Performance evaluation of ZigBee and Wi-Fi enabled Internet of Things

T.Vimala, Dr.Uma Raja ram

Abstract— ZigBee, Wi-Fi and Bluetooth wireless communication systems use the ISM (Industrial Scientific and Medical) Band .Majority of Research works are indicating that ZigBee wireless technology is one of the best networks for low cost, low power and reliable control and monitoring applications. Recently, a lot of Internet based applications are becoming more popular such as VoIP, Instant messengers and email clients etc. Now more objects are embedded with IP address and communicate self using mailbox concepts. In this paper we have analyzed ZigBee nodes and Wi-Fi enabled Internet of Things.

Index Terms— ZigBee,Wi-Fi,ISM,Internet of Things,IP address

1 INTRODUCTION

The demand for wireless personal area networks (WPANs) such as mobile computing devices and all types of computers are greatly increased. Initial stages of wireless personal area networks were transferring information between humans and computing devices. Most of the networks comprise of sensors for sensing the environments in remote Area. Most of the wireless networks are using IEEE 802.15.4 standards because of its wide range of low power consumption, low cost and reliable. Recently the wireless communication network is focusing Internet of Things (IoT).IoT comprising of more objects are embedded with sensors and gaining the ability to communicate by IP address. The huge address space of IPv6 is an important factor in the development of Internet of Things.IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) and the internet. The maximum allowable transmit power of the Wi-Fi output which could be up to 100 times higher than the maximum allowed power of the ZigBee standard, Also practically Wi-Fi network is not affected by the activity of the ZigBee network.[2].We can utilize the high power consumption of Wi-Fi network as well as low power consumption of ZigBee network for effective communication among nodes which are either situated in highly populated urban areas or remote area where human intervention is very minimum. In the ongoing decade, productivity will be driven by the Internet of Things. Successful deployment of the IoT is therefore crucial to the survival of companies and societies [1]. A major aspect of communication technology, though largely invisible to the average consumer, is computer-to-computer traffic and activity, i.e. the moving, refining, managing, presenting and storing of information. This increase shows that the expansion of the Internet from a technology for exchanging information rapidly between all kinds of physical items. [1].

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2 OVERVIEW

2.1 ZigBee (IEEE 802.15.4)

ZigBee is the product of the ZigBee Alliance. It is developing a new networking technology for small ISM-band radios that can implement even the simplest industrial and home end devices into wireless connectivity. It is designed especially for low cost, low power, low data rate wireless mesh technology.

[3]A ZigBee wireless sensor network can be implemented using three types of nodes: coordinator, routers and End Devices. The coordinator is important node in the network initialization and it performs the following tasks: the selection of the radio channel and the initialization of the network, allowing other nodes to join the network. In addition, the coordinator performs message routing, security management. A outer node can retransmit messages and allow other nodes to join the network. The main work of an End Device type device is sending and receiving messages, the latter has no routing capabilities if is of RFD (Reduced Function Devices) type, and is often powered by batteries. IEEE802.15.4 standard defines two types of nodes: FFD (Full Function Devices) that can be coordinators or routers and RFD (Reduced Function Devices) nodes that can communicate only with FFD nodes and it cannot act as coordinators. The RFD nodes are much cheaper because of the reduced RAM / ROM memory.

End devices can asleep most of their time period, wake up only when they have to communicate and they go to sleep mode after their communication period immediately in order to minimize power consumption and increase battery life. Several researches are focusing the main aspect of minimum power consumption of battery powered ZigBee nodes placed in remote area where human intervention is very rare.

