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Hybrid Intelligent Internet of Things (IOT) Systems for Automated Homes

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***Abstract**: Automation is the process of being able to control various machines, appliances, equipment without the use of manual input, with little or no manpower, which brings about convenience and efficiency. Automation spans many areas, from automobile, military, industries and so on. Such as smart cars, drones, textile and car assembly industries, etc. Home automation being a type of automation brings about convenience in the home for users such that users can control appliances in the home via their smart phones and virtual assistants as primary and secondary user interfaces respectively. Commands would be given via the interfaces which would be sent to the microcontroller ESP8266 which has Google home API integrated into it, then relayed to appliances commanded.*

***Keywords:**user, home, office, automation, channels, sensors, modules, relays, OLED screen, PCB fabrication, Bluetooth, Wi-Fi, wireless home automation technology, virtual assistant, Application Programming Interface(API)*

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I. Introduction

Home automation is anything you imagine it to be (Vesternet, 2020). In this modern age, coupled with the digital revolution and advancement in technology, it is difficult to categorically analyse the limits of home automation. Of recent, as a result of the advancement in technology, the range of the home automation has widened beyond the existing general home automation.

There already exist various automation systems and a number of them include; automated waste management system, industrial and manufacturing automation system such as the car assembly process, automated irrigation system, automated farming system, and home automation system and so on. But basically, we can say automation systems are classified into two types namely; Home automation system and Industrial automation system. Home automation thus, is further divided into three namely; wireless, bus or wired cable, and power line based home automation system.

The wireless home automation is that in which uses wireless technologies such as Wi-Fi, Zigbee, Zwave, and Bluetooth as connection, transmission of data and communication between users and devices. The bus or wired cable is that which makes use of cables as hardware for communication such as local area network (LAN) cables, coaxial and fibre optic cables for home automation communication and transfer of data in the home. Power line based home automation system is one in which is made up of cables which carry electrical power. These cables are mostly supported by poles such as street lights and this form of automaton makes use of a switch or lever such that by the pull if the switch, series of electrical power components are automated all at once. The wireless home automation helps reduce the presence of wires around the home especially if the wiring are not implemented from the inception of the building.

This project, analyses these advancement and then propose a more advanced wireless home automation system model that supports simple, elegant and compact design, which is more cost effective with improved efficient as well as a better reliable means of communication such that in homes, offices, apartments or any desired living space, a user could use the proposed model for much better interaction with appliances and convenience. Hence, leading to an enhanced interaction in terms of speed, reliability and efficiency based on its intelligence.

II. Proposed System Methodology

2.1 User

The system, Home Basic (HB) model isdesigned with flexibility ofbeingeithera single user or multi-user system. The addition ofmulti-user to the system is done through a secondary interface. The user uses interfaces, be it primary or secondary interface such as smart mobile device and virtual assistant respectively.

Example includes aniPhone, android phone as shown in Figure2.1a or a Google Sonos respectively as shown in Figure2.2b which all give commands that would control the appliances in the home.

AGraphic User Interface (GUI) is automatically on the smart devices as a result of the Google home application on smart mobile device. API integration created so that the users would pair theHB accessory to their mobile devices wirelessly via Bluetooth or Wi-Fi connection. This applications allow the user to keep track of the status of the accessory as well as what is being controlled in the office. A record comprising of the list of connected device, online or available device, offline devices, controlled or activated devices amongst other. Basically, it gives information of the devices and their properties as well as the user logs of the automations and controls. The luxury of being able to personalize and customize scenes and settings can be done via this interface.

In a situation where the user require the office to be automated in his absence, a secondary interface as shown in Figure 2.1b may be used with the model in which a virtual assistant such as a smart speaker for example, Amazon Echo and Google Home may be paired with the accessory via Bluetooth. This would give the luxury of allowing multiple users automate the office.

Users are to have Google account which would be used as a unique ID tosign in to the Google home application interface irrespective of their mobile devices be android and iOS devices. For the efficiency of the model and the seamless automation to take place despite the system having the emerging technologies, the user must be connected to the internet to ubiquitously control the office from anywhere. 5G network would work best with the model and give the users a fast automation service in real-time. The proposed system model was designed having bypassed the issue of network facing the Nigerian telecommunication companies. Such that the system would detect when there is little or no internet connection and would switch to an offline mode with the aid of sensors. For the secondary interfaces and the multi users, a network is still requires as the system would not work without internet connection.

