Designing and Manufacturing of Home Automation Monitoring System Using Internet of Things Technology

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Abstract. Home Automation System (HAS) has seen an increase in popularity as developments in connectivity and information technology. A Smart Home (SH) is a form of advanced applications for the Internet of Things (IoT) that allows users to track and manage their electronic devices through the internet. This paper describes an affordable, secure, WiFi-based smart home or home automation system, that enables the monitoring of home devices by homeowners at local and remote locations. The Arduino Mega 2560 and Raspberry Pi 3 Model B+ were used to configuring the server automation framework. Further, various sensors were used to observe current, voltages, humidity, temperature, movement, flame, smoke, gas, doors and other household conditions. The proposed automation system can monitor home conditions via the Blynk IoT Platform for both Android or IOS.

1. Introduction
Home Automation Systems (HASs) has gained substantial attention to the development of telecommunications technology [1]-[3]. An Internet of Things for SH is an option that enables users to access and manage their home devices anytime and anywhere from their PC or mobile devices [4], [5]. An SH contains automatic systems including motion detectors, heat/cool systems, perimeter alarms, sprinkler systems, air-flows, etc. [6]. Items like smart washing machines, smartphones, smart refrigerators, smart TVs, and smart sensors are now readily available within this modern generation (Fig.1). Smart gadgets are able to communicate with each other, forming a smart world. An automation framework must be built for their ability to talk and communicate between them inside intelligent homes.

The automation systems have been developed to be used in the marketplace for various purposes [7]. These systems are used to monitor and control appliances house locally/remotely. The emergence of microcontrollers has significantly lowered the costs of electronic control in the 1990s, the home has lately begun to emerge. HASs are rare and their use is still limited to the rich or hobbyists. Different automation technologies, such as music players, air conditioners, fans, and remote control for TVs, have been employed to allow home devices to have systems needed for them to be easily operated [8].
In the age of electricity widespread houses and rapid development of IT, an age of managing house devices has begun by using smartphones with wireless networking interfaces, such as ZigBee and Bluetooth, and by GSM modules and WiFi wireless networks. All of these systems encourage local monitoring of household appliances but also the residents are unable to track appliances remotely. Such mobile systems can provide protection, convenience, and energy efficiency when required. However, they are limited in communication range and functionality [9]. Most of these systems failed to use most of the powerful features of the new IoT technology that links billions of intelligent devices and (laptops, phones, actuators, and sensors ) to the Internet.

At present, most homes have some of the "smartness" such as electronic appliance controllers or built-in sensors. Devices in a smart home system can be connected with one another and reached through an Access Point (AP) to track house conditions and power home devices. In addition, Smart Home Automation Systems (SHAS) can track and control thermostats, lighting, cameras, TVs, washing machines, door locks, and refrigerators. When such a system is connected to the internet, it is an IoT-based automation system. HASs are energy-effective, reduce electric consumption, and make people more relaxed. HASs give homes more secure and make people feel safer [10]. For instance, some devices can alert homeowners upon detecting any motion in the house in the absence of homeowners, also can some of the devices report to the fire stations if a fire happens. The IoT can be used to enhance current home automation systems by entering a major control over the Internet.

The remaining portion of this paper arranged in this manner: the following section explains the background of SH, advantage, and their limitations. Section III describes how the materials and adopted methodology were used to design, fabrication, and improvement. Section IV illustrates the HAS implementation. Section V explains the results of the research and measurements. while the final section ends with the conclusion and the future work.

2. SH Overview
HAS or SH is fundamental to the IoT in which anything is given an Internet Protocol (IP) address, it can be tracked and easily accessible from anywhere and anytime. It is a manner in which house devices and other devices can access the internet for control of all facets of the intelligent home. For several decades, HASs have focused on simple devices control and controlling lighting. Technology is allowing the full control of the smart house from anywhere, so the connected world can become true [11]. House automation can determine how appliance can behave, why it should behave, and when it needs to behave. It provides ease, full-management and saving money. Besides that, HASs will alarm
owners about incidents that may occur while they are away from the property such as gas leaks, water leakage, blaze and unauthorized getting to their property. At what time, the homeowner can change the automation system’s settings to his preference by using an Android system, IOS, or another control device.

The integrated illumination control system is one of the advantages of SH. The user no longer needs to turn electrical appliances on or off manually. There are two different choices, for instance, if the person enters the bedroom: either the lighting automatically on and off after user exits the room or the user is able to control the software switch on his smartphone. The light luminosity also may be managed to reduce power consumption. Also, based on sensor readings, users can adjust room conditions (humidity, temperature, etc.) such as regulating the fan speed from their mobile app or automatically changing the fan speed according to room temperature. This will help boost energy efficiency because, if the electrical appliances are turned off automatically or readily if they are not used, it decreases energy usage and power bill costs.

