Internet of Things (IoT) Based Effective Home Automation Using a Nod Microcontroller Unit (MCU)

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Abstract - **Home automation is a topic that is gaining prominence due to its numerous advantages. Simply connecting home appliances and electrical devices to the internet or cloud storage enables home automation. In recent times, the demand for network-enabled home automation has skyrocketed due to its simplicity and comparable affordability. Using user-friendly, custom-defined portals, cloud-computing-based platforms make it possible to easily access anything and everything at any time and place, regardless of the user's physical location. Consequently, the cloud serves as an entry point for IoT. A motion sensor (PIR sensor) and an alarm bell were used to detect motion around the house. Gas leakage and fire can be detected by implementing an MQ2 gas sensor and a fire sensor. The designed system sends warnings when acceptable deviation exceeds the thresholds. The user can receive notifications on the mobile device by modifying the phone's application, i.e., Blynk. In addition, the user has full remote control over house facilities such as lighting, air conditioning, doors, security system activation, and system alarms.**

Keywords: Automation, IoT, cloud, MCU, sensors, Blynk.

I. INTRODUCTION

The Internet of Things (IoT) is a ground-breaking innovation that has revolutionized the way we live since the emergence of technology. IoT is a network of interconnected devices that communicate over the internet, allowing for seamless automation and control. In recent years, this technology has been utilized ina variety of fields, including residential automation [1–3].

Home automation utilizing IoT has emerged as a futuristic solution that offers us comfort, safety, and efficiency in our daily lives. By connecting appliances and devices to a central system, homeowners can now monitor and control their residences remotely using their smart phones and tablets. This essay explores the benefits of implementing IoT in home automation [4–6].

One significant advantage is enhanced convenience. With IoT-enabled home automation, people can easily manage household tasks such as modifying room temperatures,

regulating lighting, and brewing coffee while still in bed. Individuals can concentrate on more important aspects of their lives when they can automate mundane tasks [7, 8].

In addition, IoT-based home automation offers unprecedented security. Through the system's integrated cameras, sensors, and smart locks, proprietors can monitor their property from anywhere at any time [9].This not only deters potential intruders but also enables prompt response in emergencies such as fire or gas leakage [10].

Additionally, the incorporation of IoT into home automation contributes to energy conservation by optimizing energy usage. Smart thermostats and intelligent lighting systems automatically adjust to user preferences and occupancy patterns, thereby lowering energy consumption and utility bills. Incorporating IoT into home automation provides numerous advantages, including enhanced convenience, security, and energy efficiency [11].

The implementation of the Internet of Things (IoT) in home automation offers a multitude of benefits that will transform the way we interact with our living spaces. IoT offers an improved level of convenience, which is a significant advantage. With IoT-enabled devices seamlessly connected and the internet, homeowners can control and monitor various aspects of their residences from anywhere in the world. Individual scan, for instance, remotely adjust their thermostat settings to ensure a comfortable temperature upon their return or program their appliances to turn on and off automatically, thereby conserving energy and money [12, 13].

Additionally, IoT in home automation increases safety and security. Connected devices, such as smart locks, enable homeowners to secure or unlock doors with their smart phones, thereby eliminating the need for physical keys that can be lost or stolen [14]. Moreover, IoT-enabled surveillance systems permit real-time monitoring of a person's property via video cameras accessible via mobile applications. This not only provides peace of mind but also deters would-be intruders [15–17].

Additionally, integrating IoT into home automation improves energy efficiency and sustainability. Smart thermostats equipped with sensors can detect household

occupancy patterns and regulate heating and cooling accordingly, thereby reducing energy waste [18]. Similarly, intelligent lighting systems can autonomously dim or turn off lights in unoccupied rooms or adjust brightness levels based on the availability of natural light. By optimizing energy consumption, homeowners can simultaneously reduce their carbon footprint and their utility expenditures [19]. In addition to these practical benefits, the Internet of Things offers opportunities for enhanced health and well-being through home automation [20, 21]. Connected smart wearables can assist individuals in accurately monitoring vital signs such as pulse rate and sleep patterns. This data can be remotely analyzed by healthcare professionals, who can provide valuable insights into an individual's overall health status without requiring them to physically visit a clinic [22].

