

BASELIOS POULOSE II CATHOLICOS COLLEGE
BASELIOS MOUNT, PIRAVOM

Re-accredited with 'A' Grade by NAAC
(Affiliated to Mahatma Gandhi University)

DEPARTMENT OF COMPUTER APPLICATIONS



2021-22

Seminar Report

On

**ZIGBEE TECHNOLOGY
IN HOME AUTOMATION**

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ZIGBEE TECHNOLOGY IN HOME AUTOMATION

Submitted in partial fulfilment of the requirements for

the award of the degree of

BACHELOR OF COMPUTER APPLICATION

Guided by: Dr. Dhanya Job

(Dept. of Computer application)

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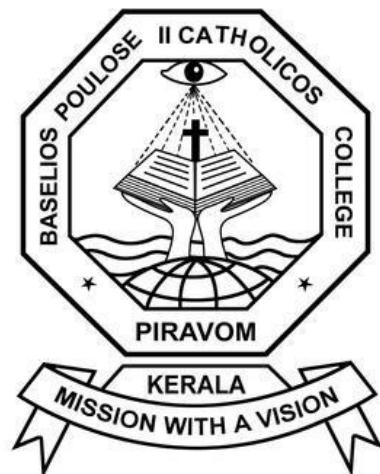
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Certificate

This is to certify that the seminar entitled “ ZIGBEE TECHNOLOGY IN HOME AUTOMATION” is a bonafide work presented by Vignesh KP (Reg no: 190021095602) in a partial fulfilment for the award of the degree of BACHELOR OF COMPUTER APPLICATION of MG UNIVERSITY during the year 2021-22.

Internal Guide:

Dr. Dhanya Job

Head of the department

Dr. Kurian M J

DECLARATION

*I hereby declare that this seminar work entitled “ZIGBEE TECHNOLOGY IN HOME AUTOMATION” is a record of original work done by me under the guidance of **Dr. Dhanya Job**, Assistant Professor, Department of Computer Applications and the work has not formed the basis for the award of any degree or diploma or similar title to any candidate of any university subject.*

Internal Guide

Dr. Dhanya Job

Signature of Student

ACKNOWLEDGEMENT

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Last but not the least, I also express my gratitude to all other members of the faculty and well wishers who assisted me in various occasions during the seminar work.

Vignesh KP

ABSTRACT

Home Automation industry is growing rapidly; this is fuelled by provide supporting systems for the elderly and the disabled, especially those who live alone. Due to advancement of technologies the home automation can be easily implemented. Home automation systems must comply with the household standards and convenience of usage. This paper details the overall design of a wireless home automation system (WHAS) which has been built and implemented. Automation is a vast field and now a day can be implemented any where depending upon the application. ZigBee protocol IEEE 802.15.4 wireless standard can be used to set up network for some specific application purpose. The automation centers on recognition of voice commands and uses low-power RF ZigBee wireless communication modules which are relatively cheap. The home automation can be useful network for physically handicapped persons as well as old age person and the same network can be used to control industrial applications as well. Wireless home automation systems have drawn considerable attentions of the researchers for more than a decade. The major technologies used to implement these systems include Z-Wave, Insteon, Wavenis, Bluetooth, WiFi, and ZigBee. Among these technologies the ZigBee based systems have become very popular because of its low cost and low power consumption.

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1. INTRODUCTION

Wireless home automation systems have drawn considerable attentions of the researchers for more than a decade. The major technologies used to implement these systems include Z-Wave, Insteon, Wavenis, Bluetooth, WiFi, and ZigBee. Among these technologies the ZigBee based systems have become very popular because of its low cost and low power consumption. ZigBee based wireless home automation systems have been addressed. Automation is a vast field and now a day can be implemented depending upon the application. Zigbee is based on IEEE 802.15.4 wireless standard. It can be used to set up network for some specific application purpose. The applications of ZigBee technologies are personal health care, home automation, toys and games, industrial and commercial, consumer electronics, pc and peripherals. Zigbee based home automation wireless sensor network can be implemented with small initial cost and can be useful to control fans, lights and other home appliances. The home automation can be useful network for physically handicapped persons as well as old age person. The ZigBee technology is introduced by the ZigBee Alliance. The ZigBee technology has evolved based on a standardized set of solutions called 'layers'. These optimally designed layers have provided the ZigBee with unique features including low cost, easy implementation, reliable, low power, and high security. Members in ZigBee alliance includes oppo, huwai, amazon etc.

