Automatic Energy Control And Monitoring System For Building

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Abstract: The use of smart home technology in the home or building offers significant potential for energy savings. In this paper, an energy management system based on wireless sensor networks. The proposed system is composed of two main components: a wireless sensor network and monitoring terminal. Wireless sensors are used for sensing and transmitting electricity data and remote monitoring and control of appliances are provided to users through computer. The system enables users to save energy by monitoring and controlling appliances through terminal. This paper gives an overview of sensor technology and wireless networks in the development of an intelligent energy management system for buildings. This technology has ample potential to change the way live and work. ZigBee is used as a communication medium in building intelligent energy management system in this paper. From the prototype setup, it is shown that ZigBee is a suitable technology to be adopted as the communication infrastructure in energy management system for buildings .The proposed system can be installed and maintained in residential environments with ease.

Keywords: Zigbee module,Voltage sensor,Current sensor,PIR sensor andLDR sensor.

I. INTRODUCTION

With the emergence of new and innovative technologies, living standards and quality of life have reached an all-time high. A significant part of the modern lifestyle is used with the usage of electronic and electrical devices. However, increases in the utilization of electronics and electrical appliances have adversely resulted in an unprecedented increase in energy consumption. Subsequently, due to the demand-supply gap, the price paid by the end user continues to increase annually. As a result, there is a serious need to optimize energy consumption and develop more energy-efficient technologies and electronic systems. This need has resulted in the development of new fundamental and applied research fields in the area of energy conservation. Among these research areas, with the potential to result in significant developments in energy consumption, is the design of integrated advanced monitoring and control mechanisms with the capability to better monitor and control power consumption, so that users can easily measure thepower consumption of electronic devices and optimize their usage to enhance their energy consumption performance .With advancements in wireless technologies and through the implementation of distributed sensor networks, residential energy consumption systems are beginning to take advantage of these systems for reducing energy consumption and thus increasing energy efficiency. By eliminating the need to runwires in an existing facility, wireless technologies can helpreduce the cost of construction in an "intelligent" building. Due to their small footprints, wireless nodes can be easily mounted without interruption of usage and without inconveniencing building occupants with renovations and changes. Another benefit of wireless technologies that makes them appropriate for residential use is their low energy consumption, as they can be powered by batteries with long service lives [1]. ZigBee is designed for reliable wirelessly networked monitoring and control networks. Zigbee has some technical advantages over bluetooth, WiFi, infrared rays etc. Zigbee is a kind of low power-consuming communication technology for coverage area surrounded by 200□, with a data rate ranging from 20□□□□to 250□□□□, it is appropriate for use in home area networks, mainly for the remote control of electric home appliances. Table. 1 shows the comparisons of bluetooth, WiFi, Zigbee[2].Therefore, ZigBee is more suitable for remote energy monitoring and control.

Table 1: *Comparison of Bluetooth, Wi-fi and Zigbee*

Standard	Range	No: of Nodes	Frequency Band	Data Protection	Power use
Bluetooh	10m	8	2.4GHz	16 bit	high
Wi-fi	100m	32	3.1-10.6 GHz	32 bit	high
Zigbee	10-200m	> 25400	868/915MHz,2.4 GHz	16 bit	low

Due to the above reason, in this paper a ZigBee-based building energy monitoring and control system is presented, which offers a promising solution for the aforementioned objective. For monitoring, the hardware is based on current and voltage measuring circuits, a microcontroller unit (MCU), a control module, and a ZigBee module. The current/voltage measuring circuit measures the current and voltage and sends the information to the MCU. The MCU checks for power abnormalities and sends information to the building server, where a database is maintained through ZigBee. For control, a relay is added to the power monitoring hardware. In the case of an emergency found by the MCU, the relay cuts the power supply to the electric building appliances after receiving thecontrol command. A graphic user interface (GUI) software program is used as an interface between the user and the end devices. Subsequently, theuser can control all electric appliances through laptop computer [2]. In this paper ZigBee is used as a communication medium in energy management systemwhich can be implemented in building, household, research laboratory and so on. The rest of the paper is organized as follows: Section II describes Background theory of the system. In Section III, the sensor and actuator networks is expressed. Section IV discusses the proposed system for the building. Section V describes the implementation details, followed by a conclusion in Section VI.

