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Efficient Power Management In Home Using Wireless Sensor Networks

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***Abstract*—Design and development of smart monitoring and controlling system for household electrical appliances in real time is proposed. Increasing power consumption is becoming a huge problem. In this sytem, we propose an intelligent energy distribution system with a fixed power use of every home set from Electricity Board(EB) office. Power distribution from EB is the major issue because of shortage in power generation from renewable and non-renewable resources. We design this, in order to reduce the frequent power cut off. Moreover monitoring and controlling of home appliances is developed either manually, remotely and with the help of internet automatically. The main aim is to provide low cost and flexible operation. The goal is to develop a newly equipped well designed prototype for consumers in home to limit the usage of power. This helps users and power distribution centre to manage the power in an efficient manner. Practically applied in home and in EB unit with the help of microcontrollers and zigbee transceivers. Internet provides the data effectively, in order to manage the power by controlling the home appliances.**

***Index Terms*—EB, Microcontrollers and zigbee transceivers**.

I.INTRODUCTION

Wireless sensor network (WSN) easily monitor assets or environment with reliable, battery-powered measurement nodes that offer industrial ratings and local analysis and control capabilities. Each wireless network can scale from tens to hundreds of nodes and seamlessly integrate with existing wired measurement and control systems. A wireless sensor network consists of three main components: nodes, gateways, and software. The spatially distributed judgment to the lowest degree possible but does not completely eliminate it. Depending on the location of its measurement nodes interface with sensors to monitor assets or their environment. The acquired data wirelessly transmits to the gateway, which can operate independently or connect to a host system where you can collect, process, analyze, and present your measurement data using software. Routers are a special type of measurement node that can be used to extend WSN distance and reliability.

The world passing the biggest problem of power. Because the production of power is less than the demand power of consumer side. In many countries the increase in demand is growing at a faster rate than transmission capacity and also the cost of providing power is also increasing due to the higher coal prices and deficiency of fuel. Also the reason of not getting the full power to consumers side is that the growing population of countries. To overcome the problem of power distribution this paper provides an overview of wireless sensor network by managing the equal power distribution by using zigbee network sensor.

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.

Automation is, where more things are being completed every day automatically, usually the basic tasks of turning on or off certain devices and beyond, either remotely or in close need to maintain as much control as we can over the automated processes. Automation lowers the human usage, automation differs in its name as industrial automation, home automation etc.

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The rest of the paper is organized as follows: Section II discusses the existing system; Section III provides detailed implementation of the proprosed system; Section IV and V presents the block diagram and experimental results. Section VI has concluded and discussed about the future work

II.EXISTING SYSTEM

In this section, we briefly discuss the existing works about smart home systems based on wireless communication technology. Various proposals are there to interconnect domestic appliances by wireless networks to monitor and control which are provided in [2], [3]. Also, smart meter systems like [3]–[5] have been designed to specific usages particularly related to geographical usages and are limited to specific places. Different information and communication technologies integrating with smart meter devices have been proposed and tested at different flats in a residential area for optimal power utilization [6], [7], but individual controlling of the devices are limited to specific houses. There has been design and developments of smart meters predicting the usage of power consumption [3]–[7]. However a low-cost, flexible, and robust system to continuously monitor and control based on consumer requirements is at the early stages of development. In this , we have designed and implemented a ZigBee-based intelligent home energy management and control service. We used the ZigBee (the IEEE 802.15.4 standard) technology for networking and communication because it has low-power and low-cost characteristics, which enable it to be widely used in home and building environments [4]. The disadvantage are: the physical wiring from the meter to the house can still be an obstacle for an easy implementation of this solution, particularly for tall or old buildings, due to cost and installation complexity.

Han *et al*. [9] proposed a Home Energy Management System (HEMS) using the ZigBee technology to reduce the standby power. The system consists of an automatic standby cutoff outlet, a ZigBee hub and a server. The power outlet with a ZigBee module cuts off the ac power when the energy consumption of the device connected to the power outlet is below a fixed value. The central hub collects information from the power channels and controls these power channels through the ZigBee module. The central hub sends the present state information to a server and then a user can monitor or control the present energy usage using the HEMS user interface. This facility may create some uneasiness for the users. For example, if the users may want low intensity of light, for some situation but the system will cut the power off leading to darkness.