2. LITERATURE REVIEW

To understand more about home automation and ZigBee technology several resources can be collected. This section deals with review of the literatures to set a foundation for discussing various home automation techniques using ZigBee technology.

Home automation industry has drawn considerable attention of the researchers for more than a decade. The main idea is to automatically control and monitor electrical and electronic home appliances. Several commercial and research versions of home automation system have been introduced and built. Among these only home security systems have become the main stream of development activities. Smart home systems have captured several technologies so far and products have been available in the market. In order to overcome some of these limitations wireless home automation system (WHAS) has been introduced and it has gained a considerable attention in the recent years. The WHAS has reduced the operation and

maintenance cost. Additionally, it has provided comfort, security, safety, and remote monitoring capability. WHAS consists of battery operated low power wireless sensors and actuators attached with the home appliances. These sensors and actuators are connected to a backbone wireless network. The availability of cheap sensors, actuators, and wireless modules has succeeded to make WHAS popular and affordable. The major technologies used to implement home automation includes Z-Wave, Insteon, Waveins, Bluetooth, WiFi, and ZigBee. Among these technologies the ZigBee based systems have become very popular because of its low cost and low power consumption. A comparison of these technologies compete ZigBee has been presented by the author.

Table 1: Comparison of different WHAS technologies

Technology	Z-Wave	Insteon	Waveins	Bluetooth	WiFi	ZigBee
Frequency	868 MHz 908MHz 2.4 GHz	904 MHz	433 MHz 868 MHz 915 MHz	2.4 GHz	2.4 GHz 5 GHz	868 MHz 915 MHz 2.4 GHz
Modulation	FSK/GFSK	FSK	GFSK/PSK	FHSS	QPSK COFDM QAM	BPSK O-QPSK
Error Control	CRC(8-bit)	CHECKSUM	BCH	CRC (16-bit)	CRC(32-bit)	CRC(16-bit)
Range	30-100m	45m	200-1000m	10m	100m	10m-100m
Network size	232	256	unknown	8	2007	64000
Power Consumption	Low power	NA	Ultra-low	Medium	High	Very Low

Although the ZigBee has numerous applications, we limit this effort only to its application in WHAS. The performances of the ZigBee based WHAS have been compared with those of other competing technologies including Z-Wave, Insteon, Waveins, WiFi, and Bluetooth. It has been shown that the ZigBee based WHAS outperforms other technology based WHAS. A comprehensive survey work on the ZigBee based WHAS has been presented in this paper. Some limitations and challenges of the ZigBee based WHAS have also been listed in this paper.

Based on this survey work we can conclude that the ZigBee can be considered as the most suitable technology WHAS compared to other existing technologies. But, there are still some challenges of ZigBee based WHAS that are still under investigations [1].

The technology offers new and exciting opportunities to increase the connectivity of devices within the home for the purpose of home automation. This paper identifies the reasons for this slow adoption and evaluates the potential of ZigBee for addressing these problems through the design and implementation of a flexible home automation architecture. A ZigBee based home automation system and Wi-Fi network are integrated through a common home gateway. The home gateway provides network interoperability, a simple and flexible user interface, and remote access to the system. A dedicated virtual home is implemented to cater for the system's security and safety needs. To demonstrate the feasibility and effectiveness of the proposed system, four devices, a light switch, radiator valve, safety sensor and ZigBee remote control have been developed and evaluated with the home automation system. The architecture is designed to reduce the system's complexity and lower fiscal costs. ZigBee is a radio frequency (RF) communications standard based on IEEE 802.15.4. The Zigbee coordinator is responsible for creating and maintaining the network. Each electronic in the system is a Zigbee device managed by the coordinator. All communication between devices propagates through the coordinator to the destination device. The ZigBee standard theoretically provides 250kbps data rate, and as 40kbps can meet the requirements of most control systems, it is sufficient for controlling most home automation devices. ZigBee based home automation system is implemented for the monitoring and control of household devices. To cater for the household's high data rate needs, such as multimedia entertainment, a Wi-Fi network is implemented. A home gateway has been developed to provide interoperability between these networks. The home gateway presents a unified interface for users to locally and remotely access home networks. The elements that combine to implement the proposed system architecture are ZigBee remote control, Wifi remote control and remote access devices. A user can login to monitor and control the home automation systems end devices, using one of three user interface devices (ZigBee remote control, Wi-Fi remote control, and Remote access device). All messages from the devices using the Internet for communication are sent to the home's IP address. The messages are forwarded to the home gateway's IP address on the local Wi-Fi network, through a Wi-Fi enabled ADSL modem. A comparison of ZigBee controller and Wifi controller is provided in the paper.