In addition, IoT-enabled assistive technologies have the potential to increase accessibility within the household [23, 24]. Individuals with disabilities or limited mobility can tremendously benefit from automated systems that enable them to independently control various aspects of their living environments. IoT-enabled voice assistants, for instance, can respond to verbal commands to alter lighting, temperature, and even appliances, empowering people with disabilities to live more independently [25, 26].

Moreover, the incorporation of IoT into home automation enables a vast array of customization and personalization options. Homeowners can customize their home's settings and preferences to suit their requirements and preferences. For instance, a person may program their smart home system to progressively increase the brightness of their bedroom lights or brew a fresh pot of coffee as they begin their morning routine. Such personalized experiences significantly contribute to enhancing one's overall comfort and contentment in their living space [27, 28].

In this work, home automation was achieved using the Internet of Things (IoT) technology based on a node MCU. A motion sensor (infrared sensor) and an alarm chime were used to detect movement within the residence. Using an MQ2 gas sensor and a fire sensor, gas leaks and fires can be detected. When acceptable deviation exceeds the thresholds, the designed system transmits alerts. By modifying the application on the mobile device, namely Blynk, the user can receive notifications. In addition, the user has complete remote control over all house facilities, including lighting, air conditioning, doors, security system activation, and system alarms.

II. METHODOLOGY AND DISCUSSION

The Node Microcontroller Unit (MCU) has revolutionized the world of embedded systems. It combines the functionality of a microcontroller with the adaptability and

connectivity of a network node, making it an excellent option for Internet of Things applications. The Node MCU's compatibility with the Arduino programming language is one of its main features. This enables developers to write code with familiar syntax and libraries for their applications [29].

The Node MCU also supports Wi-Fi connectivity, allowing for seamless integration with existing networks and cloud services. The diminutive form factor of the Node MCU, which makes it suitable for a variety of applications, is another advantage of this microcontroller. Whether controlling home automation systems, monitoring environmental conditions, or constructing wearable devices, the Node MCU can be easily incorporated into any project due to its small size. Despite its diminutive size, the Node MCU provides a high level of performance. With a clock speed of up to 160 MHz and abundant memory resources, it can efficiently perform complex tasks. This makes it an ideal option for projects requiring real-time data processing or sophisticated algorithms. The Node Microcontroller Unit (MCU) has transformed the field of embedded systems. It is excellent for IoT applications due to its compatibility with the Arduino programming language, Wi-Fi connectivity, small form factor, and high performance. As technology continues to advance at a rapid rate, we can anticipate even more remarkable developments in the future from this remarkable device [29]. As shown in Figure1, the central processing unit (CPU) is the soul of the microcontroller (MCU). It executes instructions and performs calculations to ensure the system's proper operation. The CPU is supported by random access memory (RAM), which stores data and instructions temporarily. I/O interfaces enable communication between the microcontroller and external devices. These interfaces enable interaction with sensors, actuators, and other peripherals by facilitating data transfer. Additionally, timers and countersare essential components for applications those are time-sensitive. They provide precise timing signals for a variety of applications, including measuring intervals and generating precise PWM signals. Moreover, analog-to-digital converters (ADCs) convert analog sensor signals into digital values that the MCU can process. This allows for the monitoring of physical quantities like temperature and light intensity.
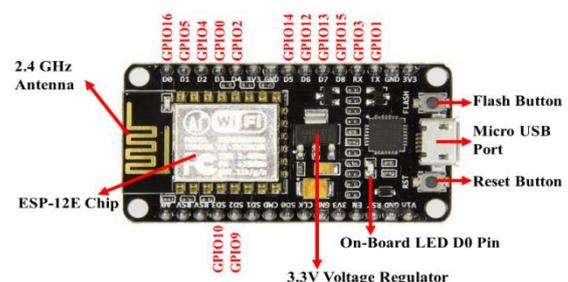

Figure 1: Node Microcontroller Unit (ESP8266)

2.1 Proposed Home Automation System

Home automation is a revolutionary technology that has revolutionized our lifestyle. It entails the in- corporation of various electronic devices and systems within our residences, allowing us to remotely control them.