Gill *et al*. [10] projected a ZigBee-based home automation system. This system consists of a home network unit and a gateway. The core part of the development is the interoperability of different networks in the home environment. Less importance is given to the home automation. Pan *et al*. [11] recommended a WSN-based intelligent light control system for indoor environments, such as a home for a reduction in energy consumption.

In this paper, wireless sensors are responsible for measuring current illuminations and the lights are controlled by applying the model of user's actions and profiles.

The above mentioned home monitoring and controlling systems have limitations with respect to home automation such as: 1) energy consumption control mechanism is limited to only certain devices like light illuminations, whereas several household appliances can be controlled; 2) energy control is based on fixed threshold power consumption, which may not be applicable to different consumers; 3) controlling the home appliances through network management functions, in practice inhabitant requirements may vary according to their behavior but not with network characteristics. A low-cost, flexible, and real-time smart power management system, which can easily integrate and operate with the home monitoring systems such as [12] is presented.

The system is designed to monitor the humidity of polyhouse environment. On-demand meter reading and remote troubleshooting allow utilities to provide better and more timely consumer support. Utilities have more at hand about outages and restorations, and are able to consumers with good information about when power will be restored. During emergencies, utilities can create "partial outages" in non-exempt buildings to ensure the power remains available where it is most needed. Partial outages are more economically efficient than full rotating outages, because the effects are limited to the reduction of a single discretionary service such as air conditioning rather than the elimination of all services. Also power factor improvement can result in a lot of power saving for industrial sector. Power demand and usage, allowing utilities and consumers alike to do their part to ensure continued and affordable supply of essential services

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III.PROPOSED SYSTEM

A.Wireless Sensing And Intelligent Buildings

Present day intelligent buildings are highly adaptable to changing environmental conditions. They have automated systems, including wireless sensor monitoring, to facilitate energy efficient, comfortable and cost effective environments by optimising structure, systems, services, building management and their interrelationships. In the context of the future 'Internet of Things', Intelligent Building Management Systems can be considered part of a much larger information system. This system is used by facilities managers in buildings to manage energy use and energy procurement and to maintain buildings systems. It is based on the infrastructure of the existing Intranets and the Internet, and therefore utilises the same standards as other IT devices. Within this context reductions in the cost and reliability of WSNs are transforming building automation, by making the maintenance of energy efficient healthy productive work spaces in buildings increasingly cost effective.

Wireless sensing in commercial and office buildings has lead to a greater awareness of the condition of buildings and their systems: As it provides information necessary for those in charge of building operation and maintenance to recognise limits and non-functioning equipment and systems and prioritise building maintenance tasks etc. based on costs and other important factors. The main benefits of this are:

- An increased lifespan for equipment/electric appliances;
- An improved building environment for occupants;
- Economies of scale gained from monitoring, tracking and responding to the status of multiple building assets from centralised or regional locations;
- The ability to detect impending faults and therefore minimise energy usage associated with facility assets and increase reliability while reducing costs;
- Lower energy and operating costs leading to an advantageous return on investment. For example energy management systems based on WSNs can save an average of 10 % in overall building energy consumption and the energy savings can be as high as 30% depending on occupancy.

B.Recent advances

The WSNs used in intelligent building management systems consist of different types of sensor nodes measuring parameters such as temperature, humidity, light, asphyxiating gases/smoke, occupancy, and energy consumption. In addition, the systems may include actuators, gateways, servers and communication and application software on different levels as well as different home appliances. A large amount of research has been conducted focusing on different aspects of WSN for building management and control.

C.ZigBee Wireless Sensor Network

The gateway functions both as a server storing network data and a connection point between the network nodes, the LAN and the external server. It has the coordinator role in the ZigBee network. A Web user interface running on the gateway enables the user to set up and manage the gateway and the WSN.

Several battery-driven wireless sensor nodes with internal sensors to measure temperature, light and humidity are deployed in the network. These nodes are able to form mesh networks and can operate within an indoor range of about 40 metres. They function as end-devices in the ZigBee WSN.

A number of remotely controlled ZigBee devices with relays are used as switches to power external equipment, such as table fans, desk lamps, etc. These devices, which act as routers in the WSN, are plugged into power points. They are also used as meters for measuring the voltage, current, frequency, power consumption and load of the attached equipment.

