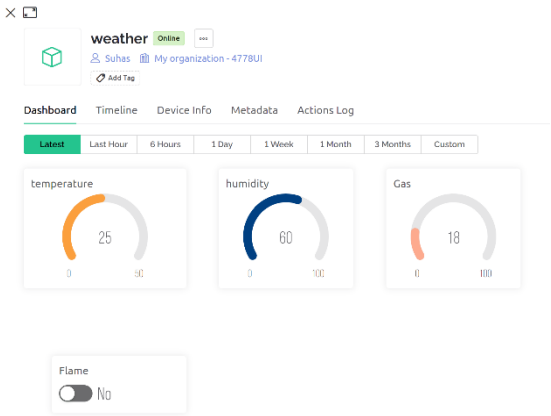
```
esptool.py v3.0
Serial port COM6
Connecting....
Chip is ESP8266EX
Features: WiFi
Crystal is 26MHz
MAC: d8:f1:5b:13:0b:12
Uploading stub...
Running stub...
Stub running...
Configuring flash size...
Auto-detected Flash size: 4MB
Compressed 292048 bytes to 212931...
Writing at 0x00000000... (7 %)
Writing at 0x00004000... (15 %)
Writing at 0x00008000... (23 %)
Writing at 0x0000c000... (30 %)
Writing at 0x00010000... (38 %)
Writing at 0x00014000... (46 %)
Writing at 0x00018000... (53 %)
Writing at 0x0001c000... (61 %)
Writing at 0x00020000... (69 %)
Writing at 0x00024000... (76 %)
Writing at 0x00028000... (84 %)
Writing at 0x0002c000... (92 %)
Writing at 0x00030000... (100 %)
Wrote 292048 bytes (212931 compressed) at 0x00000000 in 19.0 seconds (effective 123.2 kbit/s)...
Hash of data verified.

Leaving...
Hard resetting via RTS pin...
```

2. Code is getting uploaded to nodeMCU in Arduino IDE



3. The system is on and in working state

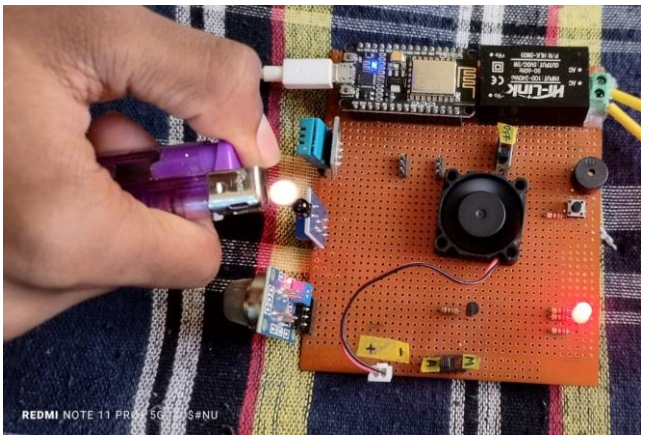


4. The real time data display in blynk

X. BENEFITS OF OUR APPLICATION

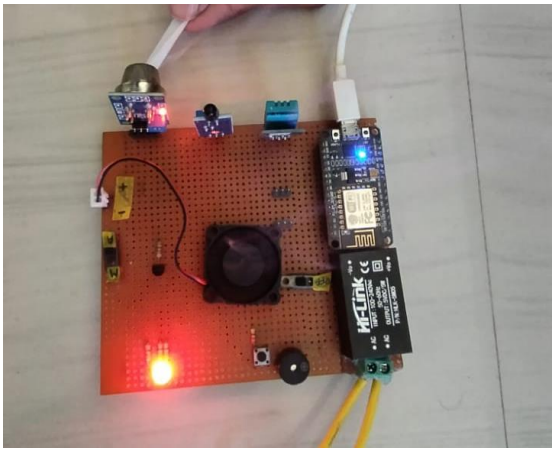
By our IoT based fire detector and extinguisher we can successfully detect and extinguish the fire. Which can prevent major accidents occurring in homes and large-scale industries, offices, etc... Through our project many industries and fire departments can use our technology to prevent the accident even when there are no people around. Our system can also be used to monitor the current room temperature and humidity.