The home automation mechanism relies on a network of sensors, controllers, and actuators. Sensors detect environmental changes including temperature, light, and motion. The transmitted signals are then analyzed by the controllers, which make decisions accordingly. Actuators are responsible for carrying out these decisions by turning lighting on/off, adjusting thermostats, and locking doors. This seamless integration of technology has improved the convenience and effectiveness of our lives. Figure2 presents the working mechanism and the circuit diagram of the proposed system.

(a)

(b)

Figure 2: (a) Block diagram of the proposed home automation system using IoT, and (b) Circuit diagram of the proposed home automation system

2.2 Blynk Software Implementation

The implementation of Blynk software has revolutionized how we interact with devices and appliances. This inventive platform enables users to control and monitor their smart devices via a straightforward mobile application. With Blynk, users can construct custom interfaces, known as" widgets," to manage various aspects of their devices. Blynk's usability is one of its main characteristics. The platform's user-friendly interface enables those with limited technical expertise to construct and modify their applications. By dragging and dropping widgets onto a virtual canvas, users can create interfaces that are uniquely suited to their requirements.

In addition, Blynk supports a variety of hardware platforms, making it compatible with a variety of available smart devices. Blynk provides limitless home automation options, including the ability to control lights, alter thermostat settings, and monitor security cameras. Blynk's cloud-based infrastructure is an additional benefit. This means that users with an internet connection can access and control their devices from any- where in the globe. This degree of adaptability and convenience has made Blynk a favorite among smart home enthusiasts.

Blynk was developed with the Internet of Things in mind. It can remotely control hardware, display sensor data, store data, and visualize it, among other interesting features. Three major components comprise the platform:

- Blynk App allows you to construct incredible interfaces for your projects using the provided widgets.
- Blynk Server is in charge of all smartphone-to-hardware communications. You can utilize the Blynk Cloud or operate a local Blynk server. It is open-source, can readily manage thousands of devices, and can even be run on a Raspberry Pi.
- Blynk Libraries enables communication with the server for all prominent hardware platforms and processes all incoming and outgoing commands.

When a user presses the Button in the Blynk application, the data is transferred to the Blynk Cloud, where it magically reaches the embedded hardware.

2.3 Programming Logic and Port Manipulation

Due to its low cost and high performance, the ESP8266 microcontroller unit (MCU) has become increasingly popular in the Internet of Things (IoT) industry. To completely utilize the capabilities of this MCU, programming logic and port manipulation must be understood. Programming logic is how computer instructions are written and executed. In the case of ESP8266, programming logic is crucial for controlling a
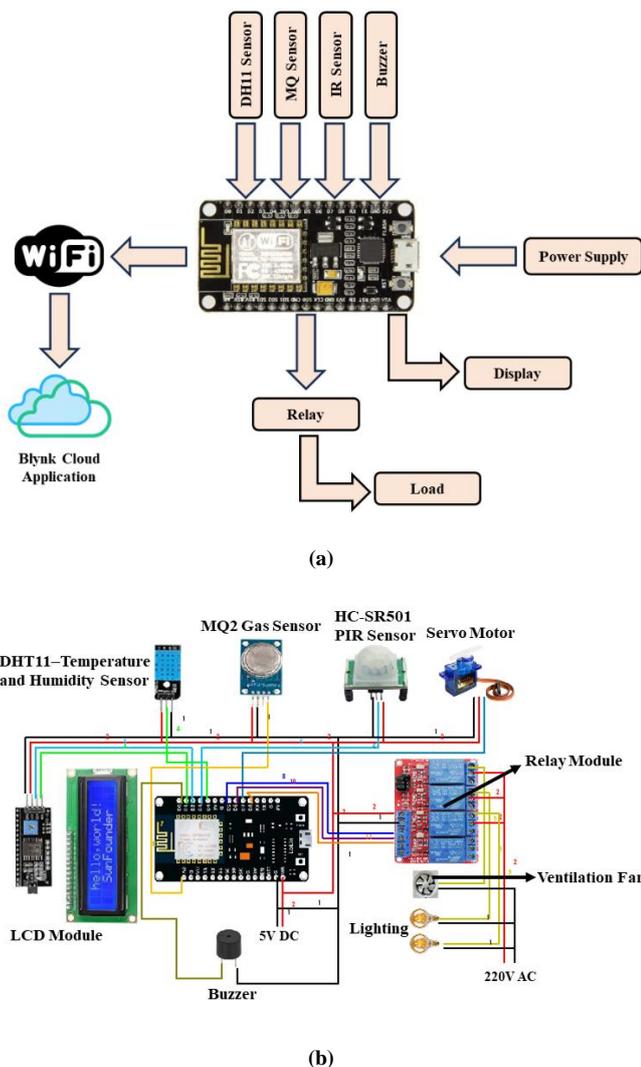
variety of features, including WiFi connectivity, GPIO ports, and serial communication. By utilizing conditional statements such as if-else and switch-case, programmers can make decisions based on specific conditions and execute the appropriate actions.