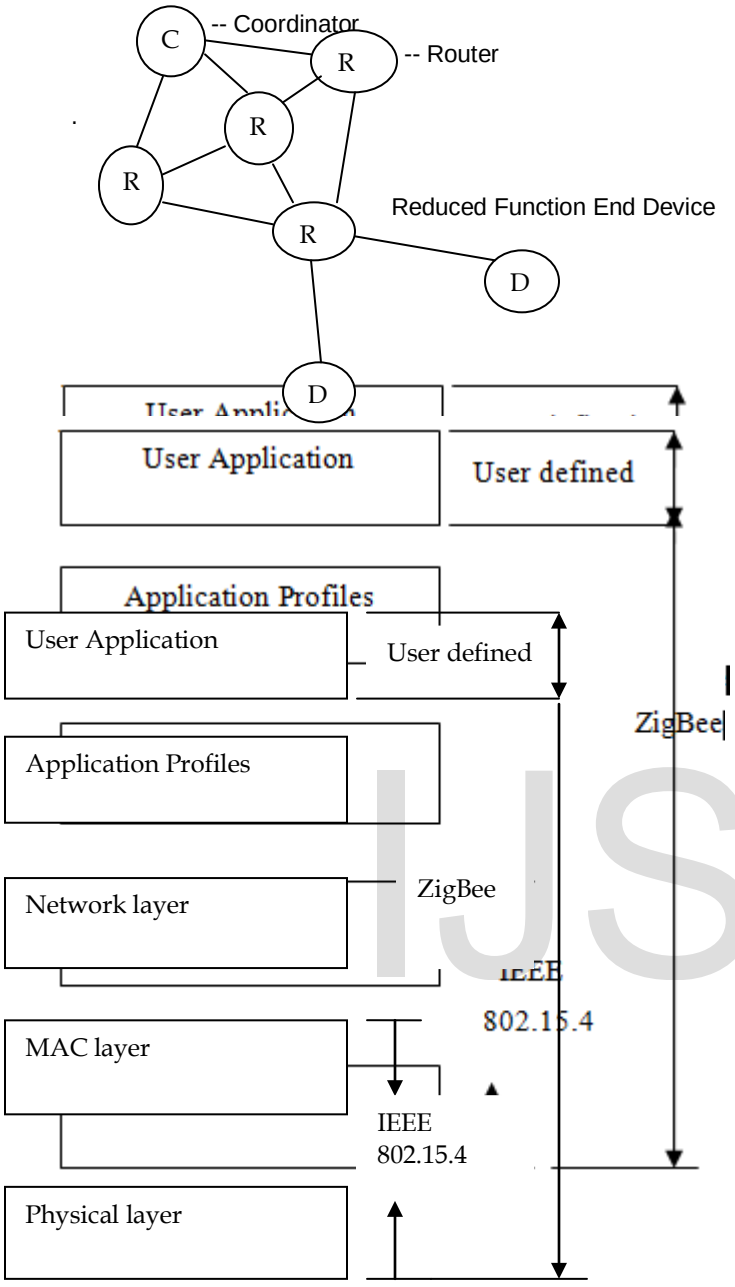

Fig.2 ZigBee stack

TABLE. 1 The characteristics of IEEE 802.15.4 (ZigBee)

Frequency Band	868-868.6 MHz	1 channel; 20Kbps
	902-928 MHz	10 channels; 40Kbps
	2.4-2.4835 GHz	16 channels; 250Kbps
Distance Coverage	10 to 30 meters	

2.2 Wi-Fi

Wi-Fi represents "wireless fidelity". Wi-Fi is used generally for WLAN (Wireless Local Area Network). Wi-Fi allows any electronic device to exchange and transfer data wirelessly over the network and gives high speed internet connections. Any device which is Wi-Fi enabled (like personal computers, video game consoles, Smartphone, tablet etc.) can connect to a network resource like the internet through a wireless network access point. Now such access points also known as hotspots have a coverage area of about 20 meters indoors and even a greater area range outdoors. Wi-Fi is known to be less secure than wired connections (such as Ethernet) because an intruder does not need a physical connection. Wi-Fi has adopted various encryption technologies [4]

[5]The modern IEEE 802.11 WLANs operate in the 2.4 GHz and 5 GHz frequency bands. The basic channel is 20 MHz wide but 802.11n and 802.11ac allow usage of wider channels by bonding several channels together. The number of available 20 MHz channels in the 2.4 GHz and 5 GHz frequency bands are 11-13 and 19-25 respectively, depending on the regulatory domain. All devices that are within the transmission range and share the same, or overlapping, channel also share the channel transmission capacity.[6]In North America, 2.4GHz and 5GHz are both allowed for unlicensed transmissions. The older 2.4GHz band is the most heavily used in most areas, ut as new devices are purchased that support the 5GHz band, it is expected to gradually fill up as well.

The following Table.2 shows the some important points about Wi-Fi and ZigBee for further analysis of these two types of networks.

