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Systematic Design Approach of Smart Home Automation Device Using Internet of Things

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Abstract

Electrical energy plays an important role in the development of a nation and the overall wellbeing of the users. The price of electric power is increasing and there is need for proper energy management to reduce the burden of over billing. This work focuses on the design and implementation of smart home automation system using internet of things (IoT). The proposed idea towards this smart home automation system is such that the user can turn on lights, control fans and turn on sockets with the use of a smartphone when the user is not within the premises of the home, and more so the user can control these same functions from a single user interface point while within the home. After the construction of the active, the system was run, observed and tested to check its performance. The android app designed for this work was tested for connectivity and performed optimally while the control switches were used to switch ON/OFF lights on the prototype house. The response time for the lights to come ON/OFF is swift but also depends on the speed of the connected internet service provider. The performance optimization of energy wastage was a key success as energy consumed with the introduction of the smart system device was far low as compared with the energy consumption without the installation of the smart home device.

1.0. Introduction

Home automation is the automatic control of electrical and electronic devices in homes. The control of these devices is achieved through their connection to the Internet with which the devices can be controlled remotely. Home automation works through a network of devices that are connected to the Internet using different communication protocols, for example Wi-Fi, Bluetooth, ZigBee, and others. Electronic interfaces enable devices to be managed remotely through controllers either as voice assistant like Alexa or Google Assistant or an app. Many of these Internet of Things (IoT) devices have sensors that monitor changes in motion, temperature, and light so that the user can gain information about the device's surroundings. Home automation system automatically controls household appliances which uses various microcontrollers and multiple parameters to monitor and control the connected appliances [1]. Home automation are intelligent system that provide control to home appliances and also security systems. There are limited numbers of intelligent systems that address multiple aspects of home automation, such as appliances control, security bridge detection and reducing energy consumption and cost simultaneously [2]. Home automation involves the use and combination of hardware and software technologies that enable control and management over appliances and devices within the home. The Internet of Things, which is commonly known as IoT, refers to any device that is connected to the Internet for example, a smart light bulb that you can turn on and off via an app. All home automation devices are IoT devices which can be automated

to trigger one another. IoT refers to the devices themselves while home automation is what you can do with the IoT devices to ease stress and the control of things around the home conveniently. IoT is a paradigm where everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the Internet to achieve some objective [3]. Smart Home technology is the future of residential related technology which is designed to deliver and distribute number of services inside and outside the house via networked devices in which all the different applications and the intelligence behind them are integrated and interconnected [4]. [5] carried out development of a home automation system using Wi-Fi and ESP8266 which allows users to control various household appliances such as lights, fans, air conditioners, and electronic devices using their smartphones or other connected devices. [6] designed firmware for intelligent control using Node MCU, a widely recognized open-source IoT platform in the automation process. The incorporation of Wi-Fi networks enables remote control of household appliances was successfully implemented with both voice mode and switch mode control approaches. [7] and [8] used basic microcontroller Arduino UNO connected to the internet via USB serial or ESP8266 (ESP-01) Wifi module to control home electrical and electronic appliances remotely. [9] presents the development and implementation of a new home automation system unit using Arduino Nano as the main processing unit and also integrates multiple sensors such as passive infrared (PIR) sensors for motion detection, gas sensors for monitoring gas issues, temperature sensors for detecting temperature changes, and light sensors for monitoring ambient light, as well as Bluetooth modules for seamless wireless communication and monitoring capabilities meant to create a smart and flexible home automation solution that enhances comfort, security, and energy efficiency. It is upon the high rising cost of electric power in Nigeria and its management at home that a research on the design and implementation of smart home automation device using internet of things (IoT) is being investigated.

2. Materials and Methods

The work involves the design and coupling of the various electrical/electronic components for the implementation of smart home automation. The components used for the design of the smart home automation system using the Internet of Things (IoT) prototype are listed below: ATmega Microcontroller, User interface device, Wi-Fi module Antenna, IR proximity sensor and the passive infrared sensor, 4 x1 Keypad, 8 Channel Relay Module, DC-DC board Converter, Crystal Oscillator and Switch.

