STUDY TO BUILD A WARNING AND MONITORING SYSTEM FOR SMART HOME THROUGH MOBILE DEVICES

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ABSTRACT

This paper focus on developing a system which can monitors and warns parameters such as ultraviolet rays, gas, indicators of weather environment or the root conditions of explosion that outbreaks in or around a smart home within the connected range of any hazards which can be dangerous to people, thereby preparing and being proactive in possible situations. Through testing and practical use, the developed product has been operated stably, meeting the requirements of a monitoring and warning system for smart houses.

Keywords: Smart home; monitoring system; alert system; support system; detection system.

1. Introduction

Smart Home was designed and installed with electrical and electronic equipment that can be controlled, automated or semi-automatic to help replace humans in performing one or more tasks of managing operations and controling devices in the house. These electronic system can communicate with users through an installed electronic board system with applications on mobile phones, tablets or a website interface for monitoring [1]-[3].

In developed countries, smart homes have become popular in recent years, equipped with technology devices which are fully interactive with people such as Internet of Things with smart features [4]-[6]. In Vietnam, the application and deployment of smart home system is only in the initial stage [7]-[14]. Numerous companies and technology groups are developing and replicating smart home solutions for residents and public infrastructure, but to a limited extent. Moreover, the cost of deploying and installing technology solutions for smart homes is actually very expensive. It's only relatively satisfying for families with good economic conditions and organizations with invested funds. Smart home devices that have been commercialized on the market often require synchronization with other devices without independence or separate operation, so the level of responsiveness for users are still limited when it comes to deploying in rural and mountainous areas. A typical example is shown in Figure 1.

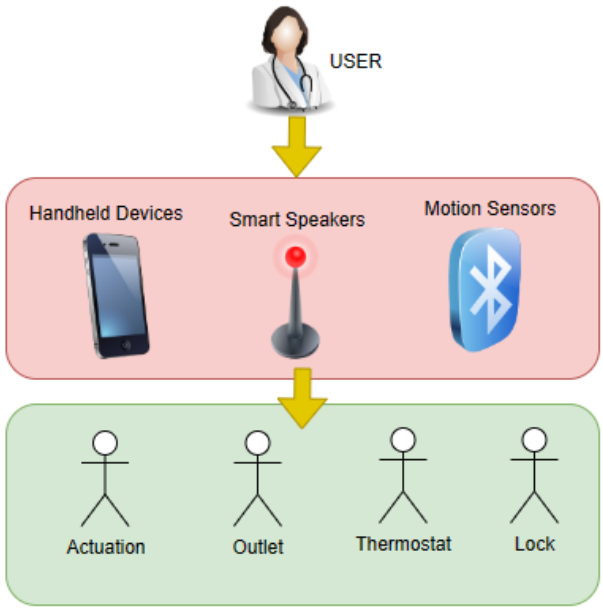

Figure 1: *Interactions between the smart home devices*

In this study, the authors focus on developing a monitoring and warning system with advantages and good responsiveness for families with limited economic conditions. These devices must ensure flexibility, convenience in use and ensure the following objectives:

- The developed system includings sensors that can measure important indicators: temperature, humidity, gas, infrared ray and the movement of objects.
- Design a block can immediately alert the users when there are changes in environmental and weather indicators.
- Design and build a processing program to send to mobile phones and send statistics data over the Internet from sensor probes. From there, continuously monitor indicators from the environment and weather to promptly come up with treatment solutions.
- Design and build a complete hardware system, which must ensure safe and stable operation.

2. Electronic design fundamentals and equipment selection

2.1. NodeMCU Development Kit/Board

NodeMCU DEVKIT (Figure 2) is the integrated Board based on the ESP-12E chip, which is designed to be easy-to-use and can connect to WiFi through a few operations. CP2102 IC was also integrated for easy communication with the computer via Micro-USB.

NodeMCU DEVKIT has a structure of 30 pins, including the power-supply pins for the entire Board (Vin, GND, 3V3). There are 13 GPIO input and output pins (00, 01, 02, 03, 04, 05, 09, 10, 12, 13, 14, 15, 16) and 1 Analog pin ADC0. EN, RST pins are used during reset and program loading for the Board [2].

