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An Intelligent Power Management in Intelligent Buildings

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ABSTRACT: Intelligent Power Management is the combination of smart sensors and actuators. The design and development of an intelligent monitoring and controlling system for home appliances in a real time system is reportedin this paper. This system principally monitors the electrical parameters such as voltage and current and subsequentlycalculates the power consumption of the home appliances that are need to be monitored. The innovation of this systemis controlling mechanism implementation in so many ways. Also the proposed system is an economical and easilyoperable. Due to these intelligent characteristics it become an electricity expense reducer and people friendly. Theprototype has been extensively developed and tested in real time scenarios also the results are appreciable.

KEYWORDS: Energy Management, Home Automation,Intelligent Control System, Wireless Sensor Network.

I. INTRODUCTION

Present day smart structures are profoundly versatile to changing natural conditions. They have mechanized frameworks, including wireless sensor observing, to encourage vitality productive, agreeable and practical situations by improving structure, frameworks, administrations, building administration and their interrelationships (Grondzik et al 2010). In the setting without bounds ' internet of Things', Smart Building Administration Frameworks can be considered part of a much bigger data framework. This framework is utilized by offices administrators as a part of structures to oversee vitality use and vitality obtainment and to keep up structures frameworks. It depends on the framework of the current Intranets and the Web, and in this way uses the same principles as other IT gadgets. Inside of this connection diminishments in the expense and dependability of WSNs are changing building computerization, by making the support of vitality proficient sound beneficial work spaces in structures progressively savvy. Remote detecting in business and office structures has led to a more prominent attention to the state of structures and their frameworks: As it gives data important to those responsible for building operation and support as far as possible and non-working hardware and frameworks and organize building upkeep errands and so forth in light of expenses and other vital variables (Brambley et al, 2005, Menzel et al, 2008). The primary advantages of this are:

• An expanded lifespan for gear/electric machines;

• An enhanced building environment for tenants;

• Economies of scale picked up from checking, following and reacting to the status of various building resources from incorporated or territorial areas;

• The capacity to identify approaching flaws and in this way minimize vitality utilization connected with office resources and expansion unwavering quality while diminishing costs.

The 6LoWPAN subsystem is formed by one server, two routers, and ten battery driven sensor nodes, see Fig. 1.The server, which stores both sensor data and network information, is connected to the Local Area Network(LAN) and provides a Web Interface, which displays data from the sensors and the network. Through thisinterface the user is able to manage and control the wireless network.

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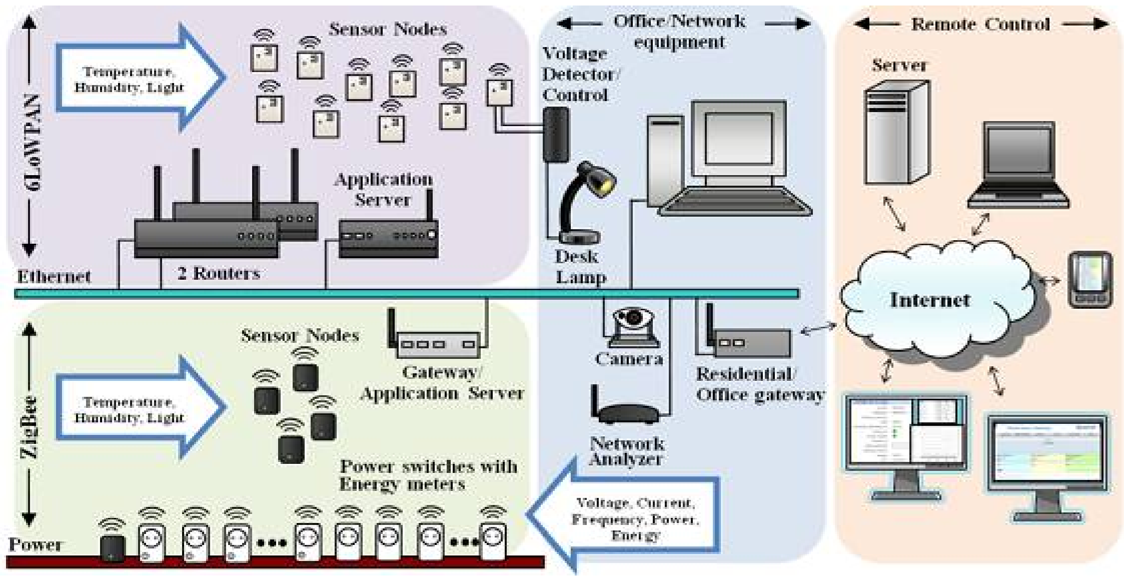

Fig. 1: The wireless sensor network concept

Access to the network from the server goes through the two parallel working routers. These routers manage the routing between the sensor nodes and the IP network connected to the server. Deploying two routers in the same network of sensor nodes will scale the throughput of the network. Each router is able to take over the other router's tasks in cases of a non-operational router, which increases the redundancy and reliability of the network. All the ten sensor nodes include integrated temperature, humidity and light sensors, and communicate with routers and each other using mesh routing protocols. The indoor operation range is approximately 50 metres. Built-in expansion ports make it possible to connect the sensor nodes to different external sensors, switches, and actuators. To utilize this range of use one of the 6LoWPAN sensors in the pilot network was connected to a device functioning as a relay controlling the mains to a desk lamp, as can be seen in Fig. 1. From the server's Web interface the lamp was remotely switched on and off.