Case 1: When the flame is detected

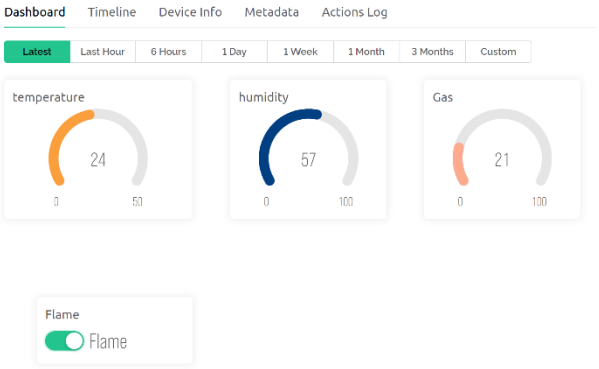


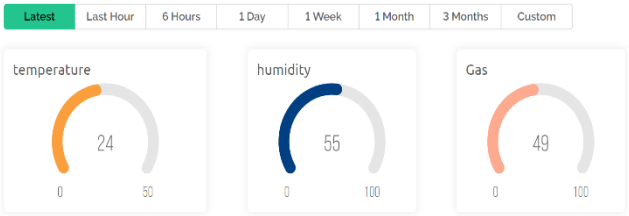
When the flame is detected by our system the exhaust fan is turned on, the RGB LED turns to red in colour and buzzer starts to beep.

Case 2: When smoke is detected



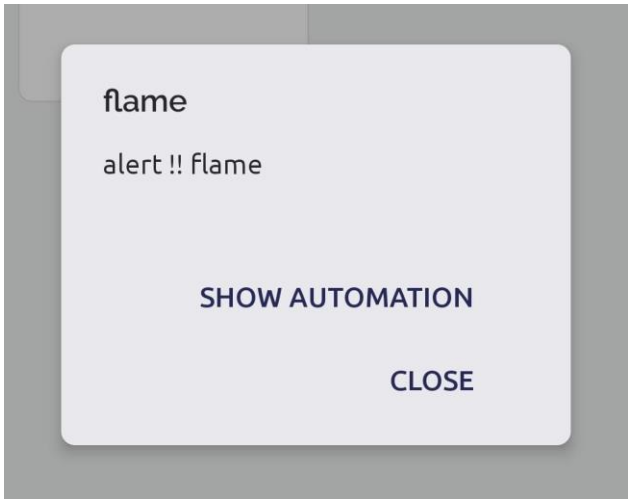
When the smoke reaches more than 30 it is detected by our system and the exhaust fan is turned on, the RGB LED glows red and the buzzer starts to beep



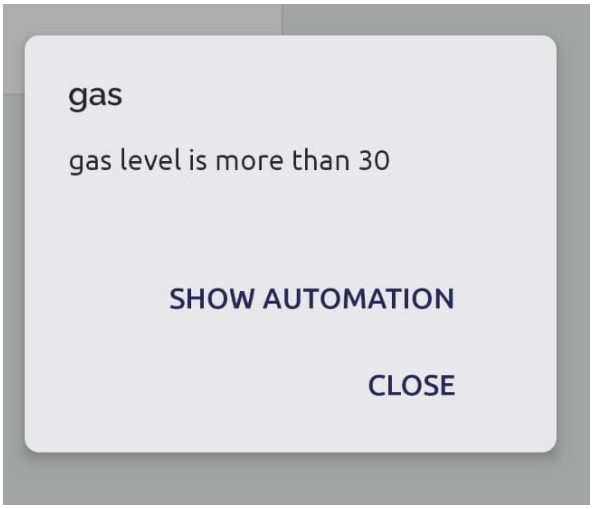


As we can see the gas levels are reached above 49 and is shown in the blynk webpage

The flame switch is turned on in the blynk webpage



The in-app notification is received informing the user that The flame is detected



The in app notification is received informing the user that the gas levels are more than 30.

XI CONCLUSION

- As the conclusion this project have cleared the objective of building a system that can detect flame, gas and extinguish it and also send a notification to the user.[1]
- The system also monitors the current room temperature and humidity and uploads the real time values to the cloud.[2]
- Installing our smart home system in households and industries will save many lives and will avoid many disasters.[3]
- Our smart home system is more accurate than all other systems as the false alarm rate is very low and accurate in our system as we are using combination of both flame and gas sensors.[4]

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