TABLE.2 General Comparison between Wi-Fi and ZigBee

Network	Wired/Wireless	Throughput	Common Uses
Wi-Fi	2.4GHz/5GHz	Varies with distance, interference, channel width	Data
ZigBee	2.4GHz	20-250kb/s	Home con-trol

2.3 . IOT (Internet Of Things)

The Internet of Things refers to uniquely identifiable objects and their virtual representations in an Internet-like structure. The idea of connecting physical objects and communicating with each other online is referred to as the Internet of Things. IPv6's huge increase in address space is an important factor in the development of the Internet of Things. The common places everyday consumers see Internet-connected devices are in the home. We can monitor remotely and control which devices are on and off at any specific time helps owners reduce monthly electric, gas and water bills. [7] When devices can sense and communicate via the Internet, they can go beyond local embedded processing to access and take advantage of remote super-computing nodes. This allows a device to run and make complex decisions and responds to local needs quickly, with no human intervention required.

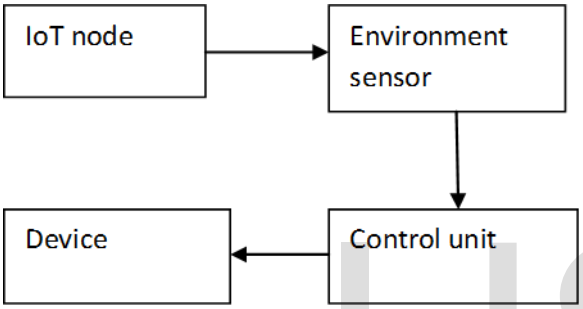

Fig.3 Simple Block Diagram Of IoT

All the devices including the control unit is connected to one another through Wi-Fi and communicates on the Internet Protocol version 6 (IPv6).The common sensors could be some smart camera for human detection and smart audio device for speech transmission. The Control unit is a microcontroller/microprocessor based block that does the processing of various inputs and generates certain outputs. The control unit also issues various commands to the smart devices to take appropriate action based on the input.

2.4 Internet Protocol (IPv4 & IPv6)

Internet Protocol is a set of technical rules that defines how computers communicate over a network. There are currently two versions: IP version 4 (IPv4) and IP version 6 (IPv6).IPv4 was the first version of Internet Protocol and there are just over 4 billion IPv4 addresses.IPv6 is a newer numbering system that provides a much larger address pool than IPv4. The major difference between IPv4 and IPv6 is the number of IP addresses. There are 4,294,967,296 IPv4 addresses. In contrast, there are 340, 282, 366, 920, 938, 463, 463, 374, 607, 431, 768, 211, 456 IPv6 addresses [8].

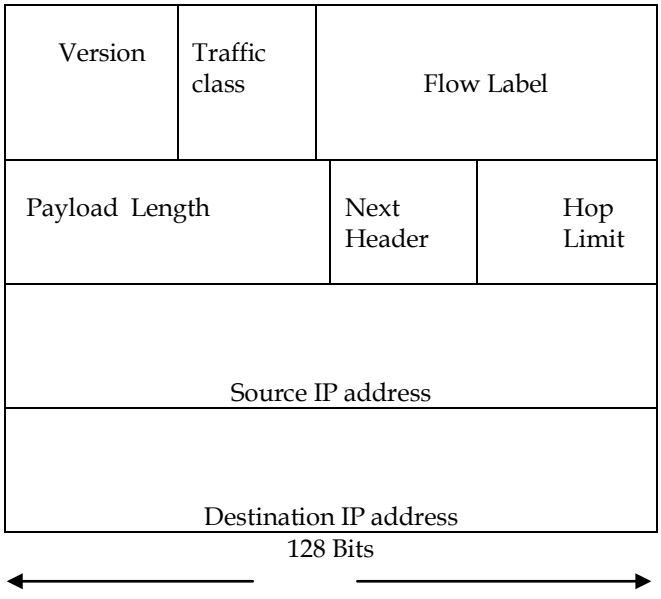

Fig.4. IPv6 Header Structure

2.5 Tunneling Concepts

It is the main mechanism currently being deployed to create global IPv6 connectivity. Tunneling is a technique by which one transport protocol is encapsulated as the payload of another. Tunneling techniques are used on top of an existing IPv4infrastructure and uses IPv4 to route the IPv6 packets between IPv6 networks by transporting these encapsulated in IPv4[14].