Port manipulation is another essential aspect of ESP8266 MCU programming. It involves directly accessing and manipulating the microcontroller's input/output interfaces. This expedites and improves the control of external devices tethered to these ports. Programmers can control individual pins without influencing other pins or wasting memory resources by setting or clearing particular bits within port registers. Understanding programming logic and port manipulation enable developers to create code that maximizes the ESP8266 MCU's capabilities. It optimizes memory usage and execution speed while enabling precise control over multiple functionalities. For IoT applications to effectively utilize the capability of the ESP8266 MCU, it is necessary to master programming logic and port manipulation. With these skills, programmers can construct robust and efficient applications that utilize the full capabilities of this versatile microcontroller. The final home automation code is as follows:

```
//Initialize the LCD display
LiquidCrystal_I2C lcd(0x27, 16, 2);
//HUAWEI_H122_E380-12345678900
char auth[] = "aejcgsmWiySsZd95tuxPl9w8tuDW6UIk";
char ssid[] = "iPhone1";
char pass[] = "123456789";
DHT dht(D4, DHT11);
BlynkTimer timer;
bool pirbutton = 0;
// Define component pins
#define Buzzer D0
#define MQ2 A0
#define PIR D3
#define relay1 D5
#define relay2 D6
#define relay3 D8
//#define relay4 D8
//Get buttons values
BLYNK_WRITE(V0) {
pirbutton = param.asInt();
}
BLYNK_WRITE(V9){
servo.write(param.asInt());
}
void setup()
{
Serial.begin(9600);
lcd.init();
```

```
lcd.backlight();
pinMode(Buzzer, OUTPUT);
pinMode(PIR, INPUT);
pinMode(relay1, OUTPUT);
pinMode(relay2, OUTPUT);
pinMode(relay3, OUTPUT);
 //pinMode(relay4, OUTPUT);
digitalWrite(relay1, HIGH);
digitalWrite(relay2, HIGH);
digitalWrite(relay3, HIGH);
 //digitalWrite(relay4, HIGH);
servo.attach(D7);
Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
dht.begin();
lcd.setCursor(0, 0);
lcd.print("Home Automation");
lcd.setCursor(4, 1);
lcd.print("System");
delay(4000);
lcd.clear();
//Call the functions
timer.setInterval(100L, gassensor);
timer.setInterval(100L, DHT11sensor);
timer.setInterval(100L, pirsensor);
}
//Get the MQ2 sensor values
void gassensor()
{
 int value = analogRead(MQ2);
Serial.println(value);
  value = map(value, 0, 1024, 0, 100);
  if (value <= 50) {
digitalWrite(Buzzer, LOW);
    } else if (value > 50)
{
servo.write(180);
Blynk.logEvent("gas_alert");
digitalWrite(Buzzer, HIGH);
digitalWrite(relay3, LOW);
lcd.setCursor(0, 0);
lcd.print("WARNING Gas Leak");
lcd.setCursor(0, 1);
lcd.print("  Detected!!!  ");
delay(4000);
lcd.clear(); }
Blynk.virtualWrite(V1, value);
lcd.setCursor(0, 0);
lcd.print("G:");
lcd.print(" ");
lcd.print(value); }
//Get the DHT11 sensor values
void DHT11sensor()
```

```
{
float h = dht.readHumidity();
float t = dht.readTemperature();
if (t <= 30)
{
} else if (t > 30)
{
digitalWrite(relay3, LOW);
 }
Blynk.virtualWrite(V2, t);
Blynk.virtualWrite(V3, h);
lcd.setCursor(7, 0);
lcd.print("T:");
lcd.print(t);
lcd.print(" C");
lcd.setCursor(7, 1);
lcd.print("T:");
lcd.print(t+273);
lcd.print("K");
lcd.setCursor(0, 1);
lcd.print("H:");
lcd.print(h);
lcd.setCursor(4, 1);
lcd.print("%  ");
}
//Get the PIR sensor values
void pirsensor()
{
bool value = digitalRead(PIR);
if (pirbutton == 1)
{
if (value == 0)
{
digitalWrite(Buzzer, LOW);
} else if (value == 1)
{
Blynk.logEvent("security-alert");
digitalWrite(Buzzer, HIGH);
lcd.setCursor(0, 0);
lcd.print("WARNING!! Check");
lcd.setCursor(0, 1);
lcd.print("Security System");
delay(4000);
lcd.clear();
}}}
//Get buttons values
BLYNK_WRITE(V5)
{
bool RelayOne = param.asInt();
if (RelayOne == 1)
{
digitalWrite(relay1, LOW);
```

```
} else
{
digitalWrite(relay1, HIGH);
}
}
//Get buttons values
BLYNK_WRITE(V6)
{
bool RelayTwo = param.asInt();
 if (RelayTwo == 1)
{
digitalWrite(relay2, LOW);
 \
} else
{
digitalWrite(relay2, HIGH);
}
}
BLYNK_WRITE(V7) {\
bool RelayThree = param.asInt();
if (RelayThree == 1)
{
digitalWrite(relay3, LOW);
} else {
digitalWrite(relay3, HIGH);
}
}
void loop()
{
Blynk.run();
timer.run();
}
```

