



ZigBee Technology For Data Communication- A Comparative Study With Other Wireless Technologies

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Abstract: ZigBee is an IEEE standard that has a set of specifications for wireless personal area networking (WPAN). It mainly works in the physical layer and Media Access Control (MAC) layer of the ISO-OSI model. It is developed to improve the capabilities of wireless networking. Since ZigBee can be used almost everywhere, it is easy to implement and needs little power to operate, the opportunities for growth in markets, as well as innovations in existing markets, is enormous. ZigBee is simpler, inexpensive and open standard protocol that consumes less power. As a result, it provides longer life to batteries. ZigBee is designed to provide highly efficient connectivity between small packet devices. It has a wide range of applications that covers almost all markets like health care, military, consumer electronics, Telecommunication Services etc. In this paper, we are mainly focusing on the importance of ZigBee technology by comparing with other wireless technologies.

Keywords: ZigBee, Physical layer, Media Access Control (MAC) layer, IEEE 802.15.4

I. INTRODUCTION

Various progressive wireless communication standards were developed and implemented during the last few years. These include Wi-Fi, Bluetooth and WiMAX. These standards have penetrated into our daily routine with great popularity. While Bluetooth concentrates on connectivity between large packet user devices, such as laptops, phones, etc., ZigBee is designed to provide highly efficient connectivity between small packet devices. It is an IEEE standard 802.15.4 fully wireless technology that works in the physical layer and in the MAC (Media Access Control) layer.

IEEE 802.15 is a working group for the standardization of WPAN (Wireless Personal Area Network). IEEE 802.15.4 is one of the seven task groups which are included in it. The first edition of the 802.15.4 standard was released in May 2003 [3]. ZigBee plays an important role in wireless communications in business and consumer devices. It is less expensive, simpler and open standard protocol that has no or negligible licensing fees. Chipsets for ZigBee is available from multiple sources and it is a remotely upgraded firmware. It mainly employs mesh networking but also uses other networking topologies such as star, peer-to-peer etc. it has very low maintenance cost but has larger network size that can support about 65,535 networks. The transmission range is about 100m which is far better than Bluetooth. The data rate is of 75mbps and bandwidth about 250kbps.

ZigBee has been developed to improve the capabilities of wireless networking between numerous low power devices. It is designed for situations where the bandwidth requirements are low and power consumption must be very low to give very long battery life [5]. With thousands of people around the globe, ZigBee uses the 2.4 GHz radio frequency to deliver a variety of reliable and easy-to-use standards anywhere in the world. ZigBee offers a wide variety of innovative standards that is smartly designed to help us to grow and save money. It has several applications such as home automation, smart phones, sensors, actuators, military security, burglar alarms, smoke detectors etc.

II. ARCHITECTURE

According to the Open System Interconnect (OSI) model, ZigBee's protocol stack is structured in layers. The first two layers (physical layer and MAC layer) are defined by the IEEE 802.15.4 standard. The layers above them are defined by the ZigBee Alliance which is the official test and certification group for ZigBee devices. There are mainly eight promoter companies to support ZigBee Alliance. They are Chipcon, Ember, Freescale, Honeywell, Mitsubishi, Motorola, Philips and Samsung.

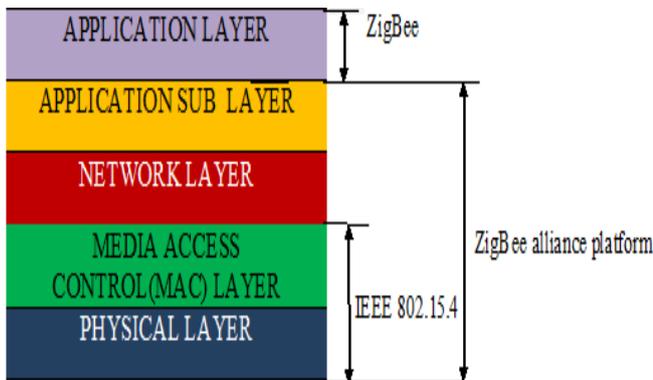


Fig 1: ZigBee protocol stack

Like Wi-Fi, ZigBee uses Direct Sequence Spread Spectrum in the 2.45GHz bandwidth with QPSK (Quadrature Phase Shift Keying) modulation.

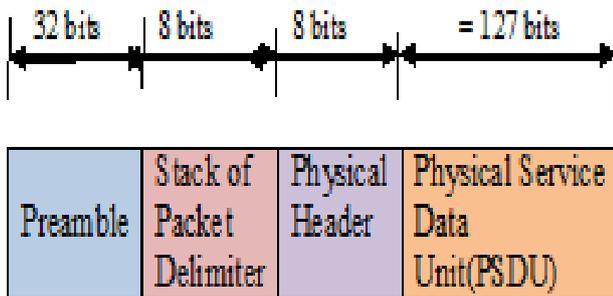
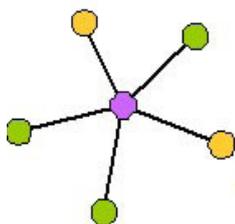


Fig 2: IEEE 802.15.4 Physical layer packet structure

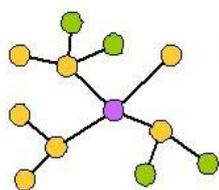
The physical layer packet contains the following fields:

- Preamble: It is 32 bit in order to achieve synchronization.
- Stack of Packet Delimiter: It is 8 bit that signifies the end of the preamble.
- Physical Header: It is also 8 bit that specifies the length of the Physical Service Data Unit (PSDU).
- PSDU: It is less than 127 bytes that represents the physical layer data (payload).