2.1 Wi-Fi Module Block

This block diagram of Figure 1 comprises the ESP8266 wireless module. The ESP8266 communicates using the Universal Asynchronous Receiver Transmitter serial communication protocol. Here one wire is used to transmit, and another is used to receive data, no clocking signal is shared from the controller to the Wi-Fi module, communication is achieved by using a frequency baud rate in which the data will be transmitted and received. By default, the ESP8266 Wi-Fi module transmits and receives data at a frequency band rate of 19200Hz. The Arduino-Uno is programmed to send and receive data at this same frequency for communication to be established. The transmission pin of the Arduino module is connected to the receiver pin of the ESP8266 module and the receiver pin of the Arduino is connected to the transmission pin of the ESP8266. The circuit diagram below shows the interconnections between the ESP8266 module and the Arduino-Uno Board. Using the ESP8266 Arduino library, the Arduino communicates with the Wi-Fi module and gives it the valid network SSID and password it requires for it to connect to the near-by router which has internet access enabled.

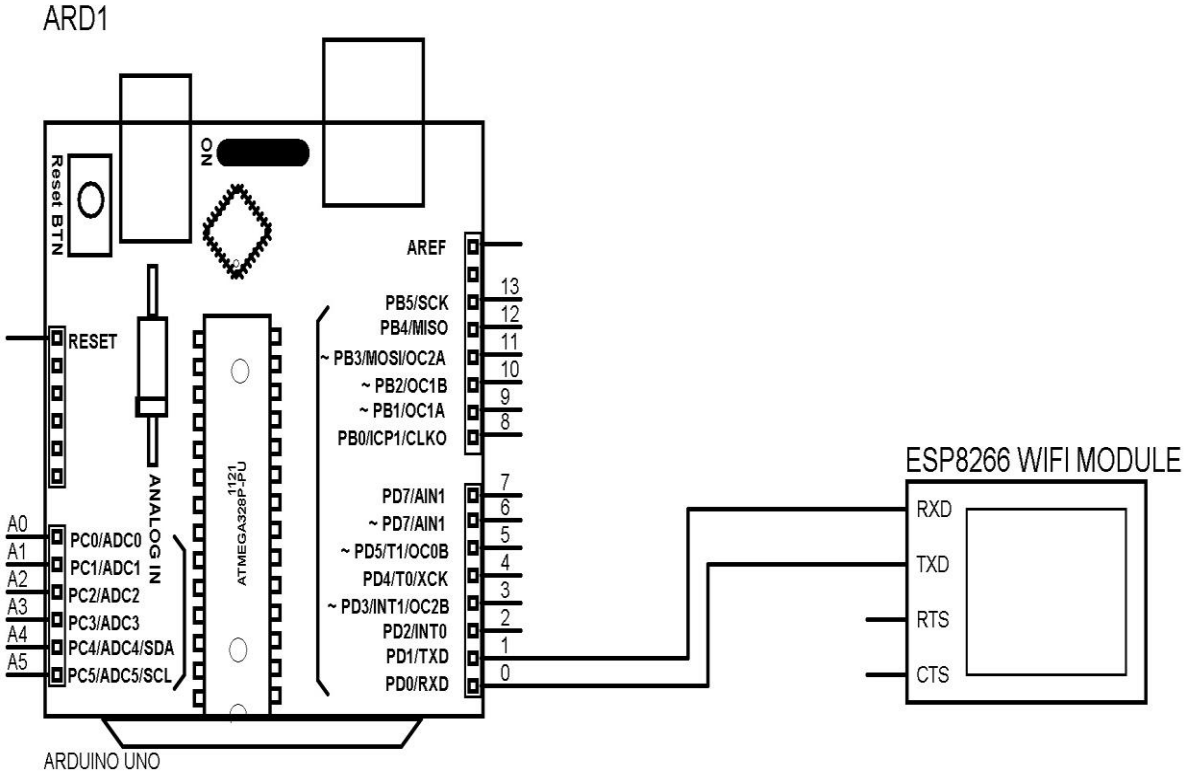

Figure 1: ESP8266 Module Connection with Arduino

2.2 Operational principle

The proposed idea towards this smart home automation system is such that the user can turn on lights, control fans and turn on sockets with the use of a smartphone when the user is not within the premises of the home, and more so the user can control these same functions from a single user interface point while within the home. Security breach detection and power optimization are added features. The control unit receives signals from the user's input interface both the remote (Phone App, via Wi-Fi module) and locally (via the keypad terminal) and processes these signals, it then switches on/off the required lighting point or regulates the speed of the Fans. A proximity sensor is used to detect when there is a security breach and will send signals to the control unit in the event of such an occurrence. A passive infrared sensor is used to detect human presence in each room, in the case of no such presence found, it signals the control unit to turn off lights and sockets, and the aim of this is to minimize energy wastage. A cloud-based server acts as a data storage support system so that the user can access information pertaining to the smart home and also control the home remotely.

