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Design and Implementation of Smart Home Energy Management system based on IoT

Moniruzaman, N. Mondol, M.Hasan
Department of Energy Science and Engineering, Khulna University of Engineering & Technology, Khulna-9203, BANGLADESH

ABSTRACT
An excellent amount of energy is wasted because of the dearth of smart management systems in home and office. Researchers are attempting to reduce the energy waste in many ways. The main target is added to avoid these varieties loss using a IoT base smart controlling system in home and office which has controlled light, fan, air-conditioner, and other electronic devices. So that introducing a new smart controller. This proposed project will be given priority in controlling during this stage to control electric device in home or office by daily companion of smartphone by android application at the identical time. The proposed system is to possible see the important time data of energy consumption for each device which can mentally force us to prevent wasting in a fun way. This controlling network is the global network once outside home so we'll be able to control the device from anywhere within the world but after receiving the communication network is that the local hotspot network. So don't need the internet. Next, include an automation algorithm to the system (where light and fan will off or on with strength, temperature & humidity) which is able to make a decision whether a tool will on or off by using different quiet sensors. This may make it a lot easier to cut back the waste and smart control of electric device. Finally, going to develop a synthetic intelligence algorithm in the system where every data of energy consumption will be stored in an excel sheet. End of the month we will see a summary of energy usage information that may not only help us to automate home but also give us the prediction of energy usages.

Key Words: Energy, Smartphone, Algorithm, Sensor, IoT.

1. Introduction

Energy consumption is increasing rapidly with the increasing world population thus we are becoming more dependent on electronic devices. This heavy consumption of electric energy increases the demand of energy. This exponential growing demand for energy makes us realize the smart use of energy utilizing every bit of it. So, we need a smart energy management system to utilize our valuable energy. Here comes an Idea of a smart controller for a home energy management system which will help an energy consumer to control home or office equipment by a simple means. By this system, energy will be used smartly so the energy waste will be reduced dramatically. Energy can be saved if there exists a network between electric devices, sensors, and other equipment. Through the network, which communicate with each other and will be able to save energy. To build the network we use the IoT. The IoT (Internet of Things) is the recent term which dictates connecting any device to the internet [1]. The internet revolution makes it very easy to connect any device to the network. Here things mean all the devices that can be connected to the internet while they can exchange data with each other, send or receive to any other devices that are part of these things. The user can also send the command through this network by the end-user gateway. This is very important for the idea of a smart home as the home appliance part of the IoT can operate without the interaction of humans that is the main objective of smart home energy management systems [2]. The programmable controller connected to the IoT makes the system more efficient. The best part of IoT is that we can embed this into our existing technology as the smartphone is a part of it. Considering all aspects of proposed IoT based Smart Home Energy Management system it is found that a good tool to be controlled energy and also automatic save our equipment when any fault is occurs in the system.

2. Description

For lack of energy management system lot of energy go to waste in home and office. Huge energy goes to waste from standby mode and don't care about it and most of the time we leave the light on when we exit the room. Many devices run unnecessarily for the lack of smart sensing. There is a need for smart sensing and management system to stop these wastes. The new challenges on Information and Communication Technologies (ICT) in Automatic Home Systems (AHS) focus on the methods useful to monitor, control, and optimize the data management and the use of energy. Several approaches have been studied in the last years such as advanced metering infrastructure (AMI), smart sensor technologies, smart home appliances, home area network (HAN), and home energy storage system (HESS) [4]. We also tried to make our project based on the past. As we tried to reduce the cost of the smart controller such that users show an interest to use this controller in their home. We also make this project user friendly as it is an IoT based project it is very easy to use compatible with smartphones thus improves the energy management in home or office.

3. Methodology

Our HEMS tracks and records the flows of electricity within the home using hardware installed within the property and software connected via the web. Users connect and interact with it via an internet dashboard (or interface) or through an app. It's a sensible controlling-

* Corresponding author. Tel.: +88-01783516851
E-mail addresses: ratanmoniruzaman@gmail.com; nibir@ese.kuet.ac.bd

based project where the full project is separated into 3 parts.

3.1. Manual Control

In this part, gave priority in controlling during this stage we controlled our electric device in our home or office by daily companion our smartphone with android application at the identical time. We were able to see the real-time data of energy consumption for each device which could mentally force us to prevent wasting in fun way. This controlling network was the global network however outside home it is possible to control the device from anywhere within the world.

