Intelligent Energy Management System for Residential Buildings Based On Zigbee Technology

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Abstract

Energy consumption in residential buildings account for 20 to 40 per cent of total energy consumed in a country and therefore represents a significant and potential source of energy savings. An Intelligent Energy Management System can contribute to major reductions of energy use in hundreds of millions of buildings. This paper gives an overview of sensor technology and wireless networks in the development of an intelligent energy management system for residential buildings (IEMSRB). This technology has ample potential to change the way we live and work. In this paper ZigBee is used as a communication medium in building intelligent energy management system. 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 residential buildings .The performance analysis discussed in this paper verifies the effectiveness of using ZigBee in energy management system. The novelty of the present scheme is its ability to save the energy and improve the performance as it learns and gains more experience in real-time operations. Results also demonstrate that the proposed scheme can achieve the minimum electricity cost for residential customers. The proposed system can be installed and maintained in residential environments with ease.

Keywords: Energy Management System, ZigBee, Sensor and Actuator Networks.

Introduction

Energy was once a commodity which most enterprises did not have that much control of in the past. In this day and age, energy control is now a top priority. It is important for all of us to have the responsibility and make sure that we have a good energy system. The energy system includes energy of water, electricity, gas, air, and steam. The energy system cannot only affect our corporation or industry, but also affect the environment around our corporation or industry. An intelligent energy management system can contribute to major reductions of energy use in hundreds of millions of buildings. Energy savings and user happiness are two major design considerations for intelligent home system.

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Intelligent homes in a building must fulfill four basic requirements. First, they must facilitate safe, convenient, and healthy lifestyle. Secondly, they must be environmentally sustainable. Thirdly, they must promote comfort. And finally, an intelligent home must provide an efficient workspace to its occupants. The most effective way to reduce energy is to turn devices off. The second most effective way is to turn them down. An automated control system can do both for consumer based on factors such as occupancy, available daylight and time of day. Removing the wires from the controls provides additional benefits, including greater flexibility in where controls can be placed, and significant savings in installation by avoiding the expense and disruption of wiring. This paper describes the development of an intelligent energy management system for residential buildings using the concept of a sensor technology and wireless network. In this paper ZigBee is used as a communication medium in energy management systems. By using this energy management system, it is possible to see and control the energy system of various devices. Wireless sensor technology is fast replacing wired technology in almost all the fields, because it is less costly and also because it is more efficient as compared to wired networks. Sensors measure multiple physical properties and include electronic sensors, biosensors, and chemical sensors. These sensors can thus be regarded as "the interface between the physical world and the world of electrical devices, such as computers".

In this paper ZigBee is used as a communication medium in energy management systems which can be implemented in building, household, research laboratory and so on.

II. Wireless Sensor & Actuator Network

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. Fig1 shows architecture 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 co-operate in transmitting data to thesinks.Fig2shows the most important fields of application. If compared the performance with wired Local Area

Network (LAN), it is generally accepted that wired LAN network offers higher speed than wireless LAN network.
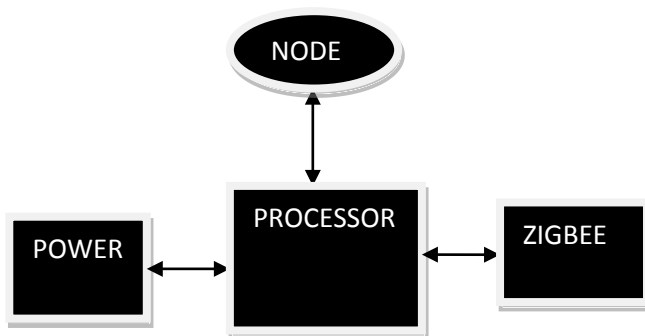
Fig 1: Architecture of Sensor Node

III. Zigbee Networks

Energy conservation, control, and safety are some of the prospects of ZigBee. Word ZigBee was originated from word Zigzag indicating cross-shaped network cables and Bee to indicate economical communication method. The name refers to the waggle dance of honeybees 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 on quality of service, security control, and high reliability .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 2AA 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.