3 RELATED WORK

In the research work [9] discusses some points about Wi-Fi and ZigBee that Wi-Fi could have a significant impact on ZigBee when increasing Wi-Fi's power level or duty cycle above what is used or reachable in today's applications (file transfer, audio and video streaming). This is true when operating in IEEE 802.11b mode. Better coexistence properties in IEEE802.11g mode can be explained by less time spent by interfering packets on air. Technical evolutions of Wi-Fi technology and possible new application patterns in the future could in theory have more impact on ZigBee.

[9]The IEEE 802.15.4 specification augments the opportunities for smooth coexistence by dividing the 2.4 GHz band into 16 on-overlapping channels, which are 2-MHz wide and5-MHz apart (Figure 4). Four of these channels (15, 16, 21, 22) fall between the often-used and non-overlapping 802.11b/g channels (1, 7, 13). Finally, Schneider Electric's Innovation Department formulated two installation recommendations and three conclusions:

• Distance of Wi-Fi interferers to ZigBee nodes should be at least 2 m.

• Frequency offset between both networks should be at least 30 MHz

• During the entire test exercise, no ZigBee message was lost.

• Interference was nonetheless seen to have an impact on latency.

IEEE 802.11g networks have less impact on ZigBee than IEEE802.11b networks due to less time spent on air.

[10] They propose WiZi-Cloud, a system that utilizes a dual Wi-Fi-ZigBee radio on mobile phones and Access Points, supported by WiZi-Cloud protocols, to achieve ubiquitous connectivity, high energy efficiency, real time intra-device/inter-AP handover, that is transparent to the applications The WiZi-Cloud system is designed as to run below the Internet Protocol layer in the TCP/IP model, and above the link layer. Their extensive set of experiments demonstrates that ZigBee achieves a factor of 11 better energy efficiency than Wi-Fi in Power Saving Mode. With all system energy usage counted, WiZi still can be 2 times more energy efficient than an optimized Wi-Fi while active transmitting, and standby lifetime can be extended upto 3 times. WiZi-Cloud has better coverage than Wi-Fi within 50ft indoor environment.

[11] In this paper, the feasibility of low-power Wi-Fi to enable IP connectivity of battery-powered devices is studied with three key practical areas of concern: Power consumption, impact of interference, and communication range. At high data rates, transmitting/receiving data and packet size have small impact on power consumption. On the other hand, at low data rates the impact of transmit/receive energy and packet size becomes noticeable. Retransmissions can have an impact on energy consumption and the impact is more pronounced for low data rate operation. Their study shows that battery lifetime of a Wi-Fi enabled sensor depends heavily on the operating scenario. However, it is favorable to operate at higher data rates to achieve lower power consumption. Hence, selection of data rate creates a tradeoff between communication range and battery lifetime.

In this paper [12], different representations of Wi-Fi access point signal information are tested on a hierarchical indoors localization system to identify the one that yields the least amount of localization error. This paper [13] explores the potential of using Wi-Fi signals and recent advances in MIMO communications to build a device that can capture the motion of humans behind a wall also in closed rooms. Law enforcement personnel can use the device to avoid walking into an ambush, and minimize casualties in standoffs and hostage situations. Emergency responders can use it to see through rubble and collapsed structures. Ordinary users can leverage the device for gaming, intrusion detection, privacy-enhanced monitoring of children and elderly or personal security when stepping into dark alleys and unknown places.

4 RESULT

We have assigned email id to node 1 and node 2 and command and control action can be taken place based on the information received on mail box message. Both the nodes are Raspberry Pi and their features are tabulated in Table 3.

Flow Chart. 1 Communication between two nodes

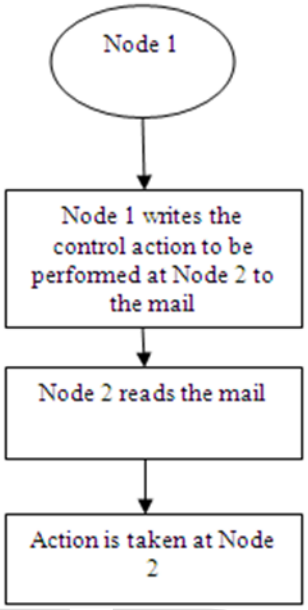

TABLE. 3 Features of nodes (Raspberry Pi)