Figure2.1a: Primary User(Depositphotos, 2020)

Figure2.1b: Secondary User(Citiusminds, 2017)

2.2 Channel

The channel comprising of communication and controller streams is the brain behind the model. This encompassed the architectures, standards, programming, protocols, tools and technologies that makes up the system. In this stream, all roads leads to the microcontroller which is the main intermediary between the users and the office. As shown in Figure 2.2, the microcontroller in use here is the ESP8266 Wi-Fi Controller. The microcontroller has an inbuilt Wi-Fi module for wireless connections and just as a normal computer comprise of inputs say SD card slots, output say the OLED display that would be connected to it and lastly, it has a Read Only Memory (ROM). Pins, port and interfaces are channels through which external hardware are attached to the microcontroller.

Figure 2.2: ESP8266 Wi-Fi Controller(Banggood, 2019)

The proposed model would have attached to the controller, sensors, modules and relays etcetera. All as external hardware which would enhance the model and increase its functionalities.

2.2.1 **Modules**

The modules to be integrate into the microcontroller includes the Wi-Fi 6 module as shown in Figure 2.2.1a as well as the Bluetooth Low energy (BLE) as shown in Figure 2.2.1b.The wifi6 module integrated in the microcontroller enables the system get connected to the internet which enables remote connection and the Bluetooth module ensure communication in a short range within the office.

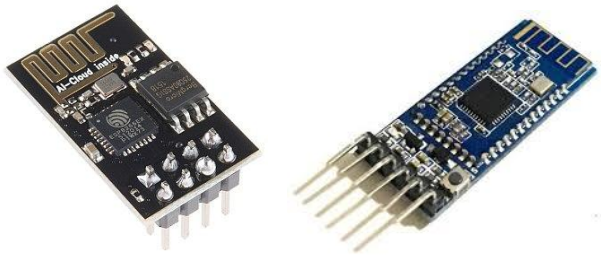

Figure 2.2.1a: Wi-Fi 6 module(konga, 2020)Figure 2.2.1b: BLE module(Hub360, 2018)

2.2.2 The sensors

The sensors used in the development of the model includes the temperature sensor, the light sensor as well as the motion sensor. The temperature sensor in use is a Digital output, relative Humidity and Temperature sensor (DHT) as shown in Figure 2.2.2a below. It controls the temperature, humidity and thermostat devices. Weather API would be integrated into the DHT sensor in the software phase that would enable it not just to turn on and off temperature devices but also to regulate the temperature of the office to be normal based on the collected data from the weather.

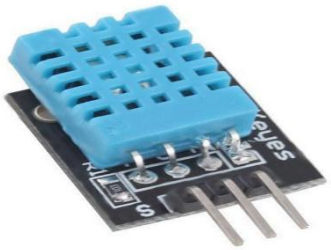

Figure 2.2.2a: DHT(Components, 2019)

The PIR motion sensor as shown below in Figure 2.2.2b is used in the proposed model based as it covers a wide range of degrees (180^{o}) which would suit the office environment. The Passive Infrared sensor (PIR) motion sensor basically activates the office appliance as soon as it detects the presence of a person. And it would be programmed such that after a given time say, 15 minutes of no presence of a person, it automatically shut down the office appliances. Here the PIR motion sensor serves as an assistance in automating the office. An offline mode is also enabled in the model such that with the PIR motion sensor, the model works offline in cases where the network signal is low or unavailable. The automatic mode would be a distinct feature in the model which serves as a form of its intelligence in which a user may decide the office be automated without his/hermanual input.

Figure 2.2.2b: PIR motion sensor(Elektor, 2019)

Light sensor for the proposed model in the study is the LUX sensor as shown below in Figure 2.2.2c. It controls the lighting and illumination of the office. This ranges from televisions, light bulbs, fridges, microwaves and so on. Users can manage and control the lights in the office. As in the case of a smart devices, the proposed system would allow the integration of smart devices such as Philips smart bulbs to the system

whereby the use user would have the flexibility of not just controlling the bulb but also setting scenes and colours for the bulb as desired. Also in the case of a smart bulb, a Light Dependent Resistor (LDR) module is a sensor that would make the smart bulbs automatically set scenes and light intensities as a result of the time of the day and also as a result of the light intensity data gotten by the module from outside. The HB model uses a standard LDR module as shown in Figure 2.2.2d below and it also combines both LUX and LDR sensors in case of redundancy as the system is a real-time system.