IV.BLOCK DIAGRAM

The system has been designed for measurement of electrical parameters of household appliances. The measurement of electrical parameters of home appliances is done by interfacing with sensing modules. The output signals from the sensors are integrated and connected to XBee module for transmitting electrical parameters data wirelessly. The XBee modules are interfaced with various sensing devices and interconnected in the form of mesh topology to have reliable data reception at a centralized ZigBee coordinator. The maximum distance between the adjacent ZigBee nodes is less than 10 m, and through hopping

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technique of the mesh topology, reliable sensor fusion data has been performed. The ZigBee coordinator has been connected through the USB cable of the host computer to store the data into a database of computer system. The block diagram of the system is shown in Fig.1 and Fig.2. The collected sensor fusion data have been sent to an internet residential gateway for remote monitoring and controlling the home environment. By analyzing the power from the system, energy consumption can be controlled. The appliances are controlled either automatically or manually. The smart power metering circuit is connected to mains 240 V/50 Hz supply.

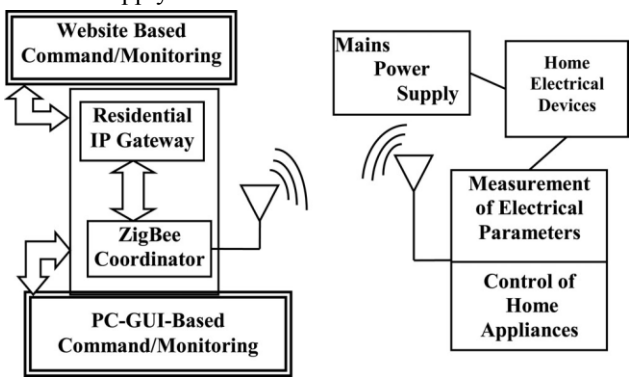

Fig 1. Block diagram of the system

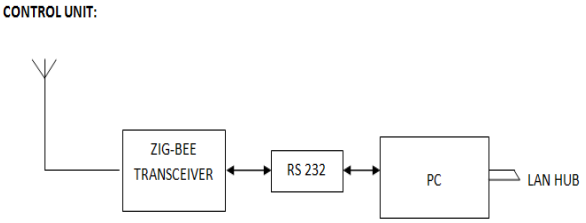

Fig 2. Control unit

The home automation system is a key for energy conservation that can be equipped in normal buildings. Now-a-days the demand for home automation systems in homes and offices are invariably increasing. These systems directly work on the household appliances to provide effortless operation and control of the devices. In this paper we have presented the concept of smart home automation to reduce the energy consumption and wastage using advanced graphical software called LabVIEW. It provides the programming tools to code power system applications more easily, which saves programming time. With the development of low cost electronic components home automation migrated from being an industrial application to home automation.

A.Zigbee Overview

There are three categories of nodes in a ZigBee system. They are Coordinator, Router and End devices.

1) Coordinator : It is responsible for initiating the network and selecting the network parameters such as radio frequency channel, unique network identifier and setting other operational parameters. It can also store the information about network, security keys.

2) Router: Router acts as intermediate nodes, relaying data from other devices. Router can connect to an already existent network, also able to accept connections from other devices and be some kind of re-transmitters to the network. Network may be extended through the use of ZigBee routers.

3) End Devices: End Device can be low-power /battery-powered devices. They can collect various information from sensors and switches. They have sufficient functionality to talk to their parents (either the coordinator or a router) and cannot relay data from other devices.

B. Control of Home Appliances

1) Automatic control: Based on the electricity tariff conditions, the appliance can be regulated with the help of smart software. This enables the user to have more cost saving by auto switch off the appliances during the electricity peak hours. The electricity tariff is procured from the website of the electricity supply company and is updated at regular intervals.

2) Manual control: An on/off switch is provided to directly intercede with the device. This feature enables the user to have more flexibility by having manual control on the appliance usage without following automatic control. Also, with the help of the software developed for monitoring and controlling user interface, user can control the device for its appropriate use. This feature has the higher priority to bypass the automatic control.

3) Remote control: The smart power monitoring and controlling software system has the feature of interacting with the appliances remotely through internet (website). This enables user to have flexible control mechanism remotely through a secured internet web connection. This sometimes is a huge help to the user who has the habit of keeping the appliances ON while away from house. The user can monitor the condition of all appliances and do the needful.

