ZIGBEE based Home Automation and Energy Conservation using Wireless Sensor Network

S.Shanmugaraju, R.Vinodhini and V.Rekha

Abstract: Wireless sensor networks have critical applications in the scientific, medical, commercial, and military domains. These applications include environmental monitoring, surveillance, and intelligent transportation systems.Buildings are important contributors to energy consumption accounting for around one-third of energy consumed in cities, where large public buildings are the dominant energy consumers and energy consumption might be significantly decreased through building energy. Sensors embedded in a building can drastically cut down energy costs by monitoring the temperature and lighting conditions in the building and regulating the heating and cooling systems, ventilators, lights, and computer servers accordingly.Wireless home automation networks comprise wireless embedded sensors and actuators that enable monitoring and control applications for home user comfort and efficient management. Increased demands on implementation of wireless sensor networks in automation praxis result in relatively new wireless standard – ZigBee.

Keywords: Energy Conservation, Energy Consumption, Home automation, Wireless embedded Sensors, Zigbee.

I. INTRODUCTION

Nowadays, energy use in buildings is responsible for roughly 40 % of total energy use and for 36 % of the CO2 emissions in the EU area. In an effort to economize scarce fossil fuels on earth, sensor networks are a valuable tool to increase the energy efficiency of buildings. Within a smart building many sensors and actuators are interconnected to form a control system.The improved wireless network sensors provides some different equipment such as HVAC (heating, ventilating, and air-conditioning), lightning, home and office appliances. In a first step, decentralized sensor nodes of different types are required to report the current energy usage or environmental conditions to a centralized monitoring system. A smart power outlet will report the current energy usage of the attached device to a central server.

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Wireless home automation systems are an attempt to enhance the standards of living around and inside the house. These systems provide the consumers with increased security and safety, economic benefit through energy control, and convenience by giving them control over every piece of domestic electrical equipment in the house. Electricity is so essential in our daily life that people cannot live without it. However, today, energy has been used more and energy conservation has become a global problem. WSNs are deployed in rooms of a building to collect information of the environment. Such information is reported to a control server to determine whether to turn off those unnecessary electric appliances in the building. WSNs have been widely used for providing context information in smart environment applications. How to automatically control electric appliances based on users' locations and requirements discussed for smart homes/offices.

1.0 LITERATURE REVIEW

Wireless Sensor Networks (WSNs) are a spatially distributed autonomous system which is a collection of power-conscious wireless sensors without the support of pre-existing infrastructure. Sensor Networks and proactive computing has the potential to improve our productivity and enhance safety, awareness and efficiency at the societal scale [9].

1.1 Wireless Sensor Networks

Wireless Sensor Networks (WSNs) are a spatially distributed autonomous system which is a collection of power-conscious wireless sensors without the support of pre-existing infrastructure. Wireless Sensor Network (2005) [1].which consists of dense sensor nodes that continuously observe physical phenomenon provides an opportunity for building monitoring Willing (2006) [2], Adam and Jakub (2009) [3]. Thomas et al., (2005) [4] reported their experience with the implementation, deployment and operation of Sensor Scope, an indoor environmental monitoring network based on WSNs. Chang et al., (2009) [5] demonstrated an industrial-strength wireless sensor network application for indoor environment monitoring. This application is integrated WSNs with a Building Management System. Won-Suk Jang showed how advanced WSN technologies can be used to monitor conditions in and around buildings.Jang et al. (2008) [6] developed a WSN system was deployed in a number of residential and commercial buildings.Tessa et al, (2009) [7]investigated WSN performance metric for building monitoring applications.

1.2 Building automation in WSN

As per the report given by freescale.com/building automation (2011) [8], building automation systems (BAS) present significant opportunities for energy conservation in the home and in the workplace, where poor scheduling and manual control can result in inefficient or even round-the-clock operation of lights, HVAC and other environmental control systems. It's estimated that a fully optimized. BAS can return energy savings of between 10 and 30 percent. The number can be greater if BAS is employed in older or poorly maintained structures, and will typically repay its initial investment within two to four years At the heart of a BAS is a programmed, computerized, intelligent network of electronic devices that monitor and control the mechanical and lighting systems, usually from a central control panel. As well as enabling more effective resource management, such systems help to reduce maintenance costs and provide increased levels of comfort, safety and security.