Figure 2: Coupling of the components used in the smart system

Figure 3: Completed design of the smart home automation system in OFF state

Figure 4: Completed design of the smart home automation system in ON state

3. Results and Discussion

After the construction of the active, the system was run, observed and tested to check its performance. Here it is observed that the user has full remote access and control over all the devices connected to the Radio Frequency (RF) remote. The Arduino module does a perfect job in initializing all other sensors in the system ensuring a smooth and fluid control for the user. Also, the temperature sensor does a good job at reading the temperature of the room and controls the fan when the temperature of the room exceeds 27 degrees or drops below. The motion sensor works with fluidity as it turns on the light bulb when a motion is sensed.

The android app designed for this work was tested for connectivity and performed optimally while the control switches were used to switch ON/OFF lights on the prototype house as seen in Figure 3 and 4. The response time for the lights to come ON/OFF varied due to variations in network connection speed. However, the response time is instantaneous which depends on the speed of the internet connecting platform.

As earlier opined that the system performed optimally is evident from the analysis of the energy consumed within one (1) week of the device installation using an apartment as a case study. It is clearly evidential that the total energy consumed without the installation of the smart home device as shown in Figure 5 is more than the total energy consumed with the introduction of the smart home device using IoT as evident from Figure 6 where the energy consumed within same period dropped drastically. This clearly demonstrates the efficiency of smart home automation devices in reducing the energy consumed and its financial implication thereby leading to high energy waste reduction. Day 6 and 7 experienced virtually the same energy consumption because the occupants were fully available to use the appliances. It should be noted that one major limitation experienced in the implementation of smart home devices is the rising cost of internet connectivity as this will greatly hamper its practicality.