II. RELATED WORK

In this section, we briefly discuss the existing works aboutsmart home systems based on the wireless communication technology. Han et al. [6] proposed a Home Energy ManagementSystem (HEMS) using the ZigBee technology to reduce thestandby power. The suggested system consists of an automaticstandby power cutoff outlet, a ZigBee hub and a server. Thepower outlet with a ZigBee module cuts off the ac power whenthe energy consumption of the device connected to the poweroutlet is below a fixed value. The central hub collects information from the power channels and controls these power channelsthrough the ZigBee module. The central hub sends the presentstate information to a server and then a user can monitor orcontrol 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, forsome situation but the system will cut the power off leading todarkness.

Gill et al. [7] projected a ZigBee-based home automationsystem. This system consists of a home network unit and a gateway. The core part of the development is the interoperability ofdifferent networks in the home environment. Less importanceis given to the home automation. Pan et al. [8] recommended aWSN-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 measuringcurrent illuminations and the lights are controlled by applyingthe model of user's actions and profiles.Song et al. [9] suggested a home monitoring system usinghybrid sensor networks. The basic concept of this paper is aroaming sensor that moves the appropriate location and participates in the network when the network is

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disconnected. Suh andKo [10] proposed an intelligent home control system based ona wireless sensor/actuator network with a link quality indicatorbased routing protocol to enhance network reliability. Nguyenet al. [11] have proposed a sensing system for home-based rehabilitation based on optical linear encoder (OLE); however, it islimited to motion capture and arm-function evaluation for homebased monitoring. Huiyong et al. [12] examined the integrationof WSN with service robot for smart home monitoring system.

The above mentioned home monitoring and controlling systems have limitations with respect to true home automation suchas:
1) Energy consumption control mechanism is limited to onlycertain devices like light illuminations, whereas several household appliances can be controlled;
2) Energy control is based onfixed threshold power consumption, which may not be applicable to different consumers;
3) controlling the home appliancesthrough network management functions, in practice inhabitantrequirements may vary according to their behavior but not withnetwork characteristics. Not a single system has taken into consideration of variable tariff of electricity, which is consumedthroughout day and night.

III. **PROPOSED SYSETM**

The system has been designed for measurement of electrical parameters of household appliances. Important functions to the system are the ease of modelling, setup, and use. From the consumer point of view, electrical power consumption of various appliances in a house along with supply voltage and current is the key parameter. Fig. 1 shows the functional description of the developed 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 details of the design and development of the sensing modules are provided in the following sections. The outputsignals from the sensors are integrated and connected to XBee module for transmitting electrical parameters datawirelessly. The XBee modules are interfaced with various sensing devices and interconnected in the form of meshtopology to have reliable data reception at a centralized ZigBee coordinator. The maximum distance between the adjacentZigBee nodes is less than 10 m, and through hopping technique of the mesh topology, reliable sensor fusion data hasbeen performed.

The ZigBee coordinator has been connected through the USB cable of the host computer, which stores the data into a database of computer system. The collected sensor fusion data have been sent to an internet residential gateway for remote monitoring and controlling the home environment. By analysing the power from the system, energy consumptioncan be controlled. An electricity tariff plan has been set up to run various appliances at peak and off-peak tariff rates. Theappliances are controlled either automatically or manually (local/remotely). The smart power metering circuit isconnected to mains 240 V/50 Hz supply. Fig. 2 shows different appliances connected to the developed smart sensingsystem. Fig. 2(a) and (b) shows the child and parent units of smart sensing measurement system.

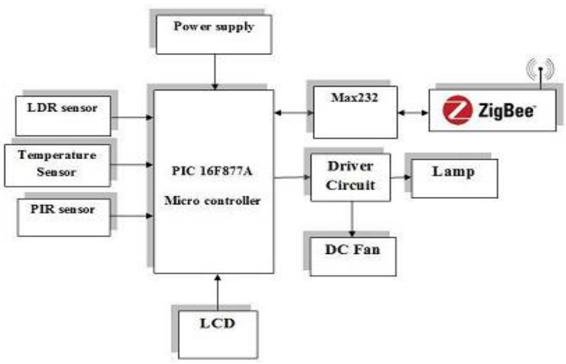

Fig. 2(a)

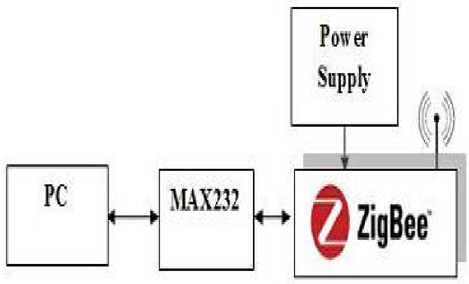

Fig. 2(b)

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The count of child unit may vary depends on the floor otherwise equipment handled by the consumer in the real time.