Residential IP Gateway: Transmission Over IP

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In order to transmit real-time sensed data over the internet from the collected computer system, the ZigBee packet information is to be transformed to the Internet Protocol Version 6(IPv6). The key element in the data transformation from Zig-Bee packet is the address translation. This was implemented at the application gateway, a program for determining the source or destination address of a packet that encapsulates a ZigBee packets' payload.

The corresponding application gateway program performs the address transformation mechanism for ZigBee to address non-ZigBee nodes. ZigBee is based upon the IEEE 802.14.5 protocol, which uses a 64-bit address for each node on a personal area network (PAN) and 16 bits to identify the PAN ID. IPv6 uses 128 bits to address a node on the network, of which 48 bits represent the network, 16 bits represent the local network (PAN ID), and 64 bits represent the host id (sensor node). Therefore, the node address for the IEEE 802.15.4 can be placed in an IPv6 address, and the PAN ID can be used to identify the ZigBee network in an IPv6 address.

B.Labview

Lab VIEW stands for Laboratory Virtual Instrumentation Engineering Workbench. Lab VIEW is a graphical programming language used to create programs called VI which are in a pictorial form called a block diagram, which eliminates a lot of the syntactical details of other programming languages like C and MATLAB that use a text based programming approach. It is simple and flexible, since it is a graphical approach no need of writing programs of 100 lines like other program languages. Each has two windows-Front Panel and Block Diagram windows. Front Panel is user interface which has controls and indicators. Block Diagram is program code which shows data travels on wires from controls through functions to indicators. The major drawback for Lab VIEW not into application is its cost. The advantage of Lab VIEW in home automation not only makes it easier to design but also increases the accuracy and speed of the system. LabVIEW is a highly productive development environment for creating custom applications that interact with real-world data or signals in fields such as science and engineering. The net result of using a tool such as LabVIEW is that higher quality projects can be completed in less time with fewer people involved. So productivity is the key benefit, but that is a broad and general statement. LabVIEW is unique because it makes this wide variety of tools available in a single environment ensuring that compatibility is as simple as drawing wires between functions. LabVIEW itself is a software development environment that contains numerous components.

V.EXPERIMENTAL RESULTS

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 voltage, current, and 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 which is shown in Fig.3 so that appropriate action can be taken from the GUI. The processed voltage, current, and power values are displayed on the graphical user interface running on a computer. The processed data are accurate and user friendly. The sensing system in the sensor node measures the parameters (voltage and current). The raw data (i.e., converted ADC values) are transmitted to the coordinator. The computer then collects the data from the coordinator in Fig.4 and processes them. The computer then applies the necessary formulas to get the actual voltage, current, and power consumption of the electrical appliances. The voltage and current readings are processed using LABVIEW. Depending on the inhabitant usages, appliances connected by smart sensing units are controlled either by automation based on the tariff conditions or by the inhabitant locally using GUI and remotely using the website. Thus, the regular household electrical appliances along with smart sensing have been internetworked through internetworking technology by integrating ZigBee with IPv6 for better remote management of household appliances.Simulated resukts are shown using Proteus 7.0.

Fig 3. Power consumption based on time scheduling

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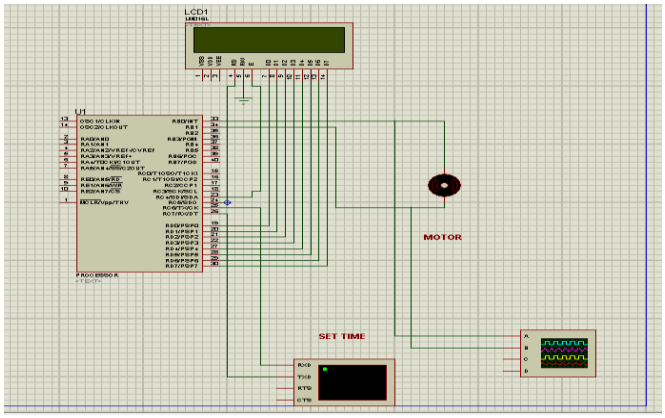

Fig 4. Schematic for power consumption

VI.CONCLUSION AND FUTURE WORK

Smart monitoring and controlling system for household electrical appliances in real time is designed. Thus the power consumption is minimized by providing periodic alert and managing the power consumption based on the usage of the customer automatically.The advantages are as follows: no cabling required, easy inclusion of significant data coming from other meters similarly equipped with centre to manage the power in an efficient manner**.** As a part of future work, prototype has to be designed for implementation of power management.

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