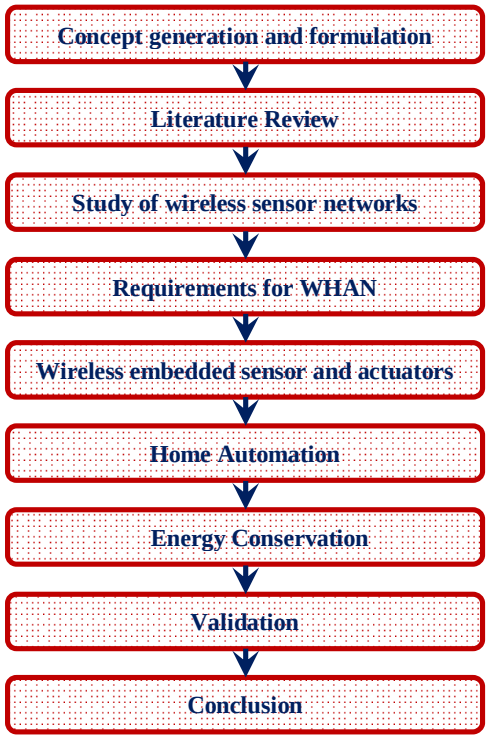
Many modern appliances have digital controls that employ MCUs with integrated interfaces to simple, low speed serial communications via wired or wireless mediums. This enables the appliances to be interconnected relatively easily, and, with the addition of a single-chip Ethernet gateway, integrated into home automation networks. Where traditional mechanical-based timer systems were once found, Ethernet-based systems can now be employed, giving users increased flexibility and control over appliance operation and in turn optimising their energy consumption.

1.3 ZigBeein automation

The introduction of IEEE 802.15.4, (2006)[10], low rate wireless personal area network (LR-WPAN) standard has been implemented for three reasons: the need for low-cost, low-power and short-range communication. Thus it suits for Wireless Sensor Network applications where a large no of tiny sensors having low power, low range and low bandwidth are deployed in an ad hoc manner for the purpose of Automation, Tracking and Surveillance in terrain regions. The standard defines the channel access mechanism, acknowledged frame delivery, network association and disassociation. The standard supports two Direct Sequence Spread Spectrum (DSSS) PHY layers operating in Industrial, Scientific, Medicine (ISM) frequency bands. As per suggestion given by Andrew Wheeler (2007) [11],A low-band PHY operates in the 868 MHz or 915 MHz frequency band and has a raw data rate of 20 kbps or 40 kbps, respectively. A high-band PHY operating in the 2.4 GHz band specifies a data rate of 250 kbps and has nearly worldwide availability. The 2.4 GHz frequency band has the most potential for large-scale WSN applications, since the high radio data rate reduces frame transmission time and usually also the energy per transmitted and received bit of data. This standard now enjoys extensive silicon support, primarily in the 2.4GHz band.

Michal (2007) [12] expressed that the industrial level, ZigBee mesh networking can help in areas such as energy management, light control, process control, and asset management. At the industrial level, ZigBee mesh networking can help in areas such as energy management, light control, process control, and asset management. A passive RFID tag can transmit only simple information such as an ID number, which is sufficient for many asset management applications. Active RFIDs, such as ZigBee devices, are battery powered and generally are more expensive than passive RFIDs. ZigBee-based active RFIDs have longer range than passive RFIDs and can provide additional services such as estimating the location of assets or personnel.

2. RESEARCH APPROACH



Wiring complicates implementation of the home automation in buildings which are already built, especially in historical ones. Therefore, an invention of an open and standardized wireless network of battery powered cheap sensors, actuators, and control devices which could effectively communicate with each other for some years, eventuate in new wireless standard. This standard was named "ZigBee". The home automation systems provide mutual interoperability between various electronic, electrical, and power devices as well as interactive interface for people to control their operation. These features are very helpful to optimize and to economize energy consumption whereby saved energy during some few years could make more money than home automation systems implementation cost. The developed architecture will be implemented not only in home/offices but also in industrial environment through proper validation.

3. CASE STUDY

Kothari (2004) [13],[14],[15] outlined that a case-study is an in-depth approach to reach the basic relationship between the theoretical and practical aspects. In order to examine the practical feasibility of developing home automation system in wireless sensor network to reduce

power consumption in home and industry had been chosen as a case study.

3.1 Features of wireless home automation networks (WHAN)

Wireless home automation networks enable a variety of uses likeLight control-lights can also be activated in response to a command from a remote control and it turned on automatically when presence of people present in the room.Remote control-Infrared technology used for wireless communication between remote control and HVAC and TVs, it require line of sight and short distances.
Smart energy-Several types of sensors that monitor parameters like temperature, humidity, light and ressure and also smart meters can be used to detect usage peaks and it alert the household devices.Remote care like patient temperature, blood pressure and insulin monitoring and glass-break sensors and motion sensors are used for detecting risk situations that is it activates fire alarms.

3.2 Requirements and characteristics of WHANs

- Residential scenarios are affected due to interference because ISM bands are crowded with WiFi,Bluetooth and microwave oven etc.
- High node density
- Home is a multipath environment due to presence of reflective surfaces like walls, tables and floors.

WSN for home automation systems contains certain characteristics that are linked intrinsically with their application, such as command and control capability, low cost, low data rate, extremely reduced energy consumption, capacity to interconnect with other networks, average delays superiors 100ms, self-organization capability.