II. BACKGROUND

There have been two approaches for electric power management in homes from smart grids and home network. A smart-grid measures and reads the consumption of electricity remotely using a smart meter and communication network. It provides real-time or near real-time information on the consumption of electricity to utility companies or service companies. However, most of the systems and projects of smart metering for homes in smart grid are only focusing on measuring the total amount of energy consumption or

electricity at a home and communication infrastructure for data transaction. If we could measure or monitor the electricity consumption of each home appliance, better intelligent services could be provided such as tracking energy consumption, statistical analysis, and rule-based configuration. In the home network area, the data of energy consumption from each home appliance are collected using sensor networks. Several systems for monitoring and controlling power consumption have been proposed. Their main contribution has been to design and implement energy measurement and control systems. In this approach, both energy management and control services are included. The proposed system focuses on deploying a wireless sensor network and implementing energy management and controlling service as prototype services in a smart home or smart building.

III. Sensor and Actuator of Wireless Networks

The whole point of a wireless network is to send reliable data between nodes in the network. Wireless sensor and actuator networks (WSANs) are networks of nodes that sense and potentially also control their environment. They communicate the information through wireless links “enabling interaction between people or computers and the surrounding environment”. The data gathered by the different nodes is sent to a sink which either uses the data locally, through for example actuators, or which “is connected to other networks (e.g. the Internet) through a gateway. Sensor nodes are the simplest devices in the network. A sensor node typically consists of five main parts: one or more sensors gather data from the environment. The central unit in the form of a microprocessor manages the tasks. A transceiver communicates with the environment and a memory is used to store temporary data or data generated during processing. Fig 1 showsarchitecture of a sensor node. To assure a sufficiently long network lifetime, energy efficiency in all parts of the network is crucial. Due to this need, data processing tasks are often spread over the network, i.e. nodes cooperate in transmitting data to the sinks. Fig 2 shows the most important fields of application. If compared the performance with wired Local AreaNetwork (LAN), it is generally accepted that wired LANnetwork offers higher speed than wireless LAN network.

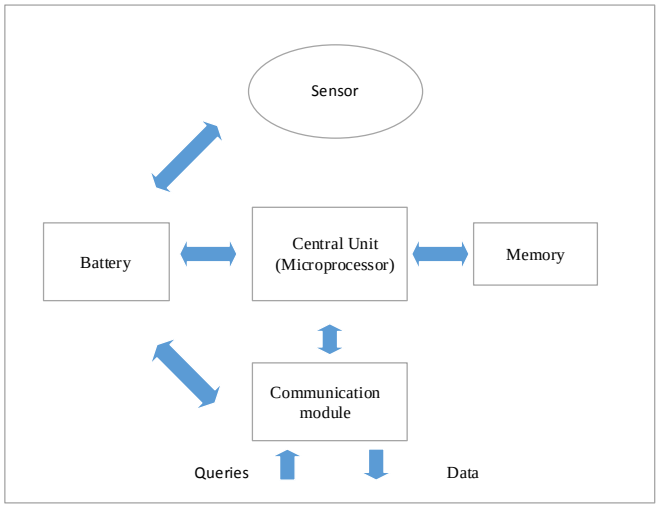

Figure 1 *Architecture of a sensor node*

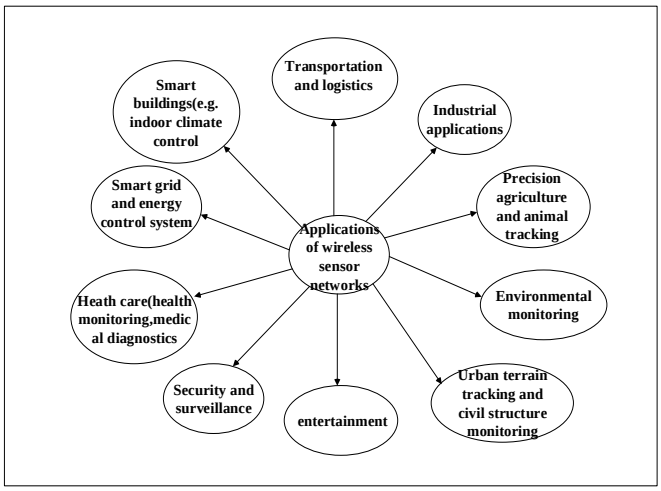

Figure 2. *Application of Wireless Sensor Networks*

The distinct in transmission speed is even more obvious when optical cable is being used in wired LAN network which transmission rate can easily reach up to 1Gbps or more. Although wireless communication system is less reliable, prone to interference and lower transmission rate at 54 Mbps, it is still being used by some power companies due to the advantages that offered only by wireless communication network .LAN technologies connect different smart devices at customers’ sites. These technologies can be classified into three main groups: wireless IEEE standards 802.x, wired Ethernet, as well as in-building power line communications Wireless IEEE standards include Wi-Fi (IEEE 802.11), WiMAX5 (IEEE 802.16), ZigBee (IEEE 802.15.4) and Bluetooth (IEEE 802.15.1).[3]

