Smart Power Monitoring and Controlling using Wireless Sensor Network

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Abstract— The design and development of a smart monitoring and controlling system for household electrical appliances in real time has been implemented. The novelty of this system is the implementation of the controlling mechanism of appliances in different ways. Proposed system monitors the electrical parameters such as voltage, current and subsequently calculates the power consumption of the home appliances that are need to be monitored. The innovation of this system is controlling mechanism implementation. Also the proposed system is a user authentication, economical and easily operable. Due to these intelligent characteristics it become an user friendly. Smart power conservation is a method of controlling home appliances automatically for the convenience of users. Controlling of electrical devices in the home that can be programmed using a Arduino controller or even via smart phone from anywhere in the world.

Keywords: Power Management, Home Automation, Intelligent Control System, WIFI Module, Bluetooth Module, Android App

I. INTRODUCTION

New technologies include cutting-edge advancements in information technology, sensors, metering, transmission, distribution and electricity storage technology, as well as providing new information and flexibility to both consumers and providers of electricity. A smart environment is a physical world that is interconnected through a continuous network abundantly and invisibly with sensors, actuators and computational units, embedded seamlessly in the everyday objects of our lives. A smart home is a residence in which computing and information technology apply to expect and respond to the occupants' needs and can be used to enhance the everyday life at home. Potential applications for smart homes can be found in these categories: welfare, entertainment, environment, safety, communication, and appliances. There is a need to cdesign and develop a real-time system which will monitor and control household appliances.

Wireless sensor networks (WSNs) have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. Due to those advantages, WSNs has been applied in many fields, such as the home automation, military, industry, environmental monitoring, and healthcare. The WSNs are increasingly being used in the home for energy controlling services. Regular household appliances are monitored and controlled by WSNs installed in the home [5]. The WSNs are increasingly being used in the home for energy controlling services. Regular household appliances are monitored and controlled by WSNs installed in the home. The system monitors electrical parameters of household appliances such as voltage, current and subsequently calculates the power consumed. The novelty of this system is the implementation of the controlling mechanism of appliances. The developed system will prove to be low-cost, flexible in operation and thus can save electricity expense of the consumers.

The WSNs are increasingly being used in the home for energy controlling services. Regular household appliances are monitored and controlled by WSNs installed in the home. The measurement of electrical parameters of home appliances is done by interfacing with fabricated sensing modules. The paper focuses on human-friendly technical solutions for monitoring and easy control of household appliances. The inhabitant's comfort will be increased and better assistance can be provided.

II. RELATED WORK

N.K.Suryaveda and S.C.Mukhopadhyay [1] reported the design and development of smart monitoring and controlling system for household electrical appliances in real time, in which it emphasizes the realization of monitoring and controlling of electrical appliances in many ways. They determined the areas of daily peak hours of electricity usage levels and come with a solution by which we can lower the consumption and enhance better utilization of already limited resources during peak hours.

N.K Suryadevara and S.C.Mukopadhyay [7] reported a mechanism for estimation of elderly well-being condition based on usage of house-hold appliances connected through various sensing units. This paper defines two new wellness functions to determine the status of the elderly on performing essential daily activities. The developed system for monitoring and evaluation of essential daily activities was tested at the homes of four different elderly persons living alone and the results are encouraging in determining wellness of the elderly. In this research wellness is about well-being of elderly in performing their daily activities effectively at their home. This will facilitate the care providers in assessing the performance of the elderly activities doing independently. The developed home monitoring system using WSN is low cost, robust, flexible, and efficiently monitor and assess the elderly activities at home in real time.

Song *et al*. [4] presented the design and implementation of a home monitoring system based on hybrid sensor networks. The system follows a three-layer architecture which combines hybrid-node networking with web access. An enhanced sensor node has been designed and fabricated to add controlled mobility to wireless sensor networks. Network repair and event tracking capabilities of the mobile sensor node were tested. Stability of the proposed system in long time home monitoring tasks was also verified.

Suh and Ko [5] proposed an intelligent home control system based on a wireless sensor/actuator network with a link quality indicator-based routing protocol to

enhance network reliability. It can integrate diversified physical sensing information and control various consumer home devices, with the support of active sensor networks having both sensor and actuator components.

