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Monitoring and Controlling of Electrical Appliances in Home using IoT Environment

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Abstract: IoT has produced a commendable advancement in the home environments. It transformed the manual system into the smart systems with the approach of automation. Home automation is the remote supervision of household appliances with the involvement of the Internet. Home automation employed with an energy management strategy provides better results. Though energy management systems are available, but they are not efficient and are high cost. The energy meters are equipped near the appliances to calculate how much energy each appliance is utilized. The user is provided with certainly enhanced facilities in this system. The user can remotely ON and OFF the electrical appliances through the web page. To enhance the better functionality to the system, the developed system is employed with a webcam in which security is provided so that user can remotely observe the home environment. To eliminate high energy consumption, a certain threshold value is provided to every electrical appliance. Upon reaching the threshold value, the appliance will automatically turn OFF and can manage the rate of energy usage. The remote control of appliances, the energy the appliances are consuming, and the data from a webcam are realized with the Raspberry Pi 3. The Raspberry Pi 3 acts as a central server and uploads the data to the web server and the user can visualize the data in the web page. The implemented system is of low cost, efficient and performs the monitoring and controlling of electrical appliances dynamically.

Keywords: IoT, Home Automation, Energy management, Web Server, Raspberry Pi 3.

1. INTRODUCTION

Internet of Things allows devices to get associated with the user at any anytime based upon the service. IoT is the revolution in the era of the internet [1]. The smart devices become prominent with the advancement of IoT. The devices are made remotely handy to the user with the association of Internet. With the proficiency of the internet, all the conventional devices are transformed into smart devices [2]. The significant goal of IoT is to make the device function intelligently with the facilities of managing, controlling [3].

IoT enables producing the smart devices into the market in an economical way so that it will be feasible for the users to utilize the services of the smart device. Many domains like industrial automation, healthcare,

smart homes, smart energy management are predominantly employed with the IoT [4]. To manipulate the key functions of the devices and their features accordingly through the internet a computer like systems are used in the IoT. Distinct stages are governed in the Internet of Things they are the accumulation stage, transmission stage, process management and utilization stage [5].

Smart homes contribute users with facilities like comfort, energy saving, efficiency, improved life quality, advanced security [6] - [7]. Internet of Things in Home automation is one of the predominant development in the technology. By enhancing the technology in the home environment provides users with automation, energy saving. For a Smart home as different sensors and devices are from different companies it may rise to incompatibility issues [8]. So by integrating all the devices via the internet can overcome the incompatibility issues. IPv6 overcomes the drawbacks of IPv4 by providing more number of IP address in IPv6. The central processing element may have a data storage issues. So by providing cloud platform as the interface can overcome this problem.

Home automation comprises the primary controlling and managing activities in a household remotely. Home automation is needed because it drives human lives in a simple way [9]. The electrical appliances like washing machine, television, air conditioners, heater, fan, the light will be monitored and controlled remotely with the enhancement of the Internet of Things. The urge for IoT in the home automation is to establish connectivity between the home and the outside world.

The energy management system is necessary because energy consumption is increasing day by day [10]. So to sustain the consumption of energy this scheme is employed. Even though the specific electrical appliances is not needed, the user sometimes may forget to OFF the electrical appliance. By the energy management system, the user can save the electricity and can eliminate the unwanted usage of electricity [11]. The employment of webcam in the home automation system enables security to the home. It facilitates continuous monitoring of home remotely so that user can know if any intruder enters the house.

2. LITERATURE ANALYSIS

The devices in the era of IoT are classified into resource constrained and resource rich devices. The resource rich devices have all the support that a smart device desires. The resource constrained devices lack the support that a smart system desires. The communication between the resource constrained and resource rich devices are not feasible. The technologies like X10, Z-Wave, ZigBee, INSTEON, EnOCEAN are the conventional and prominent technologies in the home automation [12] – [14]. The ZigBee resembles the standards similar to Bluetooth and Wi-Fi standards. It adopts the IEEE 802.15.m ZigBee is not compatible with all the devices. For the device to device communication the ZigBee employs mesh protocol. The Z-Wave is one of the primeval available home automation technologies. It has cross compatibility amidst distinct systems. Every appliance is equipped with a Unique ID for enabling security. Z-Wave functions in US at a frequency of 908.42 MHz. The functional range of Z-Wave is confined to only 30 meters. The Z-Wave extends its functionalities to only 4 devices. The Z-Wave protocol terminates if the communication exceeds over 4 devices. X10 is the earliest home automation technology. X10 can be implemented with both the wired and Wireless Radio communication. Only one command is transmitted at a time. For multiple messages transmission it may raise decoding issues. The INSTEON functions on wireless systems and it employs switches to work with Radio frequency. The INSTEON works for power line devices at a data transmission rate of 1131.65 kHz and for wireless devices the data transmission rate is 90 MHz. EnOcean is the most modern automation technology it desires at working at zero energy consumption. It has the ability to function wirelessly.