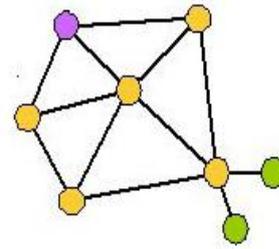
ZigBee uses different network topologies that include peer-to-peer, mesh, star etc. Star topology defines master slave network model where master is a FFD (Full Function Devices) and end devices can be FFDs or RFDs (Reduced Function Devices). In mesh and tree topologies, a FFD can talk to other FFDs within its radio range and can relay messages to other FFDs outside of its radio coverage through an intermediate FFD, forming a multi-hop network.



Star



cluster tree



Mesh

Fig 3: Different network topologies specified by ZigBee

III. TYPES OF TRAFFIC

ZigBee addresses three types of traffic. MAC layer accommodate all the three types. They are:

- Data is periodic
The application dictates the rate, and the sensor activates checks for data and deactivates [1].
- Data is intermittent
The application determines the rate. The device needs to connect to network only when communication is required. This will helps to save energy.
- Data is repetitive
Data rate is fixed. The device operates at fixed durations depending upon the allotted time slots.

IV. MODES OF ZIGBEE

ZigBee employs two modes for to and fro data traffic. They are:

- Beacon mode

Beacon mode is more powerful for controlling power consumption in extended networks like cluster tree or mesh networking topology. It allows all clients of the network to know when to communicate with each other. PAN coordinator manages the channel and arranges the calls. In beacon mode, the device watches out for the coordinator's beacon that is transmitted periodically. The device then looks and locks for the messages addressing to it. After completion of the transmission, the coordinator sends a schedule to the next beacon so that the device and the coordinator will go to sleep.

While using beacon mode, all the devices in the network is aware about when to communicate with each other. In this case, the timing circuit must be very accurate or wake up correctly to avoid missing of beacon. Beacon mode is used when the coordinator runs on batteries thus offering maximum saving of power.

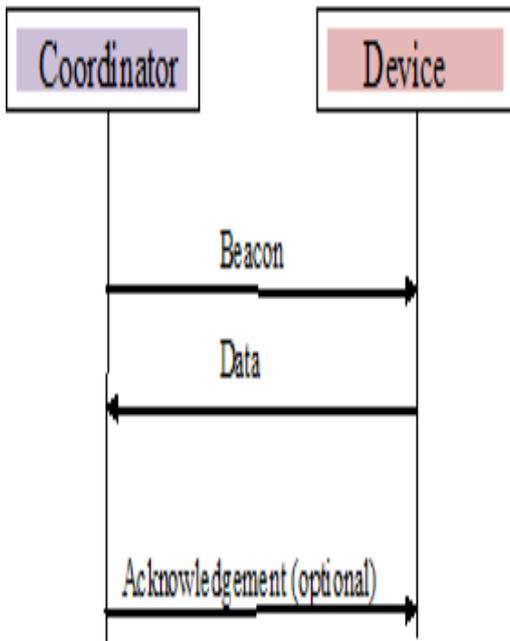


Fig 4: Beacon network communication

2) Non beacon mode

It is a simple, traditional multiple access system used in simple peer-to-peer networks and employs standard ALOHA and CSMA-CA communications. There is positive acknowledgement when packets are received successfully. Beacon mode is used when the coordinator runs on batteries and thus offers maximum power savings, whereas the non-beacon mode finds favour when the coordinator is mains-powered [1]. In non-beacon mode, the devices are asleep always. They wake up and confirm their presence at random intervals in the network. Non beacon mode is mainly used in smoke detectors and burglar alarms.

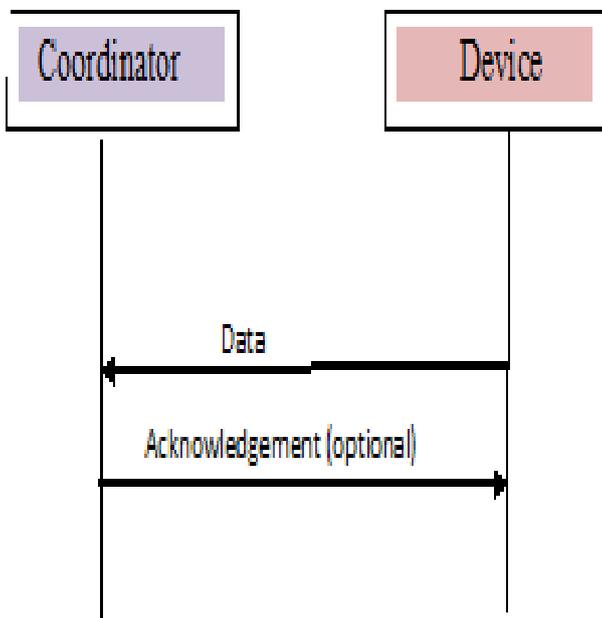


Fig 5: Non beacon network communication

✚ CHARACTERISTICS OF ZIGBEE

ZigBee has large number of characteristics that makes it unique from other IEEE standard wireless technologies. These include:

- Low power consumption which provides longer life for small batteries.
- Mesh networking provides high throughput and larger range of about 100m.
- High throughput and low duty cycle applications (<0.1%) [1].
- Less data traffic.
- High data rate of about 75mbps
- Easy to install
- ZigBee employs different network topologies like star, mesh, peer-to-peer etc.
- Fully reliable hand-shaked data transfer protocol
- Addressing space is up to 64 bit IEEE address devices about 65,535 networks.
- Channel access is using CSMA-CA (Carrier Sense Medium Access with Collision Avoidance)
- Maximum data rates allowed for different frequency bands are fixed as 250 kbps at 2.4 GHz, 40 kbps at 915 MHz, and 20 kbps at 868 MHz

Table 1

Available frequency bands for IEEE 802.15.4 standard

	Frequency Range		
	868 MHz	915MHz	2.45Ghz
Frequency band	ISM	ISM	ISM
Bit rate	20 kbps	40 kbps	250 kbps
Number of channels	1	10	16
Modulation	BPSK	BPSK	QPSK

VI. APPLICATIONS OF ZIGBEE

Hundreds of companies have selected ZigBee as their wireless technology because ZigBee works. It is not limited

to a certain level but because of being cost-effective, low-power battery and wireless connectivity, this ZigBee technology is used in almost every appliance if not in all [2].Through ZigBee, it is possible to control and monitor a whole factory unit while sitting in one cabin. It centralizes all the units in one place and enables the remote monitoring [2].

Due to its low consumption of power, ZigBee is used in battery operated products. It is used in smoke detectors, scientific equipments and in the control units of home and industry. It plays a huge role in almost all wireless devices.

ZigBee can be used for embedded sensing, medical data collection, smoke detectors, smoke and intruder warnings, building automation etc. It is widely used as it has the

capability of energy management. ZigBee has been developed to meet the growing demands and improve the capabilities of wireless networks.

Table II. Cmparison of Various Wireless Tecnoloohies

<i>Characteristics</i>	<i>Technology</i>			
	Bluetooth	Wi-Fi	WiMAX	ZigBee
Standard	802.11	802.11a,b,g	802.16	802.15.4
Transmission Range	10m to 100m	50m to 100m	50km	10m to 100 m
Topology	Adhoc , very small networks	Point to hub	Infrastructure	Adhoc, peer- to -peer, star, mesh
Protocol stack size	~100+KB	100+KB		4"32KB
Operational frequency	2.4GHz	2.4 and 5 GHz	100GHz to 66GHz	868MHz 900-928MHz 2.4GHz
Network	PAN(Personal Area Network)	LAN(Local Network)	Area MAN(Metropolitan Area Network)	PAN(Personal Area Network)
Power consumption	medium	Very high	High	Very low
Security	64 and 128 bit encryption	SSID	station authentication and encryption	128 bit AES
Cost	low	High		Very less
Battery life(days)	1 to 7	1 to 5		100 to 1000+
Bandwidth	2.45GHz	791MHz	200MHz ,25MHz, 28MHz	250kbps
Data rate	2Mbps	108 to 600Mbps	32 – 134 Mbps	75Mbps
speed	2.1Mbps	Upto 54Mbps [1]	70mbps	250kbps
modulation	FHSS	DSSS	QAM	DSSS

Access protocol	CSMA/CA	Request/Grant	CSMA/CA
Ease of use	normal	hard	Easy
Applications	Wireless USB, handset, Wireless connectivity between devices such as phones, laptops, headsets	Wireless LAN connectivity, broadband Internet access, PC networking, file Transfers, video	MPEG video, basic voice services, low cost domestic and international calls Industrial control and monitoring, sensor networks, building automation, home control and automation

VII. CONCLUSION

It is likely that ZigBee will increasingly play an important role in the future of computer and communication technology [1]. This technology offers exciting opportunities to increase the connectivity of devices within the home for the purpose of home automation. The rapid expansion of the Internet, had added potential to the remote control and monitoring of such networked devices. ZigBee has become one of the most promising wireless technologies for home networks. ZigBee devices continue to communicate effectively even in the presence of surprise amount of interference.

ZigBee is a specification that is used in networking, security and application software layers due its features such as small, low-power, cost effective, simpler based on wireless personal area networks (WPAN). This paper mainly describes the features of ZigBee that is a great solution for wireless networks. It also describes the unique features of ZigBee by comparing with other wireless technologies such as Bluetooth, WI-Fi and WiMAX.

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