3.2. Automation

In the 2nd were reception the communication network was that of the local hotspot network so didn't need the internet. Also included an automation algorithm to the system (where light and fan were off or on with intensity, temperature & humidity) which could make a decision whether a tool was on or off by using a different quiet sensor. This could make it a lot easier to cut back the waste and smart control of our electric device. Didn't only help us to automate our home but also gave us the prediction of energy usages. These data were very helpful for power plants.

3.3. AI Control

Finally, developed a man-made intelligence algorithm in our system where every data of energy consumption was stored in an excel sheet. End of the month had seen the summary of energy usage information. Fig.1 which is shows the proposed algorithm workflow

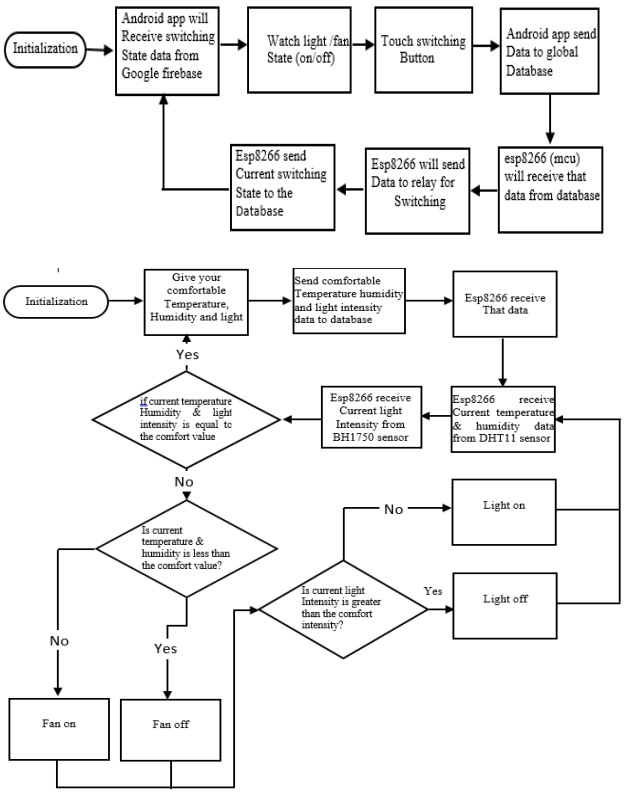

Fig.1 The proposed algorithm workflow

4. Component List uses of the project

Here are some components used in our project [3]

4.1 Esp8266

The ESP8266 is an Arduino module 11 GPIO pins (General Purpose Input/output pins), and an analog input yet which is able to use it to attach to a Wi-Fi network, connect with the web, host an online server with real websites, and let smartphone hook up with it, etc [3]. This implies that simply can program. It's no wonder that this chip has become the foremost popular IoT device. Fig.2 which is shows the Esp8266 Arduino module

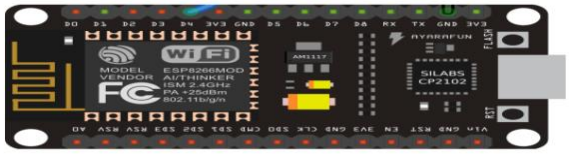

Fig. 2 Esp8266 Arduino module

4.2 Dht11

Dht11is a temperature and humidity sensor, it has a built-in chip that converts the analog data to digital data. Connecting with the controller the data can be read. This sensor is a bit slow but very cheap suitable for data logging. We need this sensor to know the ambient condition of our home. Fig.3 which is shows the Dht11 sensor

Fig. 3 Dht11 sensor

4.3 BH1750

It's a digital ambient light intensity sensor, this is most suitable to obtain the real-time data of ambient light intensity and easy to use with a microcontroller. This sensor will be used to turn on/off the light on automatic mode. Fig.4 which is shows the BH1750 sensor

Fig. 4 BH1750 sensor

4.4 Relay

Relay is a switching device. The magnet of the switch will be triggered if a small voltage is applied to it. Relay is an important part of our project as our operating voltage is 5V but we control 220 systems and rated current 10A. Fig.5 which is shows the channel relay.