The electrical appliances users used to implement Bluetooth, Infrared technologies. These technologies require a specific range to function. So IoT eliminates the operating range obstacles that are shown in Bluetooth

and Infrared technologies and hence provide a better system. Centralized controlling of all the smart devices must be employed with the help of computer-like processor. With the enhancement made in IoT, Energy consumption is one of the most challenging tasks for the smart home. About 27 % of the energy available is consumed by home appliances and consumer electronic products [15]. In this contemporary world, electricity is the essential need for every individual. Day by day the energy resources are decreasing, but the usage of electricity is widening. Sometimes users forget to turn OFF the electrical appliance which leads to consumption of more energy which is not required by the device. To collect the data from the appliances smart energy meters is employed [16].

In energy management approach, the household electrical loads are grouped into the constant and one-shot load [17] - [18]. The constant load is not turned OFF and is constantly active. The one-shot load is initiated during a precise span of time. The Power consumption in a number of smart devices is significantly based on two aspects that are standby power and normal operational power [19]. In the approach of standby power, the electrical appliances are held in static functioning. In the approach of normal operational power, the electrical appliances are held in continuous dynamic functioning. The energy management in the smart devices is accomplished by programming the appliances with the Raspberry Pi 3 with the interface of IoT [20]. For enhancing security scheme in the home environments camera can be added for providing better security [21]. The primary goal is to build understanding about energy consumption and adequate usage of electrical appliances in the home for energy saving.

3. HARDWARE USED IN SYSTEM IMPLEMENTATION

The Figure 1 represents the functional block diagram of the Implemented system and a detailed description of the modules are discussed below. In the Implemented System, the electrical appliance 1 and electrical appliance 2 are interfaced to two energy meters. Two Relays are interfaced between two energy meters and one Raspberry Pi 3 so as to do voltage conversions. The two LM358 IC is employed to count the pulses from the two energy meters and convey the power consumption information to the Raspberry Pi 3. The 16 X 2 LCD Display displays the parameters measured. The webcam is interfaced with the Raspberry Pi 3 for the purpose of security. It takes the snapshot of the intruder and sends it to the user.

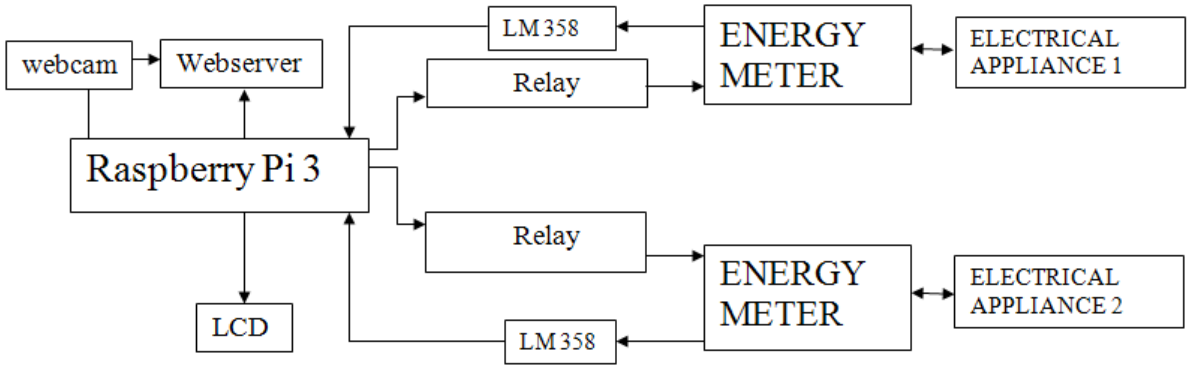


Figure 1: Block diagram of the implemented system

A. **Energy Meter:** It is a measuring device shown in Figure 2 used for the measurement of energy utilized by the Electrical appliances. The Energy consumed is visualized in terms of units. Home users generally use energy meter for monitoring and billing purposes. The traditional energy meter employs a rotating wheel for measurement of energy utilization. The modern energy meters measure the energy consumed and displays the readings on the screen available on the meter. The energy meter facilitates a two-way communication between the user and the electrical appliance.

Figure 2: Energy Meter

B. **Relay:** Relay shown in Figure 3 are used to split and set up connection so as to pass the current. Its significant application is to act like a switch. Relays are used in controlling and monitoring applications. The electrical appliances operate on 230 V, but the Raspberry Pi 3 works on 5 V. So to overcome this problem relays are used.