3.1. ZIGBEE NETWORKS

A. Introduction and Characteristics

Energy conservation, control, and safety are some of the prospects of ZigBee. Word ZigBee was originated from word Zigzag indicating cross-shaped network cablesand Bee to indicate economical communicationmethod. Thename refers to the waggle dance of honey bees after their return to the beehive. The ZigBee network automatically figures out how to route the data from one node to another with the maximum chance of success. ZigBee networks have the following requirements and features: low power consumption, low cost, low packet throughput, lots of network nodes, low request reliability [4]. ZigBee can be used in various applications such as HVAC controls, Lighting Controls, and Utility Networks. ZigBee consumes low electricity supply and can be configured to large scale sensor networks by integrating with sensor (Activity, light, temperature and humidity, etc) and transmitter/receiver devices. This type of structure is defined as foundation technology for sensing, monitoring and controlling. ZigBee has recognized as next generation short-distance wireless communication standard based on strong advantages including lowest costs, lowest energy consumption which can be last 2 years with 2 AA type batteries, scalability of up to 65,000 nodes, simple network configuration and reliability from immediate recovery function from data transmission errors. Especially, ZigBee supports multi-hop function to ensure highest transmission success rates.

B. ZigBee Topologies

ZigBee supports star, peer-to-peer i.e. mesh, and tree topologies. In star topology, there are several nodes and a central coordinator. Coordinator is the main part of star topology, as communication between nodes takes place through the coordinator. Nodes can communicate directly in peer-to-peer topology; Nodes can communicate directly in peer-to peer topology, without the need of coordinator. In tree topology, network consists of a central coordinator node along with routers and other nodes [5].

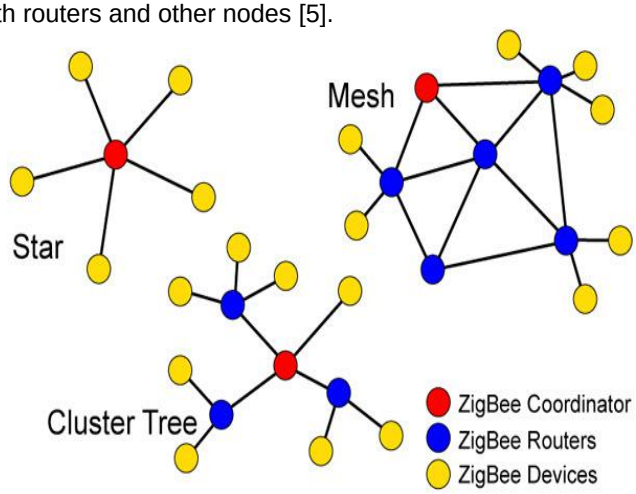

Figure 3: *The topology of Zigbee network*

IV. Proposed Energy Control and Monitoring System for Buildings

The block diagram of proposed model of Energy control and monitoring system for building is shown in figure 4.Each home of the building has one living room, one bed room, one kitchen, one rest room and each section is equipped with necessary load. But this model is mainly used forbuilding such that office, school and university. This type of model is used for building which has many rooms so that management and monitoring for energy consumption is required. The light and the power outlet include a power measurement function to measure the power consumption. They report the information periodically to the ZigBee hub through ZigBee communication. Because appliances are connected to the power outlet, their power usage can be acquired by the power measurement function of the power outlet. The ZigBee hub in the room gathers the power information reports of the light status and the power outlet, and then it transfers the information to the monitoring computer. The computer analyzes the power information of all appliances in each room. It displays the real-time active power consumption of each appliance and the accumulated power consumption of appliance in each rooms. A user can figure out which home appliance is unnecessarily turned on through the real-time active power consumption and how much power each appliance consumes in this month through the accumulated power consumption. A user can also analyze the power usage of each room through the ZigBee hub. A user can access the server and turn off unnecessarily turned on appliances in the case of no person in the each room. The power outlet periodically monitors the power consumption of the connected appliance. When person enters the room the light will turn on automatically by using PIR sensor and that status is sent to computer via zigbee. The light does not activate when the room is not dark. This is sense by LDR (light dependence resistor). The figure 5 shows internal architecture of sensor node. In this model, one room has zigbee, controller and sensing unit.