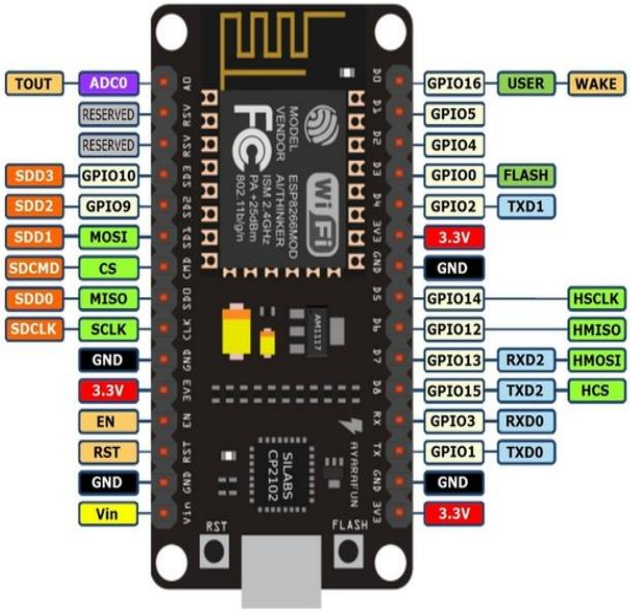

Figure 2: *NodeMCU Development Kit/Board*

2.2. DHT11 Sensor

DHT11 (Figure 3) is a popular temperature and humidity sensor with low cost and easy data acquisition, using 1-wire digital interface. The sensor has a built-in signal preprocessor that helps to receive accurate data without having to go through any calculations [3].

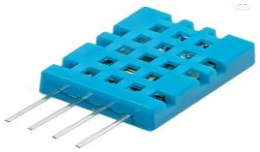

Figure 3: *DHT11 Sensor*

2.3. MQ2 Gas Sensor

MQ2 (Figure 4) is a gas sensor, used to detect potentially flammable gases. It is composed of the semiconductor SnO2. This substance has a low sensitivity to fresh air. However, when in the presence of combustible substance, its conductivity changes immediately. Thanks to this feature, a simple circuit is added to convert from this sensitivity to voltage. When the environment is clean, the output voltage of the sensor is low, the output voltage value increases as the concentration of combustible gas around the MQ2 sensor is higher [4].

Figure 4: *MQ2 Gas Sensor*

2.4. HC-SR501 PIR Sensor

Motion sensor HC-SR501 (Figure 5) is capable of detecting moving objects within its active area. The sensor module can adjust the sensitivity thanks to two rheostats: Sx rheostat adjusts the sensitivity of the sensor, Tx rheostat adjusts the closing time of the sensor, helping the sensor to operate in accordance with the requirements of the user [5].

Figure 5: *HC-SR501 PIR Sensor*

2.5. Flame Sensor

Flame Sensor (Figure 6) is often used for fire detection applications such as: fire fighting robots, fire sensors... The detection range of the sensor is about 80cm, the scanning angle is 60 degrees. It can best detect fire with wavelengths from 760nm - 1100nm [6].

Figure 6: *Flame Sensor*

3. System survey, analysis and design

3.1. The block diagram of the system

The monitoring and warning system is responsible for collecting parameters such as temperature, humidity, and rainfall through sensors and then storing it on the Internet and sending it to the phone [7-13].

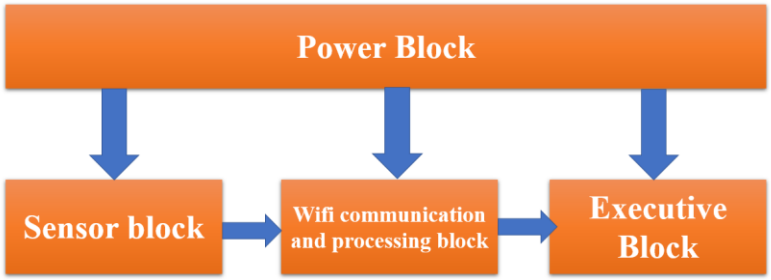

Figure 7: *System block diagram*

The system is developed including 4 blocks (Figure 7), specifically as follows:

- **Power block:** 5VDC battery has been used to supply electricity for microcontrollers and sensors as well as to all components on hard circuits.