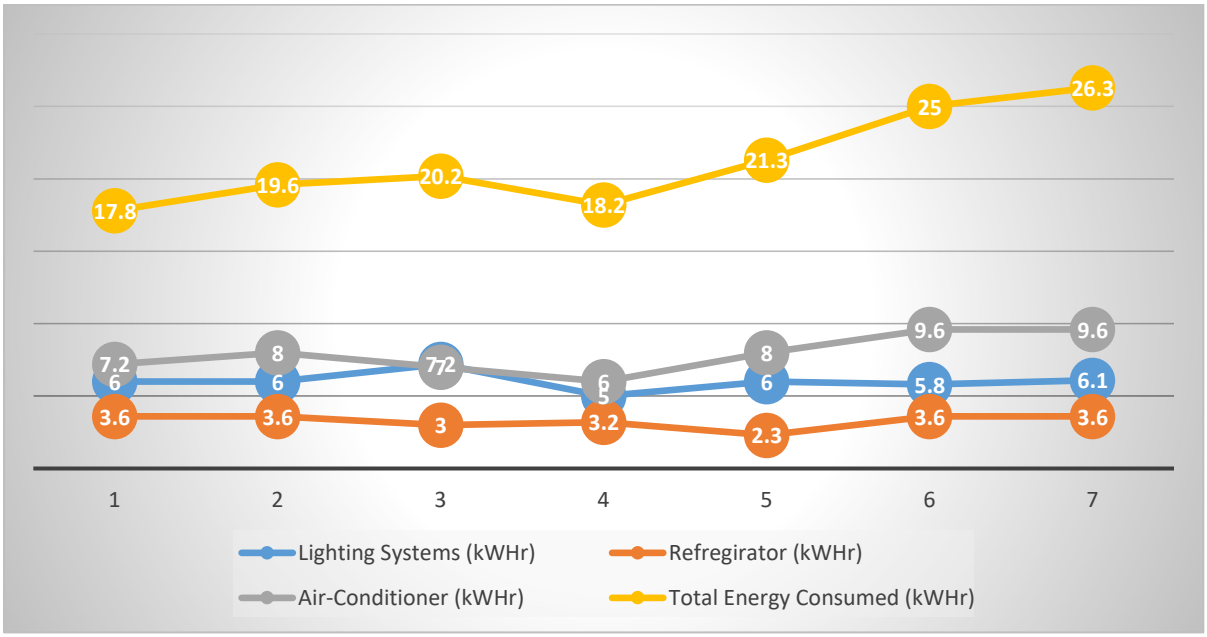

Figure 5: Shows the of Energy Consumption without the use of Automation System.

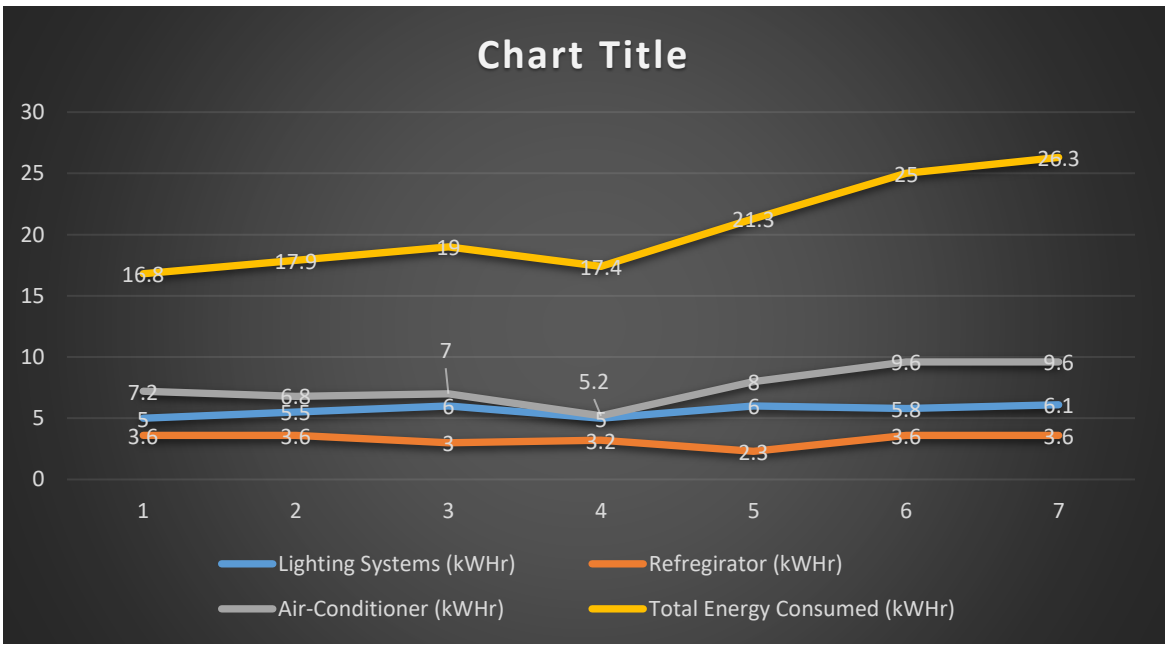

Figure 6: Shows the of Energy Consumption with the use of Automation System.

4. Conclusion

A Smart Home multi-layer system which is truly intelligent requires little to no management on a user's part and is capable of making decisions based on historical and real-time data. Thus, the system has the capability to identify significant user actions thereby assessing the probability events those actions trigger and issue appropriate commands to other devices within the network. The concept and the goal of the Home Automation is to bring down any manual settings to almost zero and aid the control of devices easily and essentially.

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