Table 2: Comparison between zigbee controller and wifi controller

ZIGBEE AND WI-FI CONTROLLER ACCESS DELAY		
	Light Switch	Radiator Valve
ZigBee Controller access delay in ms	670	*N/A
Wi-Fi Controller access delay in ms	1337	613

*N/A indicates that the time delay was too short to be recorded by the test equipment.

The use of ZigBee communications technology helps lower the expense of the system and the intrusiveness of the respective system installation. The incorporation of the virtual home concept coordinates the systems security and safety efforts in a clear and consistent manor. The inclusion of a home gateway helps overcome the problems of network interoperability. The home gateway in our implementation provides interoperability between the local ZigBee and Wi-Fi networks and the Internet. The feasibility and appropriateness of the proposed architecture and technologies in the creation of a low cost, flexible and secure system has been successfully evaluated both through experimentation and user trials [2].

The demand for wireless technology in home automation systems has recently been increasing due to several advantages such as installation cost reduction, easy placement, easy extension, aesthetic benefits, and mobile device connectivity. Among the many wireless technologies, ZigBee is one of the most useful for home automation; a wireless home networking system can be configured using ZigBee alone. KNX is a mature protocol for wired media that is recognized as an international standard. This paper proposes a KNX–ZigBee gateway to interface between KNX and ZigBee systems and thereby enable integration of wired and wireless home automation systems. ZigBee is particularly well suited to home automation (HA). ZigBee is intended to enable reliable, cost-effective, low-power, wirelessly networked monitoring and control products based on an open standard, and wireless HA can be achieved using ZigBee alone. ZigBee is a low-rate, low-power, low-cost wireless networking protocol that is targeted toward automation and remote control applications and is designed to provide connectivity for equipment that will operate for as long as several years. ZigBee defines three categories of devices according to their roles in the network: coordinator, router, and end devices. Devices

are additionally classified into two types by functionality: Full Function Devices (FFD) and Reduced Function Devices (RFD). By taking KNX as a representative HA protocol because KNX is a merger of other HA standards and is a relatively mature protocol that has been adopted as an international standard. An interface between KNX and ZigBee will enable ZigBee systems to support the conventional KNX protocol, and will allow KNX systems to support new wireless technologies, including routing and security, which were not previously supported. The KNX–ZigBee gateway as an interface between the two networks with which to translate entities from one network to the other. Although the KNX–ZigBee gateway itself will require maintenance, by its adoption, both networks, KNX and ZigBee, can be maintained as is. The gateway will enable systems to leverage the benefits of each protocol and system. KNX–ZigBee gateway to interface between KNX and ZigBee systems and enable integration of wireless and wired home automation systems. As a next step, we plan to implement the KNX–ZigBee gateway and use it to establish a home lighting control system. This experimental model will include direct lighting, indirect lighting, and artificial lighting devices, as well as ZigBee sensor and actuator nodes. With the help of this experimental home lighting control system, we will investigate the compatibility between the two protocols and also study the feasibility of a ZigBee-based HA system [3].

Home automation systems must comply with the household standards and convenience of usage. The automation centers on recognition of voice commands and uses low-power RF ZigBee wireless communication modules which are relatively cheap. The home automation system is intended to control all lights and electrical appliances in a home or office using voice commands. Home automation is one of the major growing industries that can change the way people live. Some of these home automation systems target those seeking luxury and sophisticated home automation platforms; others target those with special needs like the elderly and the disabled. The aim of the reported Wireless Home Automation System (WHAS) is to provide those with special needs with a system that can respond to voice commands and control the on/off status for the household stuffs like electrical devices, such as lamps, fans, television etc. The system should be reasonably cheap, easy to configure, and easy to run. This paper mainly deals with the voice commands and voice recognition. The speech recognition system is a completely assembled and easy to use programmable speech recognition circuit. Programmable, in the sense that you train the words (or vocal utterances) you want the circuit to recognize. This board allows you to experiment with many facets of speech recognition