The user may also use a smartphone, tablet or computer to control electrical equipment and monitor the house conditions. For instance, if the user forgot about turn off the fan and has entered his office, he can turn off the fan by using his intelligent device. The user can also mount flood sensors, carbon monoxide, smoke, to warn users if their homes are inundated or whether air is unsafe, so they can only sit at home.

The user receives an alert on his phone for a safety system if an incident occurs. If an intruder is trying to reach him, you must not worry about the house because the homeowner can monitor the motion sensor from his smartphone and the alarm continues if any motion is detected. The security system is the main element of safeguarding the houses against intruders. By installing wired surveillance cameras to prevent a burglar from entering the house. All intelligent home components, such as air conditioning, ventilation, heating, central illumination, automated devices and a safety system, can offer comfort and protection in everyday life.

According to a literature review that was made, one of the key problems with the current smart home is how they are applied and how much money they cost to use. Additionally, several existing systems include a view of the smart home on the website, which is inconvenient for people who would access a website any time they want to check on or view their homes [12]. The SH systems often lack easy-to-use interfaces to monitor and control devices. In addition, there are some restrictions in the current communication technology and the advantages of the existing communication technology. For instance, The Bluetooth range is limited to ten meters. If the range is greater than ten meters, the connection will be lost and the user will be unable to manage the home’s devices. ZigBee is ideally suited for low-rate wireless communication but the data rates inadequate for personal area networks (PANs) 250kb/s. Additionally, another networking technology includes GSM, which is capable of being accessed globally, but it is expensive, has a restricted range, and low data rate of transmission [13].

To solve the restrictions of current HASs, we propose a system to address SH needs. This can be accomplished by designing and manufacturing an affordable, Wi-Fi-based smart home prototype using Arduino Mega 2560 and Raspberry Pi 3 Model B + controllers by Using the Android system for the smartphone. The system is designed for remote monitoring by supporting the concept of the Internet of Things.

3. HAS Architecture

This part explains the conceptual framework and methods used in various stages to analyze different aspects of the research process, for the design and fabrication of the proposed system. In addition to explaining the structure and elements of the new framework of the suggested system in order to accomplish the goal of the study. Fig.2 reflects the flowchart of the analysis stages used in the current report.
Figure 2. Flow diagram of the research tasks structure
The design of the SH prototype is shown in Fig. 3, followed by the modelling process where all the requisite materials and tools are used in the fabrication of the smart home. The smart home prototype is built with a father board 3D printer as shown in Fig. 4. After that, the wiring and hardware are executed. Next, the programming process for Arduino and Raspberry Pi is done. To enhance and improvement design, any issues that arise during construction are detected and fixed during testing the project. Additional changes are made to prevent similar glitches. Finally, the full project design is assessed.

Figure 3. Designing of the smart home prototype by using auto desk fusion 360 software
Figure 4. The initial structure of the SH prototype

The Arduino Mega 2560 board is used as a secondary controller in this project and this board is based on the ATmega2560 controller as shown in Fig. 5. Includes this board digital I / O ports 54, featuring 16 analog inputs, 14 PWM ports and 4 outputs for UARTs, 16 MHz crystal oscillator, USB link, a power jack, ICSP module, and RST switch. This board contains its microcontrollers and all their supporting components. This allows the board to be operated by a USB link or a battery, or power it by plugging it into an AC outlet. This plate can be covered from accidental electrical discharges by positioning the base plate. This board have a versatile working memory space and are capable of handling various types of sensors without delay. Compared to other Arduino style boards, this board are more durable. The function of this panel is to read the data from the sensors and send it serial to the Raspberry Pi.

Figure 5. Arduino Mega 2560

Raspberry Pi 3 Model B + is the most version from the recent release of the Raspberry Pi 3 series as shown in Fig.6. It is used as the key component of this project and features a 64-bit quad-core processor operating at 1.4 GHz, Bluetooth 4.2 / BLE and a dual-band 2.4 wireless local area network, faster Ethernet, and PoE over a separate PoE HAT network. Dualband wireless LAN with compliant compliance monitoring, enabling the board to be used in finished goods, at a lower cost and in less time. The Pi 3 Model B+ retains the like physical scale as the Pi2 Model B and Pi3 Model B. Its function processes the serial data sent from the Arduino and sends it to the Blynk IoT platform.
Besides these two major components, several other sensors are in use to monitor SH conditions such as PEZM-004T sensor, temperature and humidity sensor, magnetic door sensor, IR motion sensor, flame sensor, MQ-135 sensor.