Node 1 & Node 2 (Raspberry pi)	Both nodes should be compatible for the following features: IP address Battery Powered LAN Enabled Wi-Fi Enabled ARM II Processor ,HDMI interface & USB Ports

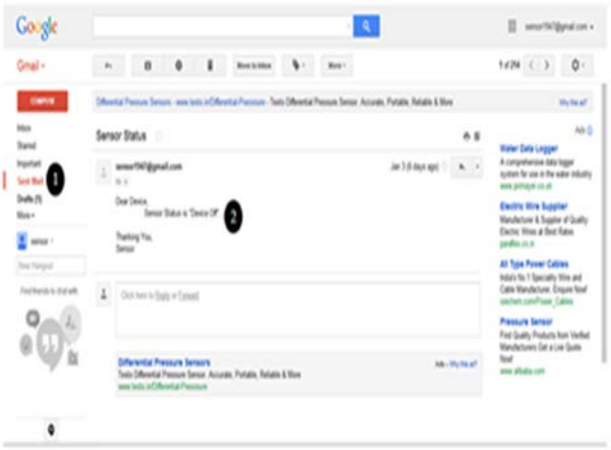

Fig.5 Selected option (2) sent mail of Sensor IoT

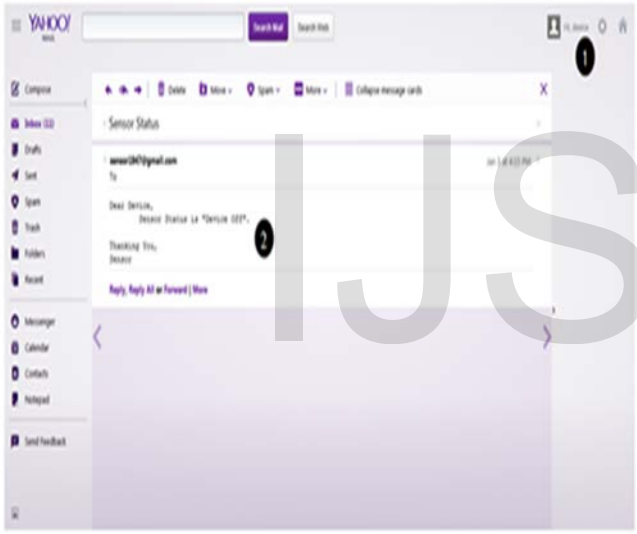

Fig.6 Device IoT mail (2) inbox of device IoT received mail from sensor1947@gmail.com

Here Node 1 has a mail id (domain) node1@ gmail.com Node 2 has a mail id node2@ yahoo.in.Node 1 sends the control action which is to be performed at Node 2 using its own mail id. After receiving the mail, Node 2 reads the mail and the approbriate action is performed in the device side . This is explained in Flowchart 1.Here SNMP Protocol is used to send the information for node 1 and POP 3 Protocol is used to receive the information for node 2 from node 1.The following two snap shots Fig.5 and Fig.6 are clearly showing the communication between two nodes using their own mail ids.

5 DISCUSSION

We have discussed about ZigBee, Wi-Fi and Practical aspects of Internet of Things(IoT) based on our research .The benefits of combining all these networks is very helpful to mankind. Because of combining ZigBee and WI-Fi we can get better energy efficiency. This paper [7] gives the clear idea of our concept. [7] The IoT will also add the concept of wireless sensor and actuator networks (WSANs) that contain sensing and embedded nodes to sense and control their environment. In recent market, a transition period before system optimization takes place and technologies become better-suited for the end IoT-related applications is likely. Now the battle between ZigBee and low-power Wi-Fi for industrial control and automation has just started. Operators are eagerly looking for new revenue streams, machine-to-machine communication and location-based services .Both are very much a part of the emerging IoT market and can also use existing infrastructure.

6 CONCLUSION

This paper evaluates the performance of ZigBee, Wi-Fi and Wi-Fi enabled IoT nodes. The purpose of this work is to establish a combined network of these nodes to achieve better communication and free from interferences because Wi-Fi has a great impact on ZigBee. This work is not to draw any specific conclusion about combining the different technologies but giving this idea by analyzing the concept of IoT nodes and their self communication practically. In our future work we will implement Wi-Fi enabled IoT nodes for machine-to-machine communication and location-based services without domain node.

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