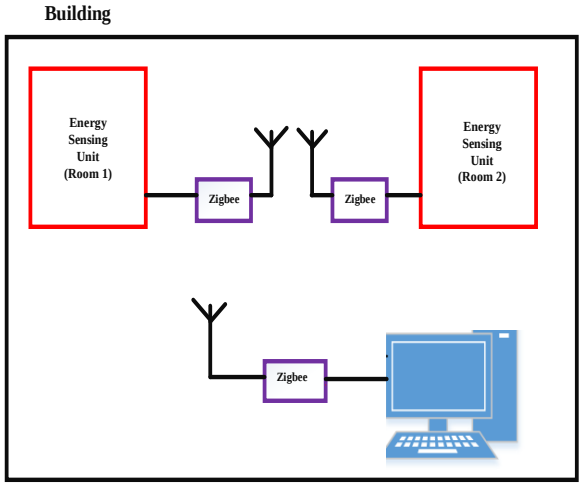

Figure 4: *Proposed Model of Building Energy Control and monitoring*

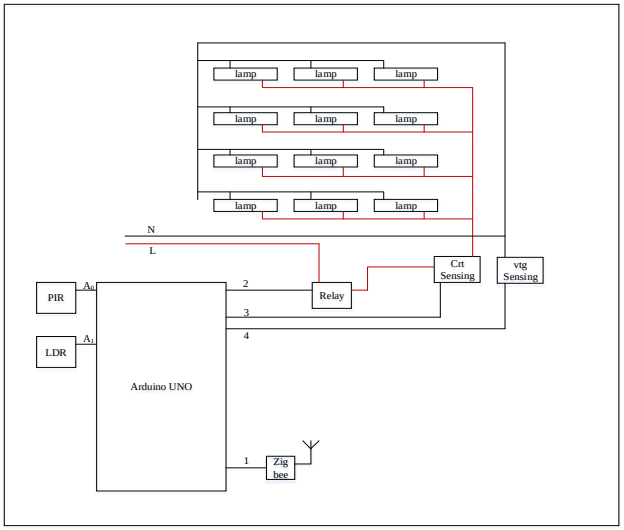

Figure 5. *Internal Architecture of Sensor Node*

V. The Implementation of the System

The Zigbee network is used as the communication medium for between remote section (room) and monitoring station. The remote section may be consists of voltage sensor, current sensor, PIR sensor, LDR sensor and Zigbee. The remote section controller is arduino. These controller senses the signal from sensing devices. And then that signal is transmitter to monitoring station via Zigbee. It shown in figure 5. The monitoring station gets signal form each of room via wireless network. And then the signal is translated into the user understand level with GUI. The GUI is implemented by visual C#. So person can monitor the building of room power consumption status. In this system, xcore 2530 Zigbee device is used as shown in figure 6. The remote sensing unit which is installed in room is shown in figure 5. Monitoring status is shown in GUI. It is described in figure 8.

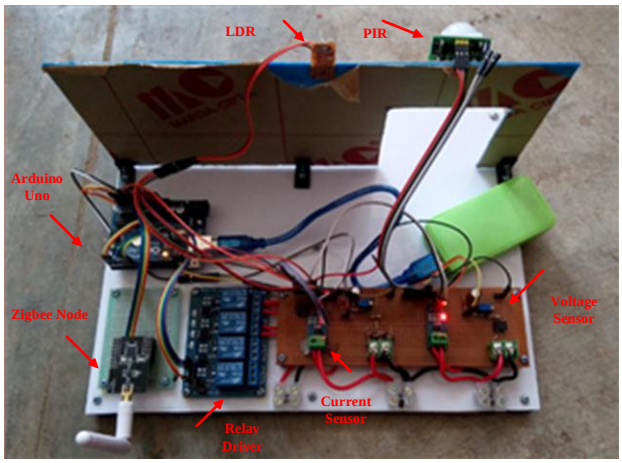

Figure 6: *Room Light Terminal at the Transmitter Side*

The computer and zb600 baseboard with xcore2530 are built for receciver portion of the system as shown figure7. The result is monitored from serial as shown in figure 8and 9.The figure 8is shown for there is dark and person isnotdetected.When there is no light in the surrounding, the status will display as “dark” and then motion is detected. It will also express “motion” and relay on as shown in figure 9.