IV. SIMULATION RESULTS

The prototype is in operation in a trial home withvarious electrical appliances regularly used by aninhabitant. The following appliances were tested: roomheaters, microwave, oven, toasters, water kettle, fridge,television, audio device, battery chargers, and water pump.In total, ten different electrical appliances were used in theexperimental setup; however, any electrical appliancewhose power consumption is less than 2000Wcan be used indeveloped system. The sampling rate for the fabricatedsensing modules was setup with 50 Hz, so that electricalappliance usages within (less than 10 s) interval of time willbe recorded correctly. By monitoring consumption of powerof the appliances, data are collected by a smart coordinator,which saves all data in the system for processing as well as forfuture use. The parameters will be entered in the datacoordinator in software from appliances include voltage,current, and power. These parameters will be stored in adatabase and analysed. Collected data will be displayed on thecomputer through graphic user interface (GUI) window sothat appropriate action can be taken from the GUI. Fig. 3 shows the smart power monitoring and control system at ahouse where the system is on trial.

Fig.3. Smart power monitoring and control system atthe residence.

The processed voltage, current, and power values aredisplayed on the graphical user interface running on acomputer. The processed data are accurate and user friendly.The sensing system in the sensor node measures theparameters (voltage and current). The raw data (i.e., convertedADC values) are transmitted to the coordinator. The computerthen collects the data from the coordinator and processesthem. The computer then applies the necessary formulas to getthe actual voltage, current, and power consumption of theelectrical appliances. The voltage and current readings areprocessed using C sharp programming. Fig.4 shows the frontend of the smart software system at the local residence. Thedeveloped system has software recovery strategies such asexception-handling, auto restart, and alert text mechanism forsensors failure. The exception handling procedure can handleerrors such as no sensor data reception and high range valuesof analog-to-digital-converted values and computational errorsresulted during the normalization of voltage and current sensedata values. Depending on the inhabitant usages, appliancesconnected by smart sensing units are controlled either byautomation based on the tariff conditions or by the inhabitantlocally using GUI and remotely using the website.

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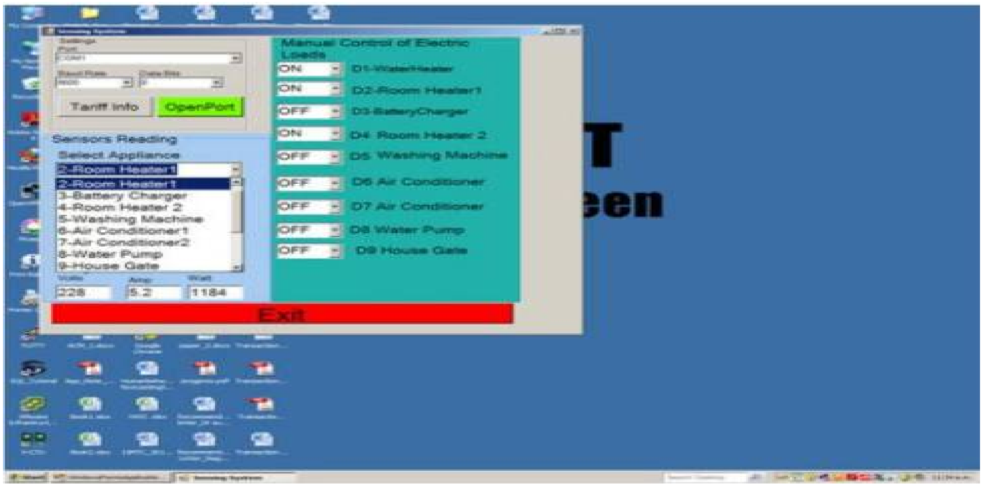

Fig.4. Graphical user interface of smart power monitoringand control system at the local residence

V. CONCLUSION

An intelligent power monitoring and control system has been designed and developed toward the implementation ofan smart building. The developed system effectively monitors and controls the electrical appliance usages at an elderlyhome. Thus, the real-time monitoring of the electrical appliances can be viewed through a website. The system can beextended for monitoring the whole smart building. The sensor networks are programmed with various user interfacessuitable for users of varying ability and for expert users such that the system can be maintained easily and interacted withvery simply. This study also aims to assess consumer's response toward perceptions of smart grid technologies, theiradvantages and disadvantages, possible concerns, and overall perceived utility.

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BIOGRAPHY

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