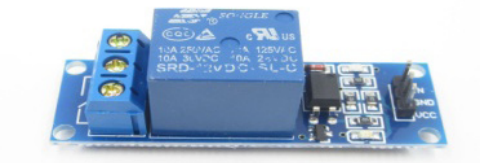


Figure 3: Relay module

C. **LM 358:** LM 358 shown in Figure 4 is a low cost, low power and dual channel operational amplifier. It is an 8 pin DIP and operates at a frequency of 1 MHz. Its main application is intended for level detections. It can operate from single power supply and distinct range of voltages 3-32 V. It also acts like a comparator. It compares the voltage applied at the input pins and produces the output. It eliminates separated power supply for running of each comparator for a distinct range of power supplies.

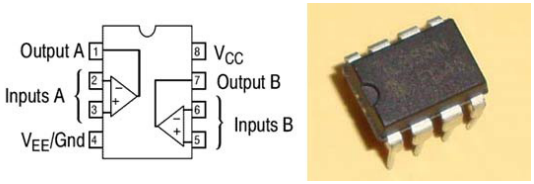


Figure 4: LM 358 pin configuration

D. **Raspberry Pi 3:** The Raspberry Pi 3shown in Figure 5 is a low cost, powerful processor. It facilitates on the operating voltage of 5 V. It can facilitate the user with all the features that are provided in the personal computer. The Raspberry Pi 3 acts as a central server and also as a gateway for protocol conversion that is from wired to wireless. The Raspberry Pi3 is programmed using Python programming language. All the information from electrical appliances is transferred to the Raspberry Pi with the aid of intermediate circuitry to achieve high computations and efficient data communication.

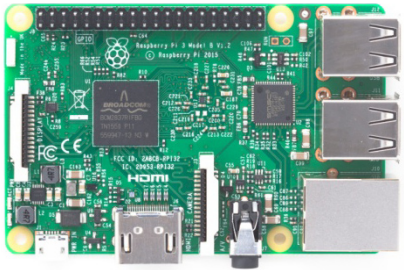


Figure 5: Raspberry Pi 3

E. **16X2 LCD Display:** 16X2 LCD display shown in Figure 6 is used to display the messages. The 16X2 LCD has a 2 line 16 character display. It will display the measurements that are ongoing in the system. The LCD display is advantageous over the seven segments and multiple segment LED's. 16X2 LCD is easily programmable and can be easily interfaced with any type of computing device. It has a set of commands to perform certain operations.

Figure 6: LCD Display

F. **Webcam:** The webcam shown in Figure 7 is used to take pictures or video call with the interfacing of computer like devices. It interfaces to the computer with the USB cable. It is low cost. The main use of the webcam is to act like a video camera and broadcast the information through the web. The Webcam is employed for security purpose in the field of home automation.

Figure 7: Webcam module

4. SYSTEM IMPLEMENTATION METHODOLOGY

The Figure 8 represents the experimental setup of the system and the working principle of the system is explained below. The Home Automation system developed is employed with energy management and security system. In this system, the implementation is done to control and monitor two electrical appliances. The devices used in this system are two electrical appliances, two energy meter, two relay integrated with Optocouplers, LM 358 IC, Webcam, Raspberry Pi 3.

Figure 8: Experimental setup of the System

The Raspberry Pi 3 provides a supply of 5 V but the electrical appliances in general operates on 230 V. So relays are employed in this system for voltage conversions and also to remotely ON and OFF the electrical appliance. The energy consumed by the two electrical appliances is governed by two energy meters. The energy consumed by two electrical appliances is displayed on the energy meters. The energy meters are given a threshold value of 200 Watts for the electrical appliances to function. If the user forgets to OFF, the electrical appliance, the appliance after consuming up to a threshold value of 200 Watts the appliance will be automatically OFF and hence the energy management scheme is employed. The LM 358 IC eliminates the electrical noise and acts as a voltage controlled oscillator. The LM 358 IC transmits the power readings taken by the energy meters to the Raspberry Pi 3. The Raspberry Pi 3 acts as central server and also a gateway because it employs in protocol conversion. The Raspberry Pi 3 uploads the meter readings into the database of the web server. The webcam in this system is implemented to enhance the security by monitoring the devices remotely through the web page. So that the user can take recommended action. The energy consumed by each electrical appliance is monitored and it also displays the user whether the appliance is in ON state or OFF state to the user in the web page. If the user doesn't want to operate the electrical appliance in ON state, the user can remotely swap the state with the help of interface provided on the web page and desired operation is performed. All the controlling and monitoring information is manipulated with the Raspberry Pi 3. The Raspberry Pi 3 is programmed using Python language. The implemented system is low cost, secure and energy consumption of the appliances is also reduced. It can provide the information in real time.