- **Microcontroller block:** NodeMCU DEVKIT has been used for receiving the values that were sent back from the sensors, which is then sent to a database on the Internet.

- **Executive block:** These are programming applications based on Blynk and LINE. It is responsible for performing requests from the central processing block.

- **Sensor block**: Includes temperature sensor, humidity sensor DHT11, gas sensor, infrared sensor, light sensor, and motion sensor. Among those, the temperature sensor is analog, which is digital for the rest.

3.2. Flowchart Diagram of System Algorithm

After starting the device, the microcontroller begins to check the information about the previously saved Wifi and password. If the password is correct, it will connect to the Wifi, otherwise the program will end.

Once connected, the values that are sent back from the sensors will be read, including temperature, humidity, and rain sensors. At the same time, the microcontroller will send those values to the Server through the previously stored addresses to ensure continuous data updates. Depending on the preset time of an hour, they will only be stored once. Instantaneous and stored values can be viewed directly on the mobile phone. The system flowchart is represented in Figure 8, while the flowchart diagrams of Gas sensor and Flame sensor are shown in Figure 9 and Figure 10, respectively.

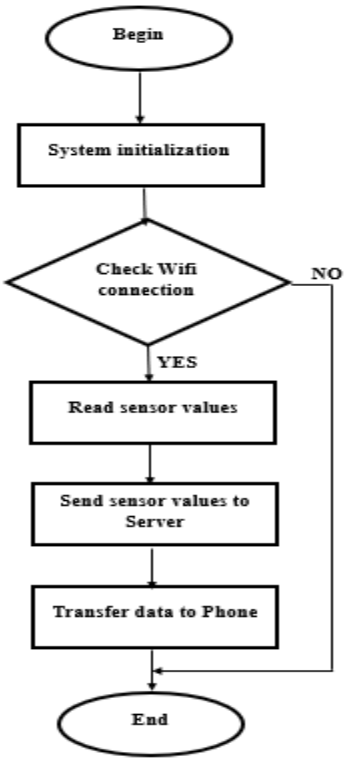

Figure 8: *System Flowchart*

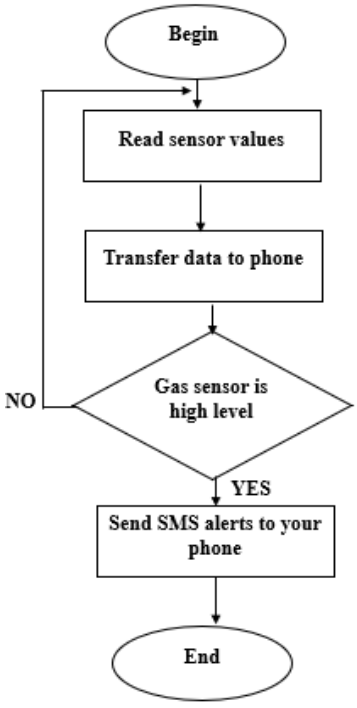

Figure 9: *Flowchart diagram of Gas sensor*

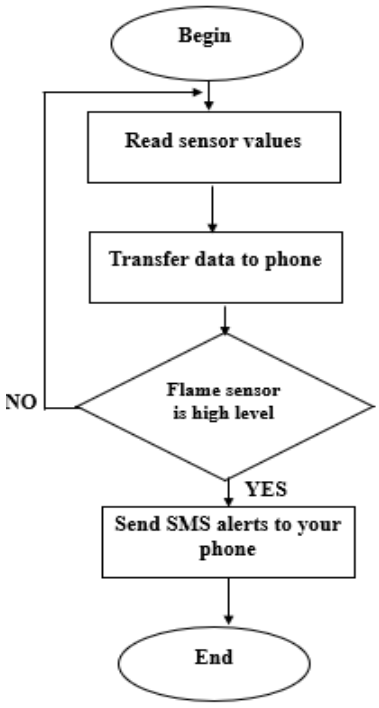

Figure 10: *Flowchart diagram of Flame sensor*

4. Software development and Hardware programming

4.1. Selection of programming tools

a. Blynk IoT Platform: Blynk is a platform for IOS and Android applications which allow to control Arduino, Raspberry Pi, ESP8266. Designed for IoT, Blynk can remotely control hardware, display sensor data, and store data. The application and selection of software solutions on Blynk is very reasonable and minimalist for small and medium systems.