3.3 Components of sensor node

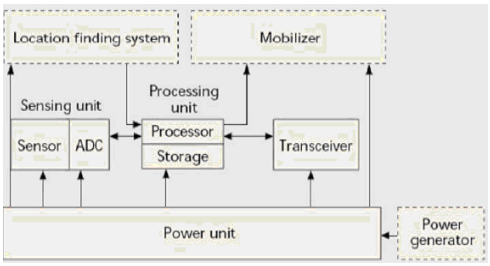


Figure 1. Sensor node architecture

3.3.1 Sensing Unit:

Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs). Sensors can be classified as either analog or digital devices. There exists a variety of sensors that measure environmental parameters such as temperature, light intensity, sound, magnetic fields, image, etc. The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC and then fed into the processing unit.

3.3.2 Processing Unit:

The processing unit mainly provides intelligence to the sensor node. The processing unit consists of a microprocessor, which is responsible for control of the sensors, execution of communication protocols and signal processing algorithms on the gathered sensor data. Commonly used microprocessors are Intel's Strong ARM microprocessor, Atmel‘s AVR microcontroller and Texas Instruments' MP430 microprocessor.

The radio enables wireless communication with neighbouring nodes and the outside world. It consists of a short range radio which usually has single channel at low data rate and operates at unlicensed bands of 868-870 MHz (Europe), 902-928 MHz (USA) or near 2.4 GHz (global ISM band). For example, the TR1000 family from RF Monolithics works in the 800–900 MHz range can dynamically change its transmission power up to 1.4 mW and transmit up to 115.2 Kbps. The Chipcon‘s CC2420 is included in the MICAZ mote that was built to comply with the IEEE 802.15.4 standard [**10**] for low data rate and low cost wireless personal area networks. There are several factors that affect the power consumption characteristics of a radio, which includes the type of modulation scheme used, data rate, transmit power and the operational duty cycle.

3.3.3 Battery:

The sensor nodes can be powered from energy storage devices or by energy scavenging. The former technique employs a variety of tiny batteries made up of thin films of vanadium oxide and molybdenum oxide .The battery supplies power to the complete sensor node. It plays a vital role in determining sensor node lifetime. The amount of power drawn from a battery should be carefully monitored. Sensor nodes are generally small, light and cheap, the size of the battery is limited. AA batteries normally store 2.2 to 2.5 Ah at 1.5 V.

4. RESULTS AND DISCUSSION

ZigBee-There are two relevant ZigBee application profiles for WHANs.

Z-WAVE-defines two types of devices: controllers and slaves. Controllers send commands to the slaves, which rely to the controllers/execute the commands.

INSTEON-defines a mesh topology composed of RF and power line links.RF devices are not attached to power line can transmit asynchronously,but the related messages will be retransmitted synchronously by RF devices attached to the power line.

IP-BASED solutions-IP based sensor networks are emerging and could dramatically increase the capillarity of the internet.In the future,fully standardized IP-based solutions for WHANs will be available.

As per the results described above table 2, with regard to a set of criteria that take into account the requirements for WHANs technical and non-technical considerations. In ZigBee based technologies use PSK modulations, which are more complex but offers better signal to noise ratio.

Table 2.Comparison of ZIGBEE, Z-WAVE and INSTEON

Parameters	**ZIGBEE**	**Z-WAVE**	**INSTEON**
Coverage Range in meters	10-100	30(indoors)100(outdoors)	45(outdoors)
RF band in MHZ	868/915/2400	868/908(All chips)2400(series chip)	904
Bit rate in kb/s	20/40/250	9.6/40(for 200 series chip)200(400 series chip)	38.4
Modulation Techniqu e	BPSK/O-QPSK	BFSK	FSK
Spreading Techniqu e	DSSS	NO	NO
MAC mechanism	TDMA+CSMA/CA	CSMA/CA	TDMA+simulcast
Message size in bytes	127	64	14(standard messages)28(extended messages)
Device types	Coordinator, router and end device	Controllers and slaves	Single type of device

Based on the characteristics tabulated in table 2, this paper suggests the ZigBee is more relevant and suitable approach for home automation due to its enhanced quality, energy conservation, security and inter operability among the approaches available in wireless sensor network.

5. CONCLUSION

This paper discusses about the identification of relevant and suitable approach for home automation in Wireless Sensor Network. This technologyoffers significant potential in numerous application domains. The unique features of various approaches available in wireless sensor networkslike command and control capability, low cost, low data rate, extremely reduced energy consumption, capacity to interconnect with other networks and self-organization capability which are suitable home automation were analyzed.Based on th above anlysis, it has been identified that the ZigBee approach was most relevant, current and emerging solutions suitable for home automation networks. Whreas ZigBee designed for general purpose applications, the rest of the approaches were developed for specific applications. The identified ZigBee appraoch is the cost-effective, more membory capacity, low-power consumption, more sucurity, better error control capability, more coverage area and better end to end reliabilty.

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