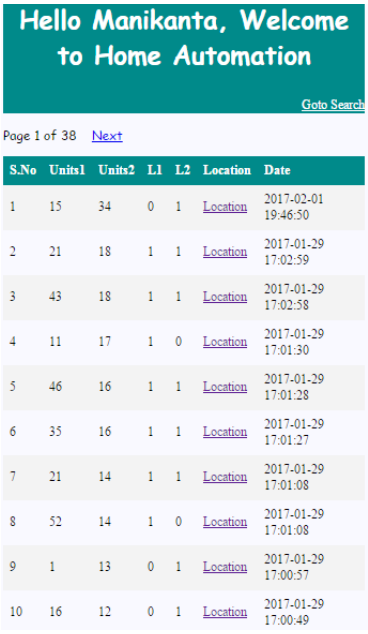
5. RESULTS

The developed system facilitates the user to monitor remotely the electrical appliance consumption from the energy meter with the aid of the web page.

In the web server the data are arranged in the form of tables and provides with as the user interface in the web page.

In the Figure 9 units1 and units 2 shows the status of energy consumed by both electrical appliance.

In the Figure 9 the L1 and L2 represent whether the device is in either ON state or OFF state and it also represents the time details.



S.No	Units1	Units2	L1	L2	Location	Date
1	15	34	0	1	Location	2017-02-01 19:46:50
2	21	18	1	1	Location	2017-01-29 17:02:59
3	43	18	1	1	Location	2017-01-29 17:02:58
4	11	17	1	0	Location	2017-01-29 17:01:30
5	46	16	1	1	Location	2017-01-29 17:01:28
6	35	16	1	1	Location	2017-01-29 17:01:27
7	21	14	1	1	Location	2017-01-29 17:01:08
8	52	14	1	0	Location	2017-01-29 17:01:08
9	1	13	0	1	Location	2017-01-29 17:00:57
10	16	12	0	1	Location	2017-01-29 17:00:49

Figure 9: The Results are displayed on the web page

The Figure 10 represents the remote operation of an electrical appliance 1 and 2. The User can remotely ON and OFF the two devices. Here electrical appliance 1 is made OFF and Electrical appliance 2 is made ON by the user.

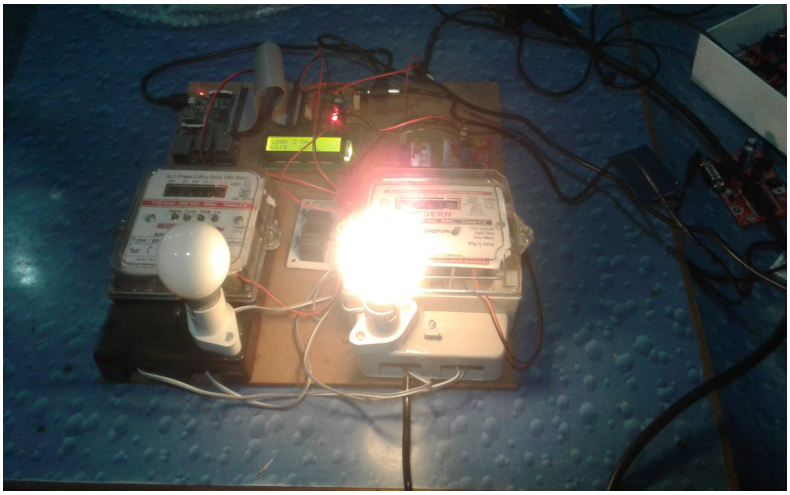


Figure 10: Remote control of electrical appliances

The Figure 11 represents the remote control of the both electrical appliances. In this case the electrical appliance 1 is made remotely ON and electrical appliance 2 is automatically switched OFF because it consumed the limit of energy. For the purpose of energy management this scheme is employed.

Figure 11: Electrical appliance 2 is employing energy management

Figure 12: Snapshot of intruder taken by web cam.

The webcam integrated in the home environment used to take the snapshot of the intruder person as shown in Figure 12. The user receives the intruder picture to the web page. So with this webcam facility the user will secure the home.

6. CONCLUSION

The implemented system resembles a key idea to control and monitor electrical appliances. The energy management scheme is also employed in this project and can also be extended to real time applications. Security scheme is also enhanced in this project with the help of a web cam. The developed concept is very efficient, low cost, and can be easily afforded by even common people. With slight modifications this project can be extended to monitor, control, manage energy consumption to the number of electrical appliances and also provide security.

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