III. PROTOTYPE OF THE HOME AUTOMATION SYSTEM

Developing a prototype for a home automation system requires several critical stages. These stages are essential for the development and implementation of the system to be successful.

First, the requirements and objectives of the home automation system must be defined. This includes determining what duties or functions the system should be capable of, such as controlling lights, temperature, security systems, and other appliances. Before proceeding with prototype development, it is essential to have a thorough understanding of these specifications.

After defining the system's requirements, the next stage is to design the system's architecture. This involves determining how various components will interact and be

connected. The architecture should be designed to enable easy scalability and expansion in the future.

Once the architecture has been designed, it is time to select and integrate hardware components. This includes selecting the sensors, actuators, controllers, and other devices required to automate different areas of the residence. It is essential to choose dependable and compatible hardware components that satisfy the specified specifications. After selecting and integrating all hardware components, software development enters into play. This requires writing code to administer and control various aspects of the home automation system. The software should be user-friendly, efficient, and able to handle multiple duties concurrently.

Testing and validation are essential stages in the development of a home automation system prototype. This entails exhaustively evaluating each component separately as well as their interaction within the larger system. Any issues or problems discovered during this phase should be resolved immediately. Figure 3 shows the final prototype of the proposed home automation system.

(a)
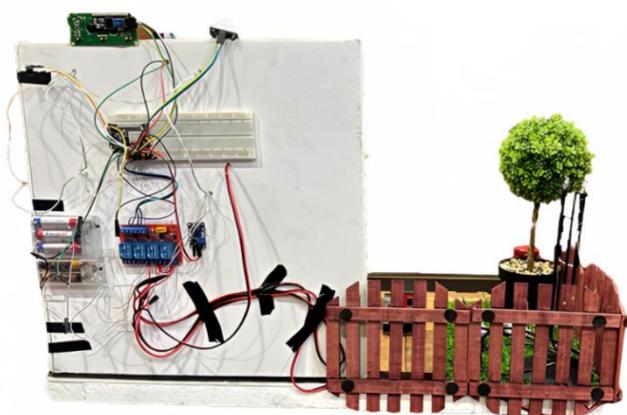
(b)

Figure 3: The Final prototype of the home automation system. (a) front side, and (b) backside

IV. RESULTS

To ensure the effectiveness and efficacy of a home automation system, it is essential to comprehend its measurements. Before contemplating a home automation system, dependability is a crucial factor. The system should be dependable and operate without hiccups or malfunctions. It must consistently execute tasks and respond quickly to user commands. Second, the scalability of a home automation system is an essential metric. As the requirements of homeowners evolve, the system should be able to accommodate additional devices or functionalities without requiring significant modifications or disruptions.