b. LINE application: LINE is the new communication application that allows free calling and texting, which currently supports a wide range of phones including iPhone, Android, Window Phone, Black Berry, Nokia.

4.2. Hardware Design

a. Principle diagram: The block diagram of the main circuit is shown in Figure 11.

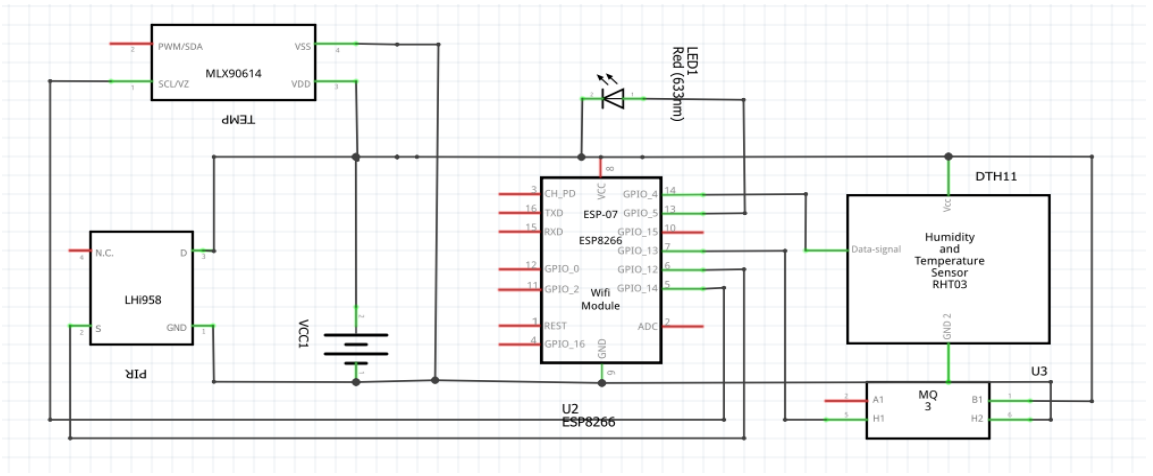

Figure 11: *Main circuit design*

b. Functional design diagram: The functional design of the system is shown in Figure 12.

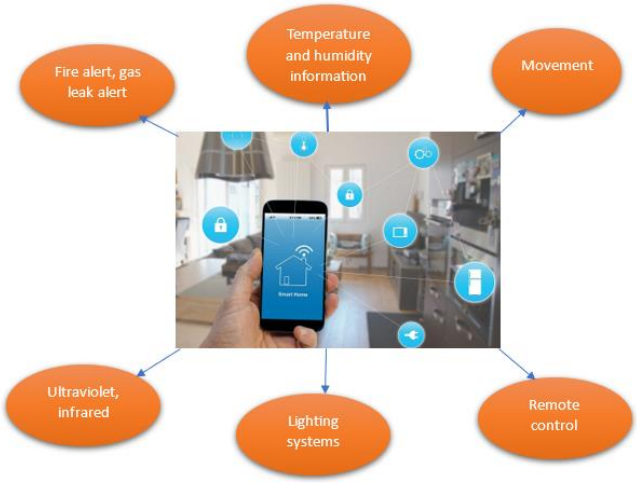

Figure 12: *The function of the system*

The following functions are included [14-20]:

- Automatic gas leak and fire alarm system
- Ultraviolet and infrared ray alarm system
- Remote control system via phone
- Movement system
- Lighting system
- Temperature and humidity notifications

c. Hard Circuit Simulation: Hardware circuit simulation is shown in Figure 13.