Nguyen *et al*. [6] have proposed building a smart home system with WSN and service robot. In which they have presented the design of optical linear encoder(OLE) based system for function of capturing human arm motion and arm function evaluation for home based monitoring and this system would also find wide range application in field of rehabilitation.

Wireless sensor networks have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. X.P.Liu, W.Gueaieb, S.C.Mukhopadhya, W.Warwick and Z.Yin reports some of the latest theoretical developments and applications in this fast-growing area. Mechatronic systems will become more and more ubiquitous at home in near future and will be very useful in assistive healthcare particularly for the elderly and disable people. Wireless mechatronic devices, services, and systems consisting of spatially distributed autonomous sensors are used to monitor globally or locally physical or environmental conditions, such as temperature, vibration, pressure, motion etc. [9]

Bellido et al [2] proposed building lighting automation system using digital addressable lighting interface (DALI) devices with wireless sensor networks.

Leccese [3] proposed remote-control system can optimize management and efficiency of street lighting systems.

III. PROBLEM STATEMENT

The Proposed system aims to design a system that can monitor electrical parameters of household appliances such as voltage, current and subsequently calculates the power consumed. This system checks the status of appliances in the absence of person at home and gives a feedback to the particular user. This system will also give an option to operate the appliance in economic mode. In economic mode bill amount will be set first and accordingly the system based on the amount sets threshold which eventually controls the appliance to get the desired power consumption.

IV. SYSTEM DESCRIPTION

The functional description of the system to monitor electrical parameters and control appliances based on the consumer requirements. The measurement of electrical parameters of home appliances is done by interfacing with fabricated sensing modules. The system operates/controls in two modes. Normal mode (controlling)and economic mode. In normal mode or manual controlling, device status changed by manually. In economic mode, device status is changed by the Android APP. In that mode set threshold value for operation of devices. If devices operates at above threshold value then only one device is operated other devices are in off state. In that system Bluetooth module and WIFI module is used. Bluetooth module is used for controlling application. Android app is paired with Bluetooth module. The Bluetooth module is interfaced with various sensing devices and interconnected to have reliable data reception at WIFI module.