Fig.5 channel relay

4.5 Voltage & Current Sensor

Voltage and current sensor is required for measuring current & voltage to calculate the power consumption of the devices. This project used Sun Robotics 5A Single Phase AC Current Sensor Module with Active Output Transformer Module and Current Sensor Module. Current sensor's input voltage VCC: 3-35V. Measure AC current within 5A, the corresponding analog output can be adjusted. High precise transmittal circuit, accurate sampling, and appropriate compensation for signal. Using the voltage sensor model is ZMPT101B voltage sensor. features of this sensor are Voltage up to 250 volts can be measured, Light weight with on-board micro-precision voltage transformer, High precision on-board op-amp circuit, Operating temperature: 40ºC ~ + 70ºC, Supply voltage 5 volts to 30 volts. Fig.6 which is shows the (a) Current Sensor (b) Voltage Sensor

Fig.6 (a) Current Sensor (b) Voltage Sensor

5. System Architecture

All the sensors to sense the parameter were connected to the microcontroller which was a NodeMCU board it had built-in Wi-Fi by which it would transmit real-time data to the Google firebase server. From a certain gateway, we were able to see the real time data and control our system from anywhere if the server also stored this data for further use. Fig.7 which is shows the Flow Diagram of the Project

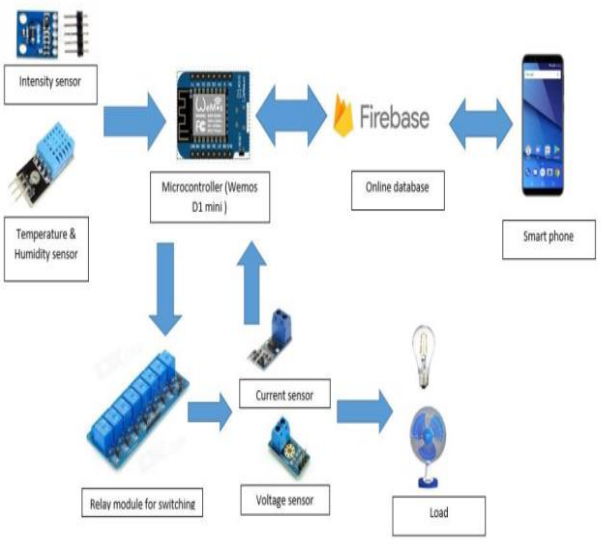

Fig.7 Flow Diagram of the Project

The whole system's control was divided into three parts such as manual control, automation and AI (Artificial Intelligence) control. The system was controlled not only in the local area network but also in the global area network. The system was controlled manually by using a Smartphone. Automation was included to the system to turn on or turn off the load with the help of the sensors. Automation helped to know about the total usage of energy and to reduce the waste of energy. AI control was a system control that made a summary of the total usage of energy and the energy management system.

The temperature and humidity sensor and the intensity sensor were directly connected to the microcontroller for the data transmission. The microcontroller sent the data to the Google firebase. Google firebase was used easily because it gave the security and the cost was low. With the help of an android app, Google firebase provided the information of turning on or turning off. Fig.8 which is shows the Database of the Project

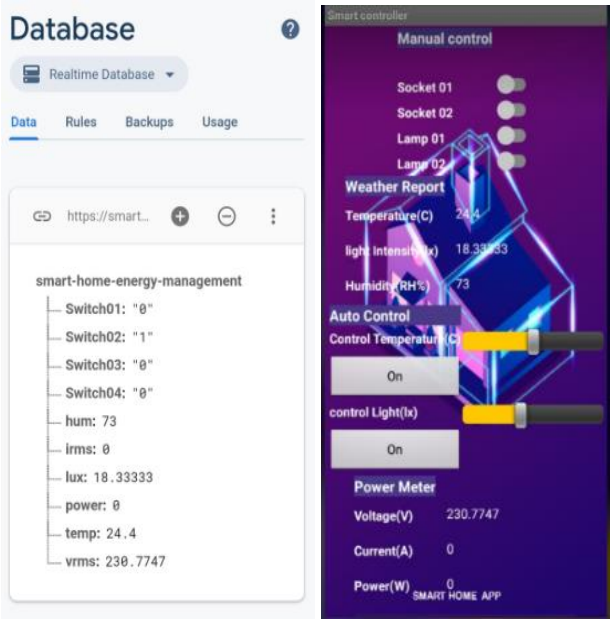

Fig.8 Database of the Project

Google firebase sent the information to the Smartphone and then Smartphone made the final decision. When the temperature crossed the certain value of temperature which was fixed for the room by using a Smartphone, Smartphone made a command automatically to turn on the fan and when the light intensity decreased by crossing the fixed value, the light was automatically turned on. Smartphone sent back its decision to the Google firebase and then Google firebase gave the information to the microcontroller. The microcontroller send data to the relay and the relay was connected to the voltage and current sensor. The voltage and current sensor was connected to the microcontroller and sent information to the microcontroller and also passed the information to the load and then the load was turning on or off due to the temperature and intensity changing. We had got the result through the turning on and turning off the load.