IV. Proposed Intelligent Energy Management System for Residential Building

Fig shows the architecture of the proposed Intelligent Energy Management System for Residential Buildings (IEMSRB). 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 as shown in Fig 2, one power outlet, and one ZigBee hub. The dimming 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 home 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 and the power outlet, and then it transfers the information to the home server. The home server analyzes the power information of all home appliances in each room. It displays the real-time active power consumption of each home appliance and the accumulated power consumption of each home appliance. A user can figure out which home appliance is unnecessarily turned on through the real-time active power consumption and how much power each home 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 home server and turn off unnecessarily turned on home appliances. The power outlet periodically monitors the power consumption of the connected home appliance. As soon as the monitored power consumption of the home appliance is below the threshold for the determined period, the power outlet automatically cuts off the AC power to reduce the standby power of home appliance.
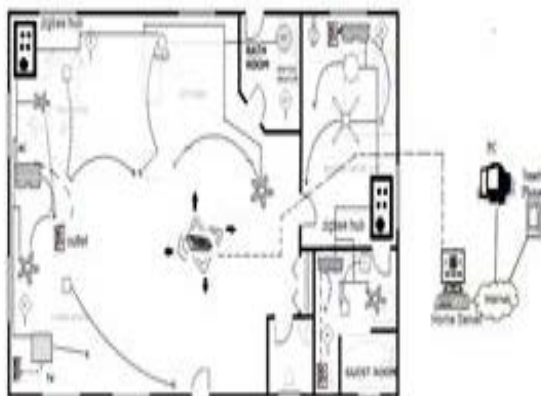
Fig 2: Architecture of proposed intelligent energy management

V. Implementation Details & Performance Analysis

To show the achievability of the proposed architecture an experimental based case study has been done on the system which is developed to demonstrate that smart, simple sensor devices can be used to manage, control and save energy in smart home in a smart building. We have developed as mart node that has sensing, processing and networking abilities. It is equipped with a microcontroller (8952) as shown in Fig 6 and a narrow-band radio frequency (RF) device that can support physical-layer functionalities of IEEE802.15.4.Various optional sensor and actuator modules can be equipped with this smart node with the help of a connector and directly controlled by the microcontroller in our smart node. Temperature sensor is included in the smart node. An experimental based case study has been done on the system which is developed to demonstrate that smart, simple sensor devices can be used to monitor activities of daily living and lifestyle of person living in smart home in a smart building. The system has been tested by connecting the soldering iron to the temperature sensor as shown in Fig
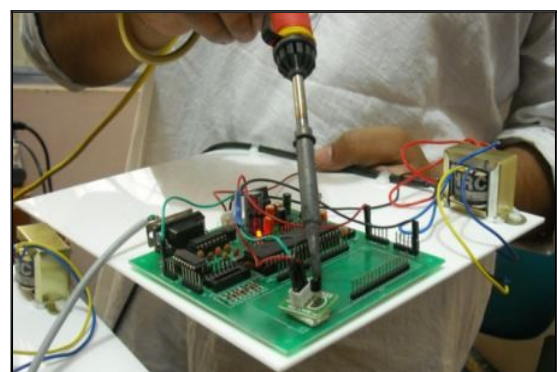
Fig 3: System Testing with Soldering Iron

VI. Conclusion

The system has been tested by connecting the ZigBee based temperature sensor to the following appliances-soldering iron, air conditioner and tube lights.

The data collected during various seasons and Electricity bill on monthly basis for the said duration. The monthly kWh consumption of energy with and without ZigBee based sensors. This captured data can help us to identify load pattern and energy saving in smart homes of an intelligent building. The proposed system can be installed and maintained in residential environments with ease. A ZigBee based Intelligent Energy Management System for residential building system can provide significant cost savings in a building environment, great level of flexibility and control for the building administrators and great comfort for the occupants.

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