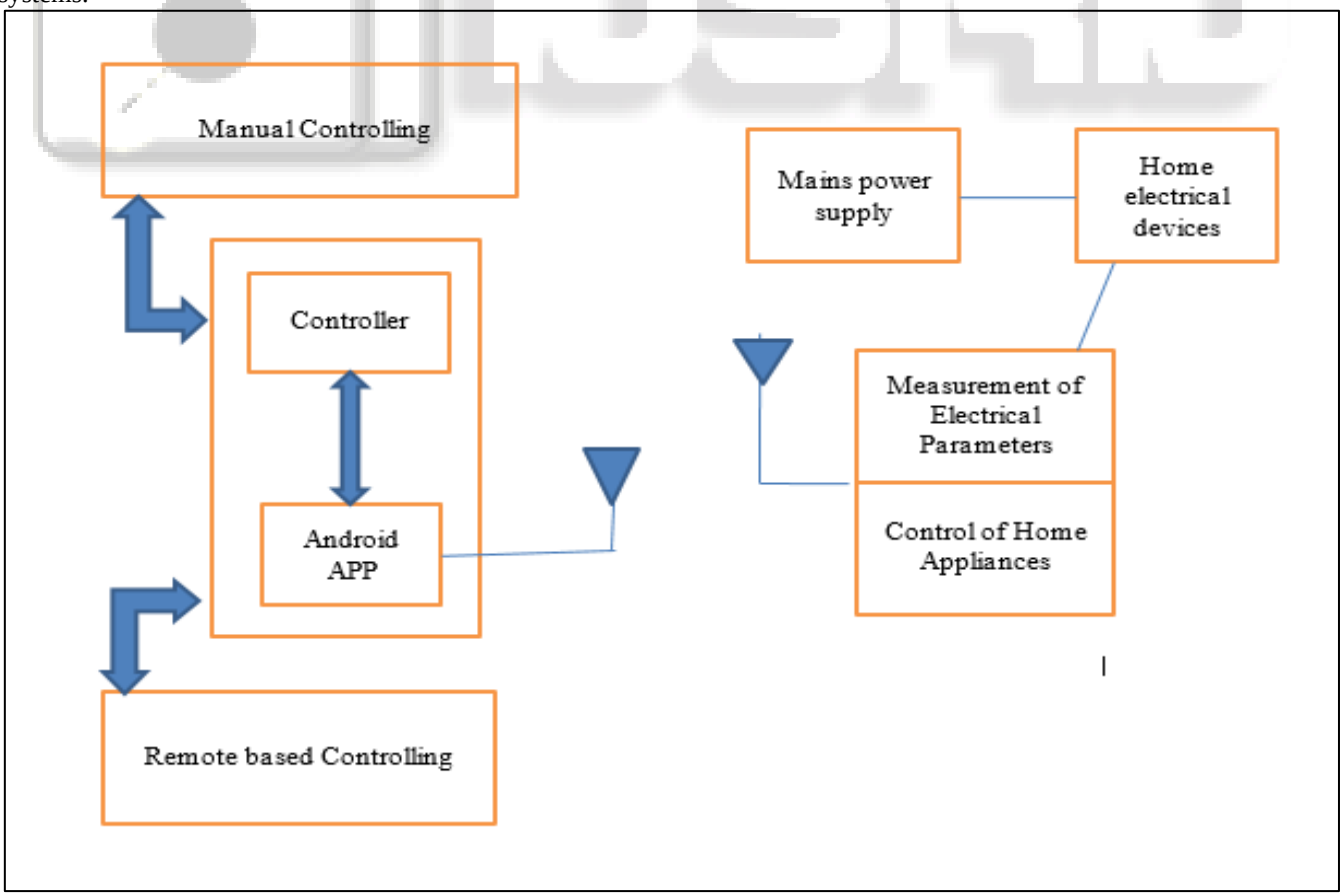


Fig. 1: Functional block diagram of the system

With the help of WIFI module data is displayed on GUI i.e ThingSpeak. GUI is plotted with respect to power and date. From GUI, getting different power ratings of different devices at different time. The appliances are controlled either automatically or manually. The smart power metering circuit is connected to mains 230 V/50 Hz supply.

By monitoring consumption of power of the appliances, data are collected by a smart coordinator, which saves all data in the system for processing as well as for future use. The parameters will be entered in the data coordinator in software from appliances include power. These parameters will be stored in a database and analyzed. Collected data will be displayed on the computer through graphic user interface (GUI) window so that appropriate action can be taken from the GUI.

A. Hardware Implementation

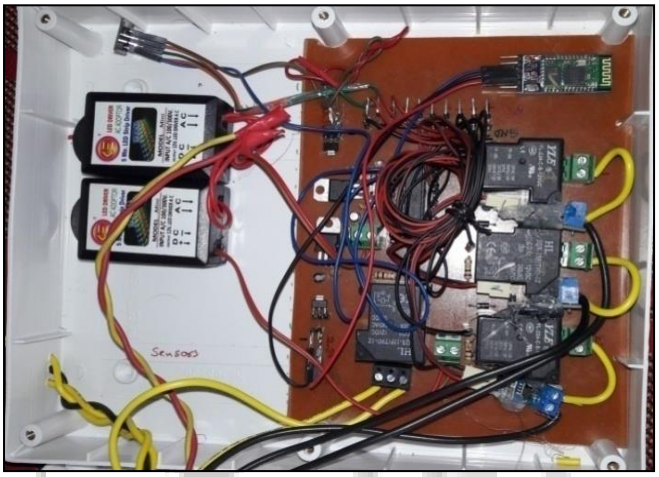


Fig. 2: Hardware setup with manual mode

Fig. 3: Hardware setup with economic Mode

B. Power Measurement

Power is rate of expending energy. Watt is the unit for power (joule per second (J/s)). The difference in potentials between two points is equal to the energy per unit charge and this is required to move electric charge between the points, as we know, electric current measures the charge per unit time (in coulombs/second). The electric power *p* is given by the product of the current I and the voltage V (in joules/second = watts).

P=work done per unit time=qV/t=IV

Where: *q* is electric charge in coulombs, *t* is time in seconds, *I* is electric current in amperes, *V* is electric potential or voltage in volts

1) Energy:

The amount of energy used (or supplied) depends on the power and the time for which it is used. Energy is defined by scientists as the ability to do work. This energy is found in different forms, such as light, heat, sound, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.