In addition, a successful home automation system must be compatible with a variety of devices and technologies. It should integrate seamlessly with various devices, sensors, and platforms to provide consumers with a unified experience. In addition, security plays a crucial role in determining the efficacy of a home automation system. To protect sensitive data from unauthorized access or cyber threats, it should employ robust encryption protocols and authentication mechanisms.
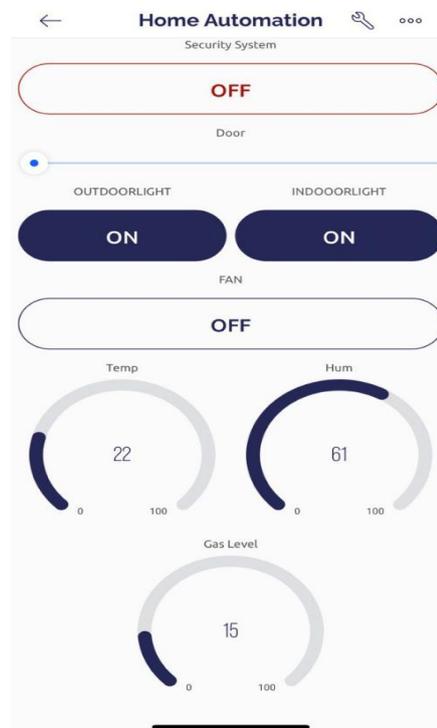

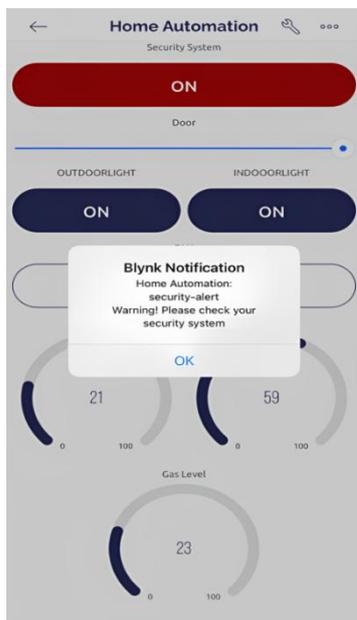**Figure 4: The user interface on the Blynk software**

Lastly, energy efficiency is a crucial factor for any contemporary household. A quality home automation system should optimize energy consumption by intelligently controlling lighting, heating/cooling systems, and other appliances in accordance with user preferences or occupancy patterns.

As soon as power is supplied to the project, the ESP8266 initiates the process of connecting to the home's Wi-Fi network and begins its quest for it. After that, a message containing the name of the project (Home Automation System) is displayed, followed by readings for the gas level, humidity, and temperature in Kelvin and Celsius. We can also monitor the gas level, humidity, and temperature using the Blynk application that is available on the Blynk website and the Blynk mobile app. Using an internet connection and the Blink app, home appliances can be managed and controlled virtually anywhere, as seen in Figure4

The home's PIR sensor functions as a security guard when it detects motion. With its sharp vision, it alerts householders to any intruders or unanticipated movements. This technological marvel provides individuals with peace of mind, allowing them to sleep soundly in the knowledge that their residence is safe. The ability of the PIR sensor to detect even the slightest movement demonstrates its dependability and effectiveness. It exemplifies human ingenuity and the never-ending pursuit of safety in a world that is constantly changing. When the PIR sensor in the home detects motion and the security system is activated, the security system will sound an alarm, display the status on the screen inside the home, and notify the user's phone, as presented in Figure 5.