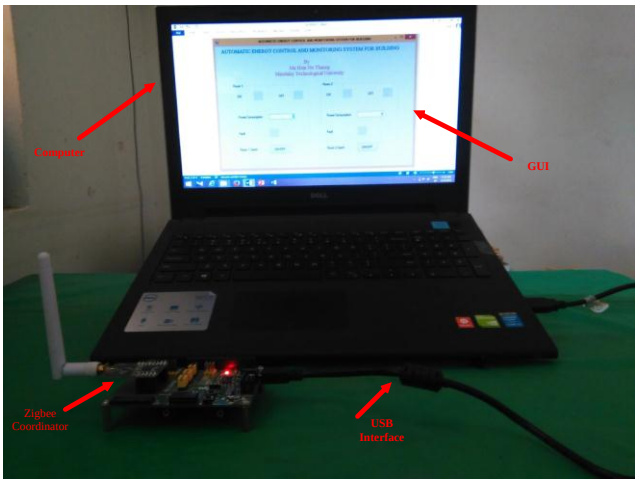

Figure 7: *Control Unit at the Receiver Side*

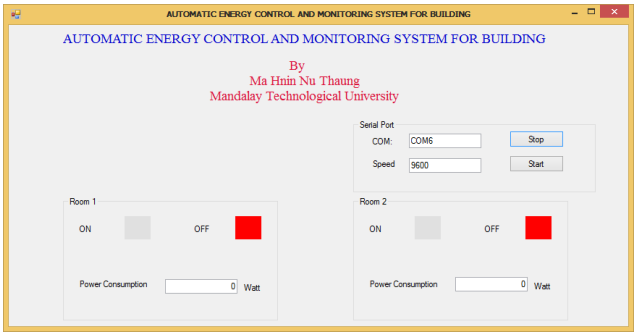

Figure 8: *GUI Result (LDR is ON and PIR is OFF)*

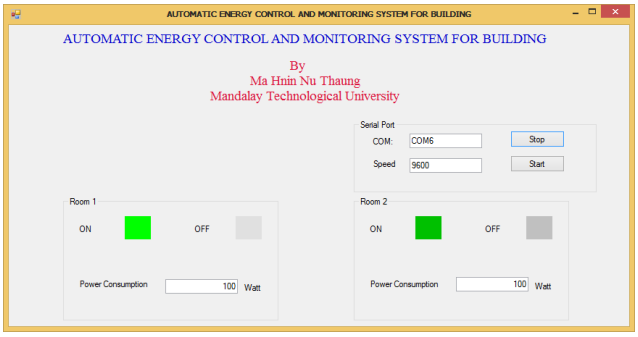

Figure 9: *GUI Result (LDR is ON and PIR is ON)*

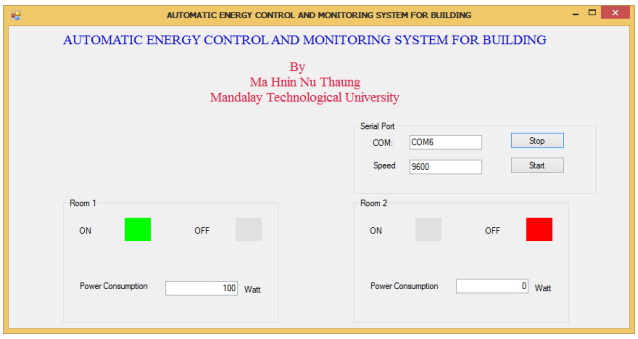

Figure 10: *GUI Result(Room1 is ON and Room2 is OFF)*

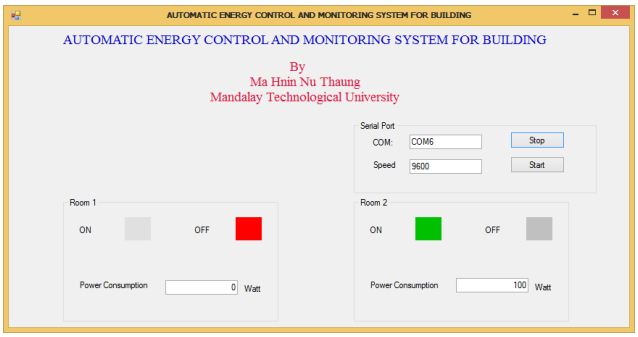

Figure 11: *GUI Result (Room1is OFF and Room2 is ON)*

VI .Conclusion

This paper presents a smart energy management system for homes and buildings. The proposed system can monitor and measure electricity usage in real-time. With the proposed system, users can remotely control real-time electricity usage through computer. The future work will focus on expanding the current system to include the following functionalities: automatic home appliance detection and context inference. The automatic identification of appliances and detection of the location of appliances are important for developing efficient energy management systems. Automatic detection of appliances can offer easy and usable services and information on the location of appliances is used for providing various context-await. A user’s behavior, based on data from electricity consumption, can be used to infer the current or future context of users. For example, a user’s intention to operate certain appliances at certain locations can be determined from the context inference engine of the system.

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