technology. It has 8 bit data out which can be interfaced with any microcontroller for further development. Some of interfacing applications which can be made are controlling home appliances, robotics movements, Speech Assisted technologies, Speech to text translation, and many more. The voice recognition application is implemented through HM 2007 IC. The main program for this system is written by using the c programming language. The main program was developed in the Kiel Integrated Development Environment by using the C programming language. The .c program was converted into .HEX file in this IDE and dumped into the ROM part of the AT89c51 micro controller. Voice recognition unit consist of HM 2007 IC, SRAM and keypad. In this unit voice is recorded and then recognized. The speech recognition system will process the signal and store the command in a static RAM IC. The system is target at elderly and disabled people. The prototype developed can control electrical devices in a home or office. The system implements voice recognition unit using HM 2007. The system implements the wireless network using ZigBee RF modules for their efficiency and low power consumption. The preliminary test results are promising [4].

ZigBee based home automation wireless sensor network can be implemented with small initial cost and can be useful to control fans, lights and other home appliances which operation can be controlled with the help of a microcontroller. The home automation can be useful network for physically handicapped persons as well as old age person and the same network can be used to control industrial applications as well. ZigBee protocol IEEE 802.15.4 wireless standard can be used to set up network for some specific application purpose. GSM, WiFi and Bluetooth are well known by most people in the modern society. These standards have penetrated into their daily routine with outstanding popularity. Even though it seems that all peoples' wireless requirements have fulfilled, it turns on, that they lack of something like "an internet of things" especially in mainstream Home Automation (HA). ZigBee standard development is still under progress, the ZigBee market is opened for many various applications. The most promising are: Home Control, Personal health care, Industrial control, Building automation, Consumer electronics, PC & peripherals, Environment etc. Network devices, whether wired or wireless, are commonly described by the Open Systems Interconnection (OSI) reference model. ZigBee network model does not use presentation, session or transport layer and user application is directly tied into Application layer (APL). APL consists of Application sub layer (APS), ZigBee device object (ZDO) & Application framework. The ZigBee IEEE802.15.4 standard defines three frequency bands to employ a standard all over the world. Out of these thee frequencies The 2.45 GHz platform is used commonly at 250KBPS data transfer rate. Secure

data transfer is possible with the help of secure service provider (SSP).The common medium access control (MAC) Layer provides a variety of functions of wireless LANs. The MAC Layer manages and maintains communications between radio network and access points by coordinating. The ZigBee devices that incorporate ZigBee radios and its working are, Coordinator (ZC): Organizes the network and maintains routing tables, Routers (ZR): It can talk to the coordinator, to other routers and to reduced-function end devices, End devices (ZED): It can talk to routers and the coordinator, but not to each other. ZigBee Based Home Automation Wireless Sensor Network is useful project for adults and physically handicapped persons who are not able to do various activities efficiently when they are at home and need one assistant to perform those tasks. With the ZigBee network we can eliminate the complication of wiring in case of wired automation. ZigBee Home Automation provides operating range much higher as compared to Bluetooth. With the use of ZigBee Home Automation circuit considerable amount of power saving is possible and it is flexible and compatible with future technologies so it can be easily customized for individual requirements [5].

3. THEORETICAL BACKGROUND

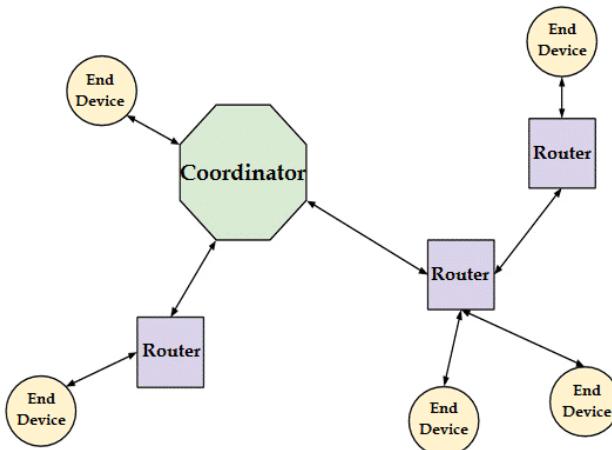
ZigBee is a PAN network task group with low rate task group 4. It is a technology of home networking. ZigBee is the PAN network of task group 4 so it is based on IEEE 802.15.4 and is created by Zigbee Alliance. ZigBee is a standard that addresses the need of very low-cost implementation of Low power devices with Low data rate for short-range wireless communications.

Types of Zigbee Devices:

Zigbee Coordinator Device; It communicates with routers. This device is used for connecting devices.

Zigbee Router: It is used for passing the data between devices.