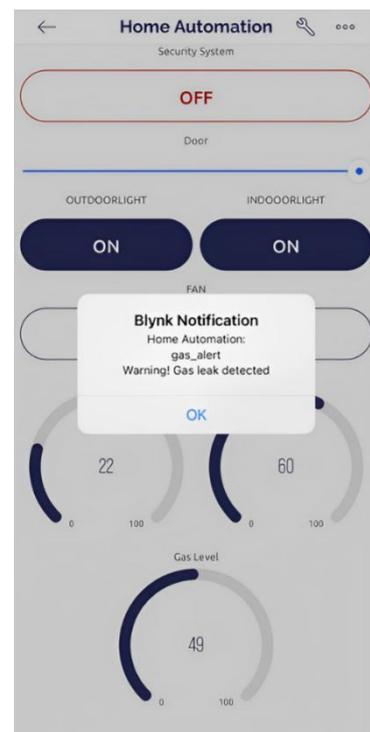The MQ2 sensor will detect any change caused by a gas discharge. The MQ2 sensor is a widely used gas sensor that can detect gases such as methane, propane, and carbon monoxide. It is based on the principle that resistance changes when exposed to distinct gases. Leaks of gas can be hazardous and potentially fatal. If they are not detected early, they can cause combustion, fires, and health problems. The MQ2 sensor plays a crucial role in detecting these breaches by monitoring air quality and alerting users when there is a significant change in the concentration of gas. When exposed to various gases, the sensor measures the resistance of its sensing element. Each gas has a distinct response pattern, which allows the sensor to distinguish between them. When there is a gas leak, the concentration of the leaked gas in the neighboring environment increases. This causes the MQ2 sensor's resistance reading to fluctuate significantly. When there is a gas leak, the MQ2 sensor will detect the change, and when the gas level rises above the preset level, the system will sound an alarm, display a warning on the screen, and send a notification to the user's phone, as shown in Figure 6. All of these events will occur when the gas level exceeds the system's designated level.

(a)

(b)

Figure 5: System alert in case of motion detection. (a) LCD alarm, and (b) user interface alarm

(a)

(b)

Figure 6: System alert in case of gas leak detection (a) LCD alarm, and (b) user interface alarm

V. CONCLUSION

The incorporation of the Internet of Things (IoT) into home automation systems provides numerous benefits. This essay's subtopics have cast light on the various advantages that IoT brings to our homes. IoT enables greater control and convenience for homeowners over their living spaces. Individuals can easily manage and monitor various aspects of their residences, such as lighting, temperature, security systems, and appliances, using a single interface when smart devices are connected to a central network.

Given that the provision of security in smart home systems is presently one of the most pressing concerns, it is necessary to install a home security system. We installed a PIR sensor and an alarm bell to monitor the area surrounding the residence for signs of motion and to sound an audible warning. As part of the endeavor, both the MQ2 sensor, which detects gas leaks and fire, and the sensor's connection to the system were added. This ensured that the system's safety was also taken into account. This allows us to distinguish between the normal and aberrant readings of these gas sensors. When the thresholds for acceptable deviation from the norm are exceeded, the proposed system will emit an audible warning signal. Additionally, the system will transmit a notification to the user's phone via the application that controls the phone. The system has proven its efficacy and stands out among comparable alternatives. It is possible to control all of the house's illumination, as well as the air conditioning system, the opening and closing of doors, the activation of the security system, and the deactivation of the alarm via the phone from any location. The final model was constructed according to the circuit diagram, and the expected results were realized. The valves for household appliances could be remotely controlled over a Wi-Fi network. Control was achieved utilizing both switch-mode techniques. Additionally, the Blynk application displayed the present status of all other applications.

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