E=P*t

Where: E= energy in watt hrs, P= power in watts, t= time taken in sec

where *R* is the electrical resistance.

2) AC Circuits:

Energy storage elements such as inductance and capacitance results in periodic reversals of the direction of energy flow which are alternating in nature.

3) Active Power:

The power consumed by the resistive elements in the circuit or the portion of power flow that, averaged over a complete cycle of the AC wave form, results in net transfer of energy in one direction is known as real power ,also called as Active power. It is the power that is actually being consumed by the load.

Active power *P* or real power watt (W)

4) Reactive power:

Power flow due to storage elements that returns to the source in each cycle is known as reactive power. When the voltage and current are periodic with the same fundamental frequency, the instantaneous power is also periodic with twice the fundamental frequency.

5) Reactive power,

Q: volt-ampere reactive (var)

6) Complex power,

S: volt-ampere (VA)

7) Apparent power,

|*S*|: the magnitude of complex power *S*: volt-ampere (VA)

C. Power calculation

Appliances	Load (W)	Voltage (V)	Current (A)	Power Factor
Hair dryer	1000	220	4.54	0.91
Iron	1000	240	4.16	1
Tea maker	900	220	4.09	0.91
Mixer	750	230	3.26	1
Hot water bag	500	220	2.27	1
Hand blender	200	230	0.87	0.99

Laptop charger	66	20	3.3	1
Mobile charger	5	5	1	1
Trimmer	15	220	0.68	0.1

Table 1:

D. Software Implementation

1) Bluetooth Terminal APP

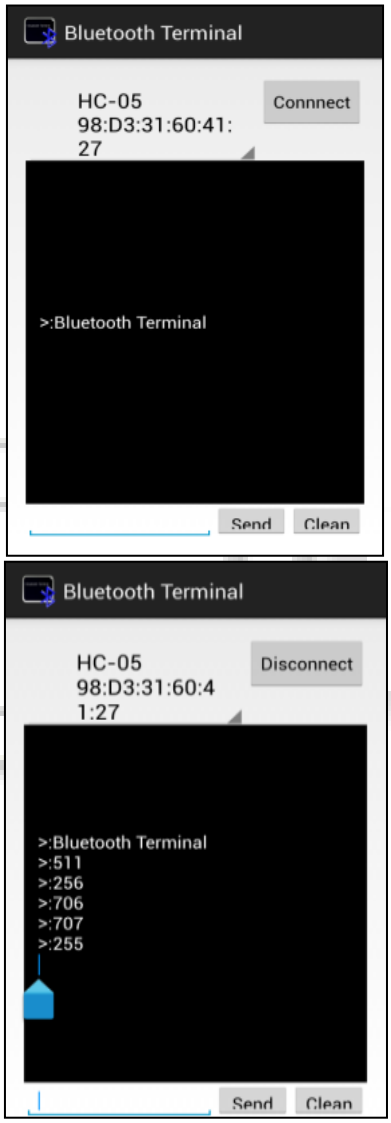


Fig. 4: Controlling using Bluetooth terminal App

E. Software:

1) HTTP

The Hypertext Transfer Protocol (HTTP) is designed to enable communications between clients and servers. HTTP works as a request-response protocol between a client and server. A web browser may be the client, and an application on a computer that hosts a web site may be the server.

Two HTTP Request Methods: GET and POST

Two commonly used methods for a request-response between a client and server are: GET and POST.

– GET - Requests data from a specified resource

– POST - Submits data to be processed to a specified resource

1) The GET Method:

Note that the query string (name/value pairs) is sent in the URL of a GET request:

/test/demo_form.asp?name1=value1&name2=value2

Some other notes on GET requests:

GET requests can be cached

GET requests remain in the browser history

GET requests can be bookmarked

GET requests should never be used when dealing with sensitive data

GET requests have length restrictions

GET requests should be used only to retrieve data

2) The POST Method:

Note that the query string (name/value pairs) is sent in the HTTP message body of a POST request:

POST/test/demo_form.aspHTTP/1.1

Host:w3schools.com

name1=value1&name2=value2

Some other notes on POST requests:

POST requests are never cached

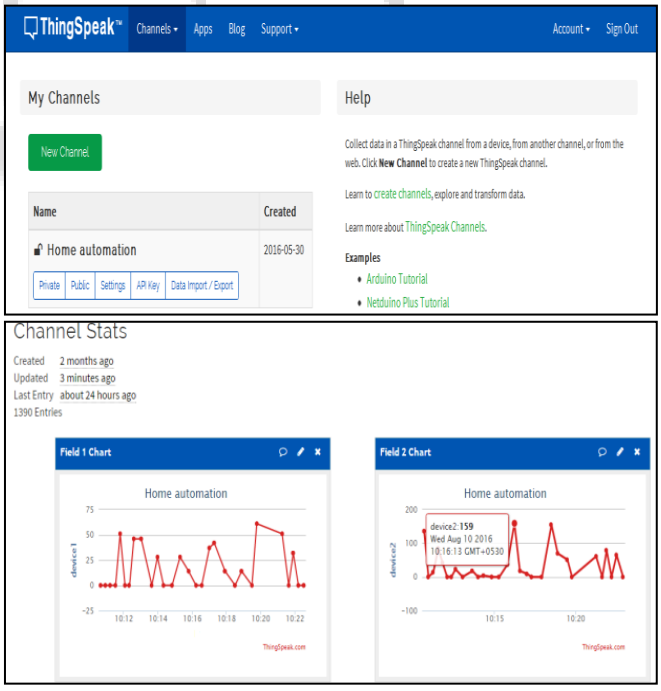
POST requests are never cached

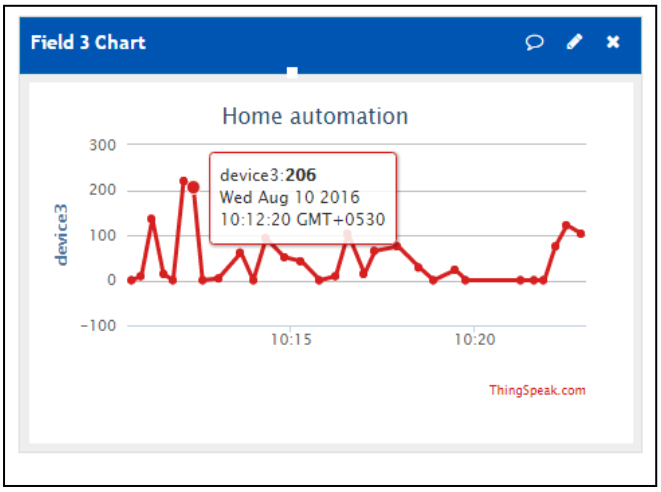
POST requests do not remain in the browser history

POST requests cannot be bookmarked

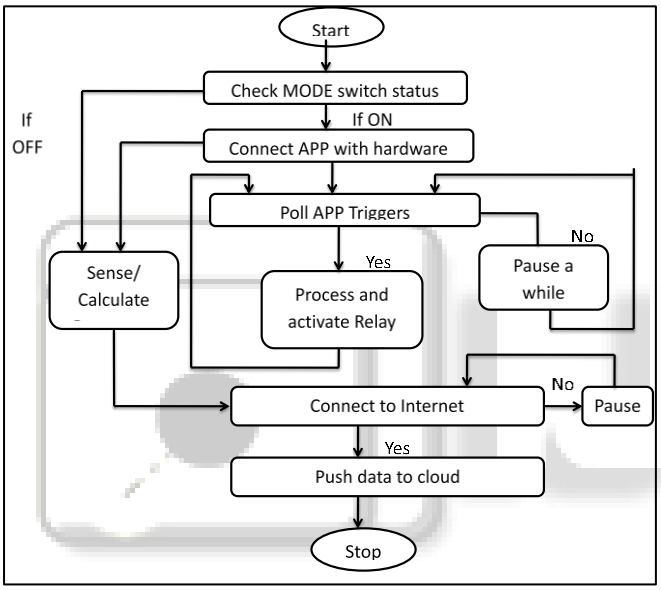
POST requests have no restrictions on data length

V. RESULTS





VI. SYSTEM FLOWCHART



VII. CONCLUSION

An intelligent power monitoring and control system will be design and develop towards the implementation of smart building. The proposed system will monitor and control the electrical appliance usages at home.

The real-time monitoring of the electrical appliances can be viewed through website. The sensor networks will be programmed with various user interfaces suitable for users such that the system can be maintained and interacted easily.

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