4. HAS Implementation
This paper focuses on using an Arduino mega controller with a Raspberry Pi 3 in HAS to monitor home conditions or control home devices. A local monitoring system via WiFi and a remote monitoring system, based on the Internet of Things is established. A suitable android or IOS application is used based on Wi-Fi which is the Blynk IoT Platform because it has an easy-to-use interface, which can work effectively with Arduino Mega and Raspberry Pi either for monitoring or controlling via smartphone. Raspberry Pi Arduino controllers are programmed to interact with the Blynk IoT Platform app. The sensors PEZM-004T, temperature and humidity, magnetic door, IR motion, flame, MQ-135, connect to the Arduino Mega microcontroller directly, the Arduino Mega sends the data coming from the sensors to the Raspberry Pi 3 in serial form, the Raspberry Pi receives the data coming in serial from the Arduino, then sends it to the Blynk IoT Platform, split this data in Blynk app and this data takes its own addresses, then homeowner monitored home conditions via the smartphone. Fig.7 a flowchart of the proposed operating system is shown. The circuit for the proposed system is illustrated in Fig.8 drawn via fritzing software. Fig.9 the sample structure details and how the proposed system will operate. Fig.10 shows the steps on how to monitor home conditions with the Blynk IoT Platform via a smartphone.

![Flowchart of the system flow process](image-url)
Figure 8. The practical circuit of the proposed HAS system

Figure 9. The shape illustrates the proposed system architecture

Proposed System

Start

Connect Raspberry Pi 3 Model B+ with Wi-Fi

Connect smartphone with Internet Connection

Login to VNC Viewer/Blynk IoT Platform

Monitor Home Conditions and Safety Issues via Blynk IoT Platform (temperature, humidity, voltage, current, power, energy, frequency, flame, gas, motion, doors, windows)

End

Figure 10. Flowchart of monitoring all home conditions
5. Results And Measurements
This part offers an instance in order to make sure and test the proposed HAS implementation. Our preliminary research findings will be used for this paper for more guidance and improvement. This research has succeeded in developing a WiFi-based HAS by using an Android smartphone. First, we need to link our Android smartphone to the Existing WiFi network. Then, we open the Blynk IoT Platform in our smartphone and configure its settings. We Connect the Blynk IoT Platform app to WiFi. Now we can monitor all household conditions such as movement, temperature, humidity, flame, gas, doors, current, voltages, power, energy, etc. as shown in Fig.11.

Moreover, the DHT11 DHT22 Sensors, the smartphone can measure and monitor the humidity and temperature in the house via these sensors, and these humidity and temperature data can be used to completely automate the fans and air conditioner system. The IR sensor will detect motion in a particular area and will respond by issuing an alarm through the buzzer (If the reading is zero, meaning there is movement, but if it is one, there is no movement), which can be used in the safety system or automatic lighting. Also, the flame sensor, it can sense fires and automatically operate water sprinklers, for example. And also for the MQ-135 sensor when it detects smoke and gases, it can use a Reverse fan to rid the house of them. As for the magnetic door sensor, it gives protection to the house from the entry of intruders, if the reading is zero, that means that there are people entering the house, and except for that, there are no people. RFID cards can be used to increase safety in a SH. The PZEM-004T sensor is used to measure electricity in a home. The PZEM-004T sensor can automatically turn off the electricity when the sensor detects high loads in the smart home. All these parameters will be used for all sensors in the next step of HAS to automatic control or via relays.

Figure 11. The SH prototype for monitoring all home conditions via an Android-based phone
At the close of this step of our project, we can monitor all household conditions with the Blynk IoT Platform through our Android-Based Smart Phone as shown in Fig. 12.

![Image of Blynk IoT Platform](image)

**Figure 12.** Use the Blynk IoT Platform to monitor all SH conditions

### 6. Conclusion And Future Work

This research project proposed designing and manufacturing an affordable WiFi-based home automation system for a SH prototype using Arduino Mega 2560 and Raspberry Pi 3 Model B + based on an Android smart system. Allows monitoring of all home conditions of current, voltage, power, energy, temperature, humidity, movement, flame, smoke, gases, doors via Wi-Fi using the Blynk IoT Platform. The SHAS provides a comfortable, intelligent system and improves the standard of living. With this SH system, the homeowner can monitor the electronic devices at any time he likes and this saves on energy costs. Moreover, the system is safe, so the movement of intruders can be monitored when entering the house and take the necessary action.

The next stage of our study is going to be to control electrical appliances in the prototype of the proposed system using relays or automatically based on the concept of IoT. So when the DHT22 and DHT11 sensors read the humidity and temperature in the house from an Android or IOS smartphone, these humidity and temperature data can be used to completely automate the fans and air conditioner system. The IR sensor can be detect motion in a particular area and will respond by issuing an alarm via the buzzer, which can be used in the safety system or automatic lighting. Also, the flame sensor, it can sense fires and operate water sprinklers automatically or via relays, for example. Also for the MQ-135 sensor, when it detects smoke and gases, it can use the reverse fan to rid the house of it, as for the magnetic door sensor, it can send an alarm via the bell or send a message via Gmail to the owner, to act immediately when intruders enter for example. Finally, the PZEM-004T sensor can make the electricity switch off automatically when there are high loads causing damage in home appliances to avoid related disasters.

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