Figure 2.2.2c LUX sensor(Duino4projects, 2019) Figure 2.2.2d LDR(Kitronik, 2019)

A Real Time Clock module (RTC) as displayed in Figure 2.2.2e would be attached to the system since all the controls, automations, home management and commands are all factors of time and time constrained. Hence, the integration of a Real Time Clock module (RTC) that can accurately have a time record and keep track of records in terms of second, minutes hours, days, weeks, months, years and even almost a decade. That way, the microcontroller would not bother about such records and devices connected on the network can be more flexible to automate at given time or days of the week.

Figure 2.2.2e: RTC module(Gmelectronic, 2019)

2.2.3 Relays

The relays as shown in Figure 2.2.3 basically acts as switches which is used in the alteration of states of a device. Asides from being switches and altering the state of appliances based on given commands from the user, they are devices that respond in real-time to any given signal. The relay triggers the appliances to come on or off based on the signal sent from the microcontroller by the user. This serve as the last phase of communication in the medium stream that makes the automation possible in the office. The type of relay used in this proposed system is a solid state relay which switches appliances without any moving parts operations.

Figure 2.2.3: Relay(Banggood, 2018)

2.2.4 OLED screen

Figure 2.2.4a and Figure 2.2.4b shows an OLED screen which stands for Organic Light Emitting Diode is an interface, say screen used to generate output on the system. It is a hardware made of a light emitting diode that contains sheets of electroluminescent materials that are organic and flexible used for digital display screens.

Figure 2.2.4a OLED screen(Hackaday, 2017)

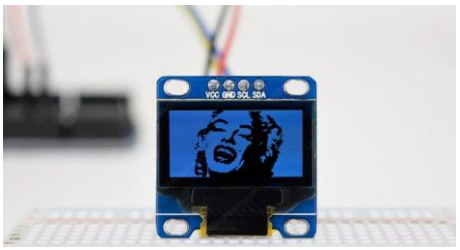

Figure 2.2.4b(Lastminute, 2018)

2.2.5 PCB Board fabrications

The Printed Circuit Board (PCB) as shown in Figure 2.2.5a is a substrate which is non-conductive supports mechanical and electrical connection of electronic components via the use of pads, tracks and other etched cooper sheet features that are conductive board. It can be used for prototyping as shown in Figure 2.2.5b below.

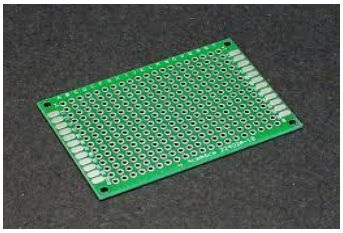

Figure 2.2.5a: PCB(Rhombus, 2017)

Figure 2.2.5b: PCB(Stevenson, 2015)

2.2.6 3D printing casing

This serves as a housing that encloses the designed model as shown in Figure 2.2.6a. Case printing would be customized, not just to be a model but its presence would also beautify the home as the model can come in various shapes and designs as shown in Figure 2.2.6b. As well as user's defined taste.

Figure 2.2.6a: 3D printing(Recrosio, 2017)

Figure 2.2.6b:Casing(Holmes, 2018)

2.2.7 Controlled Home Appliances

The home appliances as shown in Figure 2.2.7 below, with the proposed system have now transformed the ordinary manual controlled office into an automated one such that the appliances would be automated and respond to commands from the users interface relayed to them via the microcontroller. Depending on what is being controlled, the relay sends the command signals to the appliance and switches its state.

Figure 2.2.7: Appliances(Molier, 2018)

III. System Methodology module and workflow

3.1.1 Model layout

The HB model is such that it acts as a universal system and accessory, bridging the gap between various manufacturers and devices. The basic concept of the model is divided into three main streams.

1. The user
2. The Medium and
3. The home appliances.

Figure 3.1.1: Block diagram of the HB model

3.1.2 Analysis

The HB accessory has an input, memory and output as it exists in the Von Newman architecture. The HB model would run on Microcontroller ESP8266 Wi-Fi which would be interfaced with three different sensors; PIR motion sensor, DHT temperature and humidity sensor and LUX light Sensor. These sensors makes the detection of human presence, the control of thermostat and lighting appliances possible respectively. The controller takes readings from the sensors, checks timing and acts according to users preferences.