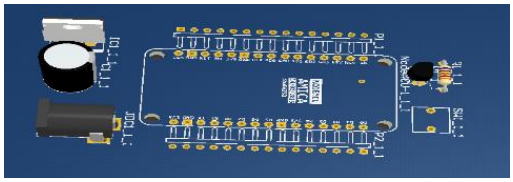

Figure 13: *Hardware circuit simulation*

4.2. Hardware Programming

a. Programming WiFi connection for microcontroller: The <ESP8266WiFi.h> library allows NodeMCU DEVKIT to perform functions to connect to WiFi networks in various modes. The connection to the WiFi network was made as follows:

```
const char* ssid     = "Tên WiFi";
const char* password = "Mật khẩu WiFi";
void setup() {
  Serial.begin(115200);
  delay(10);
  Serial.println();
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);

  WiFi.begin(ssid, password);

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

  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
}
```

b. Programming for connection to sensor blocks: The rain sensor supports reading directly from the digital pin of the microcontroller. The DHT11 temperature and humidity sensor transmits data in a 1-wire standard supported by the <DHT.h> library. To read the value from the sensor, the following commands has been used:

```
DHT dht2(D4, DHT11);
const int pinDmua = D3;
int mua;
float temp;
float humi;
void setup() {
pinMode(pinDmua, INPUT);
    }
    void loop() {
temp = dht2.readTemperature();
      humi = dht2.readHumidity();
      mua = digitalRead(pinDmua);
      delay(500);
     }
```

c. Programming to send the values to the Server: After performing the tasks of connecting to the WiFi network and reading the sensor values, the microcontroller will send the values to the Server through following commands:

```
client.print(String("GET ") + url + " HTTP/1.1\r\n" +
"Host: " + host + "\r\n" +
"Connection: close\r\n\r\n");
unsigned long timeout = millis();
while (client.available() == 0) {
  if (millis() - timeout > 5000) {
    Serial.println(">>> Client Timeout !");
    client.stop();
    return;
  }
}
```

Combining the above parts will be a complete program to load into the hardware that is responsible for reading the parameters and sending it to the Server.

5. Evaluation of results and discussion

Figure 14 presents the shows the actual product after design.

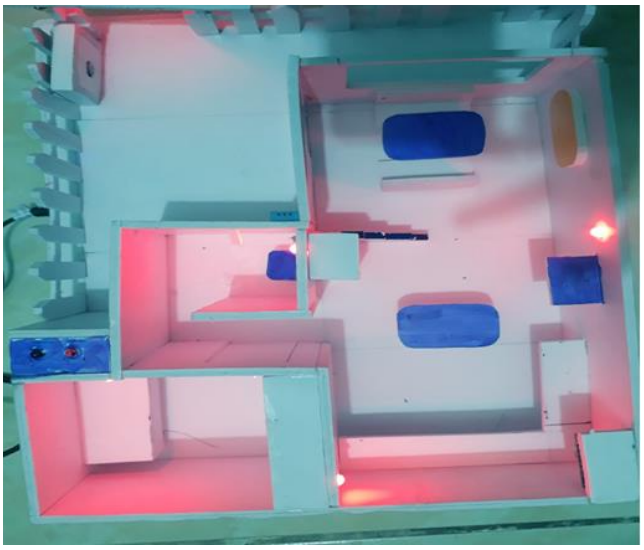

Figure 14: *Actual product after design*

Some evaluations had been performed to investigate the reliability of the systems. Table 1 describes the transmission speed with various network providers for Wifi infrastructure.

Table 1*: The transmission speed with various network providers for Wifi infrastructure*

Use network package	Viettel (ms)	FPT (ms)	VNPT (ms)
3 Mb	>5	x	x
4 Mb	>4	x	x

Use network package	Viettel (ms)	FPT (ms)	VNPT (ms)
10 Mb	~3	~3	~3
15 Mb	~3	~3	~2
20 Mb	~2	~3	~2
25 Mb	~2	~2	~2
26 Mb	x	x	~2
30 Mb	~2	~2	~2
35 Mb	~2	~2	~1
40 Mb	~2	~2	~1
50 Mb	~1	~1	~1

The data in Table 1 shows that the system's high efficiency depends on the choice of network service package of each service provider (such as Viettel, FPT or VNPT). Test results show that network packets with a transmission speed of more than 35 Mbps will give a good signal and help the system operate optimally. System reliability is high when the equipment is installed and operated according to the design of this study. Figure 15 represents the transmission speeds based on network speeds.