6. Experimental setup and Methodology

The experimental set-up was mainly divided into two parts. In the first part, there were DHT-11, ESP-8266, and BH-1750. In the second part, there were circuit breakers,

voltage sensors, current sensors, micro-controller, relay, switch, etc. Fig.9 which is shows the Experimental setup of the smart controller.

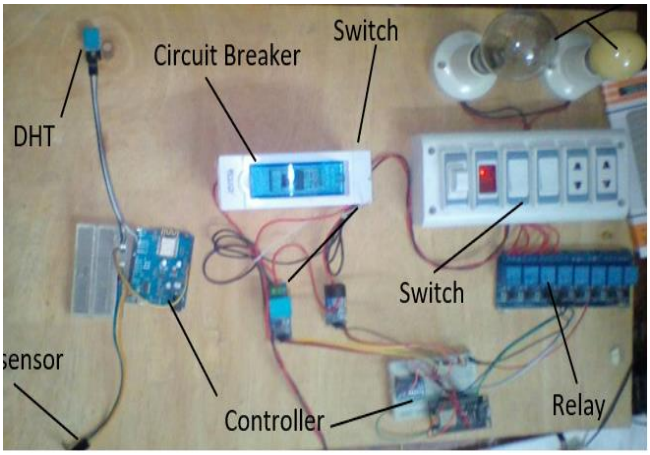

Fig.9 Experimental setup with smart controller

In the first part, the experimental set-up is described below:

6.1.1 DHT-11

The DHT-11 sensor is a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin. It is very easy to read the digital signal by using any micro-controller. DHT-11 was connected to the micro-controller for imparting the collected data and working on it. Single bus data communication protocol was used for the data communication. There was a one-wire communication between the DHT-11 and the microcontroller. DHT-11 needed a start signal from the micro-controller for starting the communication. It was needed every time to send the start signal from the microcontroller to the DHT-11 sensor for requesting to send the data. DHT-11 sent a response signal to the microcontroller after completing the start signal.

6.1.2 ESP-8266

ESP-8266 is a system which is Wi-Fi enabled on SoC (System on a Chip) module. The 3.3V power pin was in the microcontroller. The signal pin was connected to the digital pin. If the size of the processor was slightly big, the voltage, we had got, was low. Micro-controller worked on the data which was collected by the sensors and stored the data and gave the decision to operate the switches automatically. ESP-8266 was connected to the DHT-11 and the BH-1750.

6.1.3 BH-1750

BH-1750 is a digital ambient light sensor. It mainly works on the increasing and the decreasing of the intensity of light and gives the data to the microcontroller to turn on or off the light. It is an ambient light sensor IC for the I2C bus interface. There was I2C (Inter-Integrated Circuit) communication between BH-1750 and the microcontroller. It was needed that the clocks of the two IC remained the same for the I2C communication. The clock pin (SCK/SCL) of the BH-1750 was connected to the clock pin of the micro-controller and the data pin (SDA) of the BH-1750 was connected to the clock pin of the microcontroller.

In the second part, the experimental set-up is described below:

6.2.1 Circuit Breaker

Circuit breaker was used for switching. It is an automatically operated electrical switch designed to project an electrical circuit damage caused by excess current from an overload or short circuit. It was connected to the voltage sensor and the current sensor. We use 6 amp miniature circuit breakers.

6.2.2 Voltage Sensor

Voltage sensor (model is ZMPT101B) was used for determining the AC voltage or the DC voltage level. It calculated the amount of voltage. It was connected in parallel. It sent the analog signal to the ADC (Analog to Digital Converter) and then ADC converted the analog signal to the digital signal. ADC sent the digital signal to the microcontroller. The communication with the microcontroller was the I2C communication.

6.2.3 Current Sensor

Sun Robotics 5A Single Phase AC Current Sensor Module with Active Output Transformer Module and Current Sensor Module was used. Current sensor is either open or closed-loop. Current sensors detected the current in a wire and then generated a signal either in the form of analog voltage or digital output. The signal was proportional to that current. It was connected in series. It sent the analog signal to the ADC (Analog to Digital Converter) to convert the analog signal. ADC was used to convert the analog signal to digital signal and then ADC sent the digital signal to the microcontroller. The communication with the microcontroller was also the I2C communication.

6.2.4 MCU

MCU is a small computer on a single metal-oxide semiconductor (MOS) integrated circuit (IC) chip. It is an integrated circuit that contains a micro-processor along with memory and associated circuits and that controls some or all of the functions of an electronic device or system. It received the signal from ADC and stored the signal. It worked on the signal and gave the decision to power on or off.