A Bluetooth module along with Real-time Clock (RTC) would also be interfaced to the microcontroller on board as shown in Figure IV below. Such that in a scenario where there is no network or internet connection for the Wi-Fi to remotely automate, the system can still be automated using Bluetooth. The RTC module makes the system time bound, ensuring time factors are considered and set on the system for automations even with the user's absence. Hence, bringing about a level of intelligence.

The Light Dependent Resistor (LDR) module would be activated in cases where a smart bulb appliance is installed on the system. This would enable the smart bulb automatically adjust lighting in the home as a result of light intensity from outside given, the time of the day.

IV. Connection

The HB system is designed in such a way that it is also capable of running standalone routines in case of internet downtimes. The Home Basic system would be connected to Google API via a local Wi-Fi hotspot connectivity. Third party applications such as Google Home can be installed and on all smart devices irrespective of operating system or manufacturer. Hence, a user using either IOS or Android platforms can access the system. The application serves as the interface for the smart system. The Google API for home automation is plugged into the project during software development phase. This would enable the Google home application on any smart device communicate with the system as well as enhancing strong connectivity wirelessly via cloud.

Also at the software development phase, IFTTT (IF This Then That) may be integrated to the system. This is to add more features to the system such as triggering the system when interrupt is detected. But by default, the Google Home application interface would be used in receiving updates and push notifications.

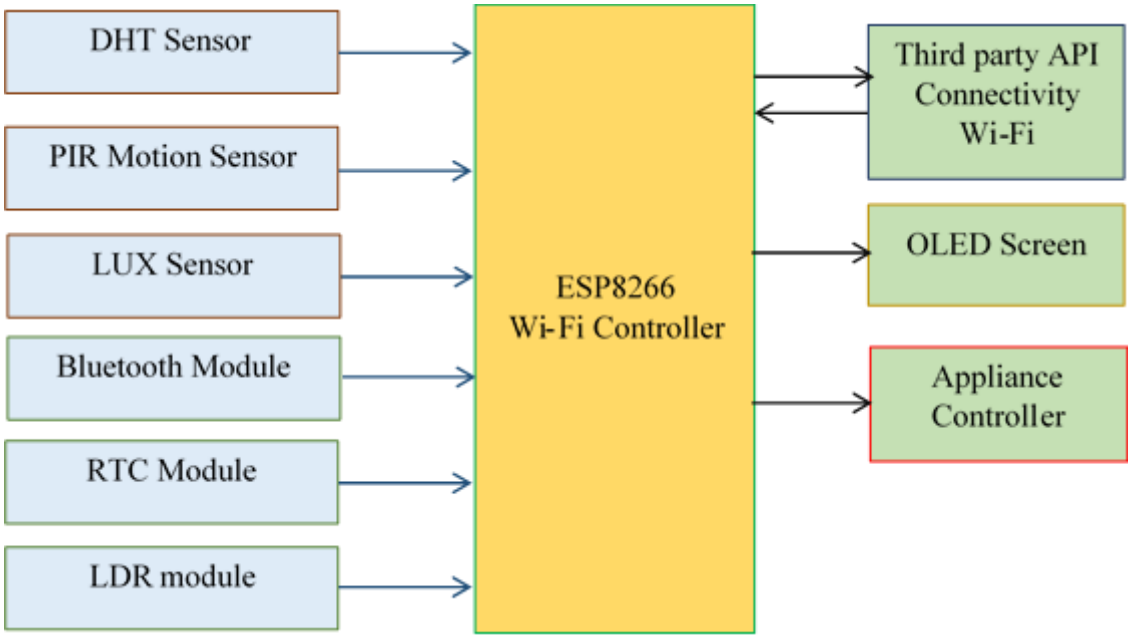

Figure IV: The designed HB model

V. Requirements

This includes the basic necessities that would be required by the system and the users. These requirements lead to a beautiful user experience.

User requirements

The user is required to have a mobile device, which must be smart, powered and may be connected to the Internet to enable remote connection to the office or home.The user should have a Google account and have a Google Home application installed on their smart phone.

System requirements

The system requires an uninterrupted power supply and might as well have an internet connection. This is to increase users experience and make automation possible from outside the office or home.Hence, for an optimal wireless performance by the system, we recommend that the HB system is be installed in the open and central location in the office or home.

VI. Summary

The designed HB model is an embedded real-time cross platform dedicated system which help manage appliances, gadgets and utilities in the office in a flexible manner bringing about the luxury of seamless control, convenience and efficiency.

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