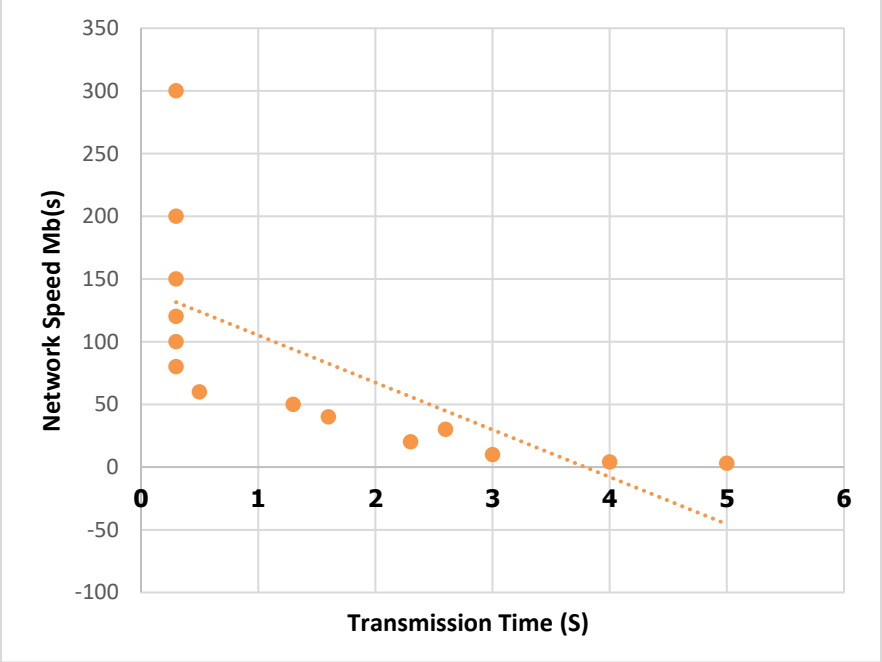

Figure 15: *The transmission speeds based on network speeds*

6. Conclusions

With the goal of applying advanced technologies to help smart homes perform functions such as energy saving; control intelligent lighting system; control environment, temperature, humidity; automatic curtain control system; intelligent air conditioning control; control smart home by voice; ensure security for the whole smart home, etc., in

this study, the authors have researched and developed a design system that meets a number of requirements as described above. Through testing and real-world usage, the product of this research has demonstrated stable operation and meets the requirements of a monitoring and alerting system for a smart home.

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TÓM TẮT

NGHIÊN CỨU XÂY DỰNG HỆ THỐNG GIÁM SÁT, CẢNH BÁO CHO NGÔI NHÀ THÔNG MINH QUA THIẾT BỊ DI ĐỘNG

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Ngày nhận bài 30/3/2023, ngày nhận đăng 20/4/2023

Bài báo này tập trung nghiên cứu, xây dựng một hệ thống có chức năng giám sát, cảnh báo các thông số như tia tử ngoại, khí Gas, các chỉ số về môi trường thời tiết hoặc các điều kiện dễ gây ra cháy nổ bên trong hoặc xung quanh ngôi nhà thông minh trong phạm vi được kết nối về mọi nguy cơ có thể gây nguy hiểm cho con người, từ đó có thể chuẩn bị và chủ động trong các tình huống xấu có thể xảy ra. Qua kiểm nghiệm và sử dụng trên thực tế cho thấy sản phẩm của nghiên cứu này đã hoạt động ổn định, đáp ứng được các yêu cầu của một hệ thống giám sát, cảnh báo cho ngôi nhà thông minh.

Từ khóa: Ngôi nhà thông minh; hệ thống giám sát; hệ thống cảnh báo; hệ thống hỗ trợ; hệ thống phát hiện