ZigBee End Device: It is the device that is going to be controlled.



General characteristics of ZigBee Standard:

- Low power consumption.
- Low Data rate (20-250kps)
- Short-range (75-100m)
- Network Join Time (~30msec)
- Support small and large networks (up to 65000 devices (theory); 240 devices (practically))
- Low cost of products and cheap implementation (Open source protocol)

Operating Frequency Bands

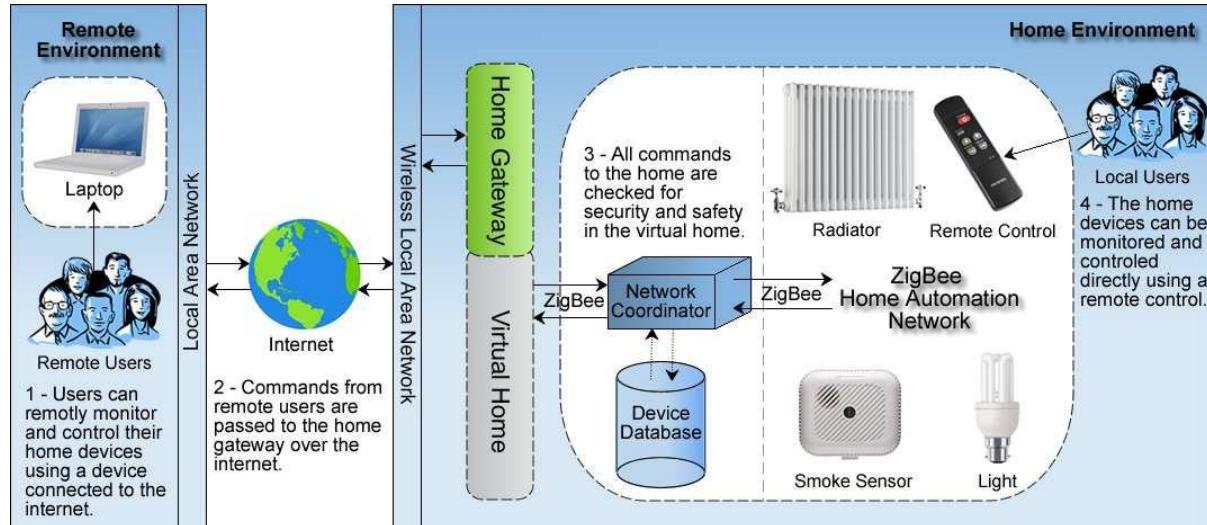
- Channel 0 : 868 MHz (Europe)
- Channel 1-10 : 915 MHz (US and Australia)
- Channel 11-26 : 2.4 GHz (Across the world)

ZigBee Topologies

- Star topology (ZigBee smart energy)
- Mesh topology (Self healing process)
- Tree topology

3.1 ZIGBEE ARCHITECTURE IN HOME AUTOMATION

This section describes the conceptual design of a flexible and low cost home automation infrastructure. The home's low data rate, control and monitoring needs are catered for using Zigbee. The home's high data rate needs, such as multimedia applications, are met by the Wi-Fi (IEEE 802.11g) standard.



A home gateway is implemented to provide interoperability between the heterogeneous Zigbee and Wi-Fi networks, and facilitate local and remote control and monitoring over the home's devices. A virtual home is implemented for the provision of real time security and safety for the home and its inhabitants. The proposed system consists primarily of four steps. Remote user can access the system using the Internet. The remote user's communications traverse the internet until they reach the home network. They are then wirelessly transmitted to the Home Gateway

using the homes Wi-Fi network. The Home Gateway is integrated with a virtual home. These communications are checked and processed by the home gateway and virtual home, as discussed in greater detail later. This checking process involves communication with the home networks coordinator, which is integrated with the home's device database and contains the status of all connected devices. Additionally, a local ZigBee based remote control can be used to directly control connected devices. As discussed, the proposed system architecture implements a ZigBee based home automation network and a Wi-Fi based multimedia network. Alternative standards could have been integrated with the home gateway. However, the use of Zigbee and Wi-Fi offers certain advantages. Zigbee technology is designed to be used on applications that require low data rate, low-cost, low power consumption, and two way wireless communications. The Wi-Fi standard is designed to provide relatively high data rate communications. Wi-Fi has the advantage of an existing and wide spread presence in homes in the United Kingdom. The combination of Zigbee and Wi-Fi technologies has the potential to provide a comprehensive home automation solution.