6.2.5 Relay

Relay is mainly a switch which is operated electrically. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. It controlled electrically as well as electromechanically the opening and closing of the circuit contacts of an electronic circuit. It was connected to the microcontroller. It sent the signal to the switch. It was used to turn on or off the load.

7. Circuit Diagram

The circuit diagram of this project is given below, where all the connection is simulated on protease here all the equipment is connected in the same way as our project. We can simulate this setup without even doing it in real life. Fig.10 which is shows the Schematic simulation Circuit diagram of the Project.

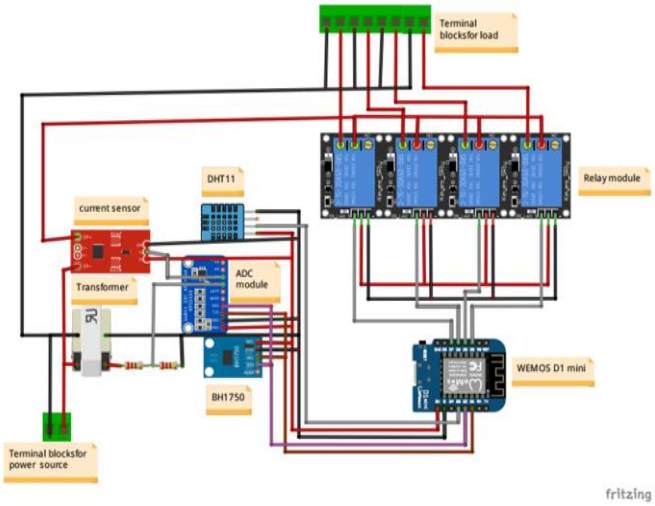

Fig.10 Schematic simulation Circuit diagram

8. Result and discussion

An extensive comparative study using the proposed IoT based smart controller and other different control schemes. Here are some results from the projected android app and the online gateway. From analysis, with this IoT controller save a large amount of energy which can control any type of load over the internet from anywhere with a single android software.Table.1 which is shows the Result from firebase console data

Table.1 Result from firebase console

Switch-1	0
Switch-2	0
Switch-3	1
Switch-4	0
Hum	53.48
Lux	91.66
Pres.	101382.1
Temp	25.02

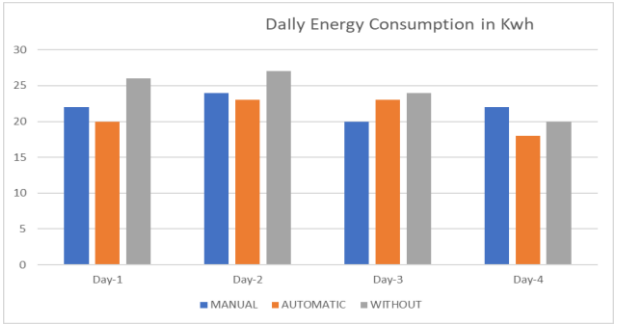

Fig. 11 Daily energy consumption With HEMS and Without HEMS

From the experiment and data analysis it has been seen that without proposed controller significant amount of energy was waste but when used proposed controller then energy loss reduces which save energy. Therefore the integration of the proposed smart controller into home or office energy management can be an effective means which save power loss and automatic detect the system fault.

9. Cost Analysis

For the sake of simplicity, took data from living room with smart home management system. From the result got that save the energy using home energy management system. With using the proposed IoT based control system approximately every day 1 kWh energy save, now let see the total cost of the project. Table.2 which is shows the Cost of the equipment of project

Table.2 Cost of the equipment of project

No.	Equipment	Price in (taka)
01	Relay 8 channel	500
02	Wemos dl mini (mcu)	300
03	Voltage sensor	200
04	Current sensor	250
05	Temperature & Humidity sensor	100
06	Light intensity sensor	300
	Total/=	1650//=

From the table we see the total cost of the project is around 2000 taka. From this proposed system save around 1 kWh of electricity per day that is 30 kWh (unit) per month. The current price of Bangladesh per unit electricity bill is 6 taka approximately. So total saving 180 Taka per month. To compensate our cost, we have to use this system for only 14 months.

10. Conclusion

This report shows the smart way to reduce unnecessary waste of energy in home and office. Considering all aspects of proposed Home energy management System that makes home a smart energy saver, sensible home with all kinds of comforts and alerts present in them. Internet of Things based systems will be operated all over the globe using internet connectivity. With the help of this user will analyze all conditions and situations at home. The IOT based home system is the future of homes. This research paper also presents the design and provides an implemented model with the systems that could be used in the future homes. The IOT in the coming time makes lives easy with its best automated Smart Homes.

11. References

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