ZigBee is a radio frequency (RF) communications standard based on IEEE 802.15.4. The Zigbee coordinator is responsible for creating and maintaining the network. Each electronic device in the system is a Zigbee device managed by the coordinator. All communication between devices propagates through the coordinator to the destination device. The wireless nature of ZigBee helps overcome the intrusive installation problem with the existing home automation systems identified earlier. The ZigBee standard theoretically provides 250kbps data rate, and as 40kbps can meet the requirements of most control systems, it is sufficient for controlling most home automation devices. The low installation and running cost offered by ZigBee helps tackle the expensive and complex architecture problems with existing home automation systems, as identified earlier.

Wi-Fi is used for two primary purposes. Firstly, it is the chosen communication standard for multimedia applications in the home. Secondly, it is used to provide access to the home automation system from Wi-Fi enabled devices, as an alternative to the ZigBee based local controller. This approach was taken because homes increasingly have Wi-Fi networks and the additional cost of a Zigbee based controller in these situations is unwarranted. Wi-Fi implements the IEEE 802.11 standard and offers wireless networking through the use of radio frequency. There are different versions of this protocol. The dominant protocol in use today is IEEE 802.11g, which operates in the unlicensed 2.4 GHz band and provides a maximum raw data rate of 54 Mbps. The use of Wi-Fi offers several advantages over alternative technologies.

The home gateway provides two primary functions for the proposed architecture. Firstly, the home gateway provides data translation services between the Internet, Wi-Fi, and ZigBee networks. Secondly, the home gateway provides a standardized user interface for devices connecting to the ZigBee home network, remotely using the Internet or locally using the Wi-Fi network. The home gateway does not provide a standardized interface for the local ZigBee remote control. This decision was made to provide greater freedom for interface design and avoid limitations that have to be taken into consideration in the design of the low data rate, low power ZigBee remote control interface. Although, as depicted, the close cooperation between the home gateway and device database allows for the real time control and monitoring of all home devices, regardless of the access device and network used. The home gateway is implemented in the system architecture to overcome the problem of insufficient network interoperability, identified in existing home automation approaches. Moreover, the proposed approach looks at the existing network structure within the home environment and integrates networks which are predominantly established in the existing home environment. Additionally, the home gateway reduces the inflexibility in the control modes of existing home automation systems; this is undertaken through the provision of manual, local and remote control. Furthermore, the interface of the controlling devices is standardized across the control modes.

The virtual home is responsible for the administration of security and safety for the home automation system. The virtual home, as the name suggests, is a virtual environment where the actions requested by users are checked. For the purposes of security, all the messages received by the virtual home are checked by authenticating the senders, checking the integrity of the messages to ensure they have not been tampered with, and protecting the confidentiality of messages through the use of encryption. The system's safety is protected by ensuring the commands received are appropriate for the respective home network and that all changes requested fall within the specified safety limits. The primary objective of the virtual home is to prevent any event that may pose a security or safety concern from implementation in the home networks. The virtual home is included in the proposed architecture to tackle the security and safety problems.

4. ADVANTAGES

The advantages of ZigBee Technology in home automation:

- It consumes less power
- Less time consuming
- Zigbee home automation is comfortable and very safe
- The range of Zigbee is approximate 100-300 feet
- Faster communications between devices
- Long battery life to the devices
- It is very helpful to handicapped people
- Most of the devices in a home can be connected to a Zigbee network
- 240 devices can be connected to a single ZigBee network whereas WiFi can connect up to 64 and Bluetooth can up to 8 including the host.

5. CONCLUSION

In this work, a technical overview of the ZigBee technology has been presented. The main features of the ZigBee technology have been highlighted in this paper. Although the ZigBee has numerous applications, we limit this effort only to its application in WHAS. The performances of the ZigBee based WHAS have been compared with those of other competing technologies including Z-Wave, Insteon, Waveins, WiFi, and Bluetooth. The system is target at elderly and disabled people. The prototype developed can control electrical devices in a home or office. ZigBee Based Home Automation Wireless Sensor Network is useful project for adults and physically handicapped persons who are not able to do various activities efficiently when they are at home and need one assistant to perform those tasks. With the ZigBee Home Automation provides operating range much higher as compared to Bluetooth. With the use of ZigBee Home Automation circuit considerable amount of power saving is possible and it is flexible and compatible with future technologies so it can be easily customized for individual requirements.

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