ITS323 REPORT

Assignment 1

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Submitted to

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September 8, 2010

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ZigBee

ZigBee

ZigBee is a new wireless technology using small power consumption, low data transfer rate, low cost. ZigBee bring the Physical layer and MAC layer of IEEE 802. 15. 4-2003 standard for wireless home area networks (WHANs). There are many companies that are utilizing the performances of ZigBee, and the produced a products such as a wireless switch and censoring devices.

Protocol Architecture

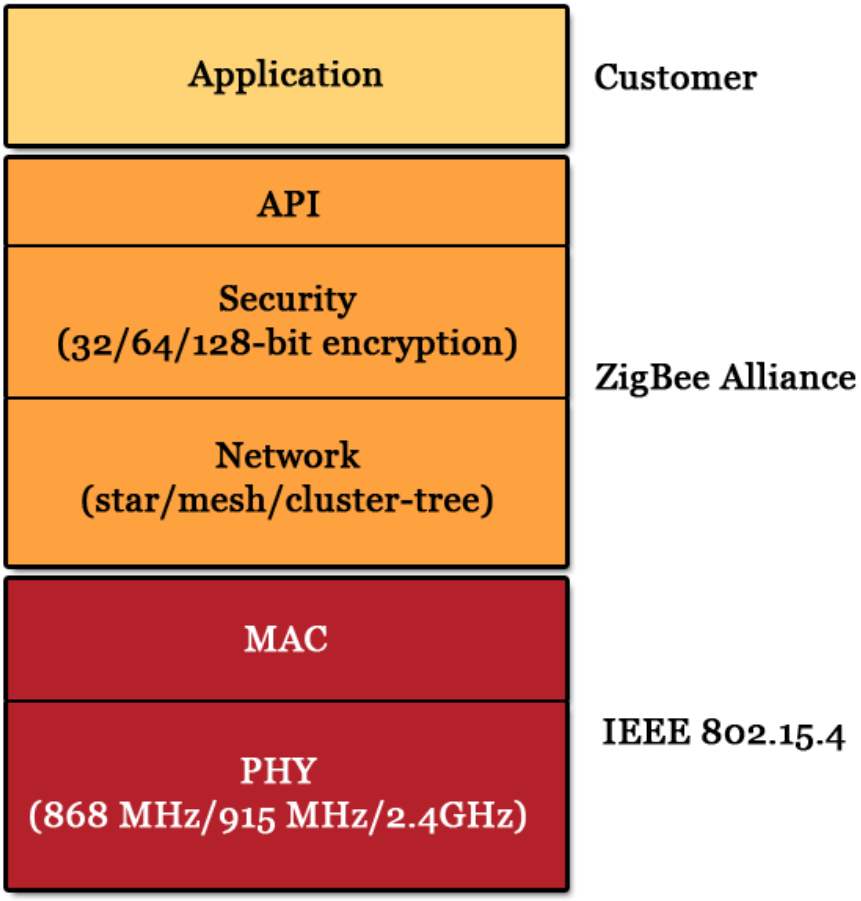


Figure 1 : ZigBee Layer Stack

The ZigBee Alliance is an association of companies working together to produce a low-cost, low-power, wirelessly networked. The goal is to provide the flexibility, mobility, and ease of use by building a wireless intelligence and capability into everyday devices.

There are 3 types of network topologies that ZigBee supports which are Star topologies, Cluster topologies, and Mesh topologies and 2 types of devices which are Reduced Function Device (RFD) and a Full Function Device (FFD)

1. Star topology Network

The communication is established between devices and a single central controller called The PAN coordinator. The PAN coordinator is the main power and the devices are likely to be battery power.

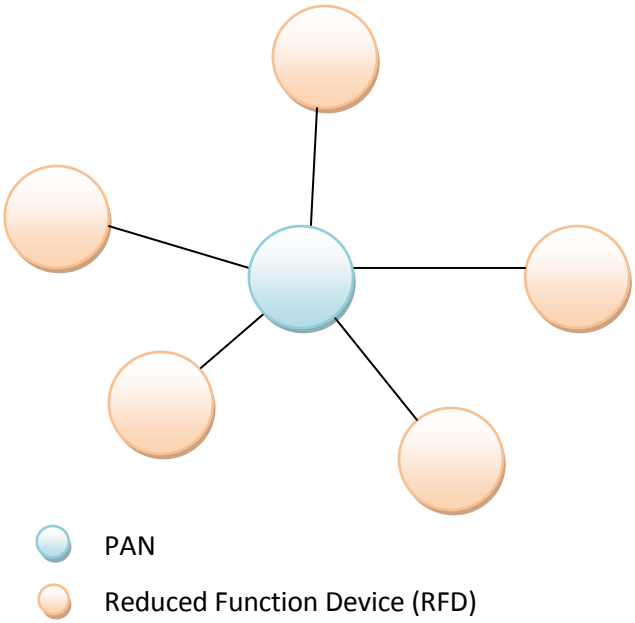


Figure 2.1 : Star topology network diagram

2. Cluster-tree Network

Cluster topologies is a special case of peer-to-peer network which most devices are Full Function Device (FFD) and an Reduce Function Device may (RFD) connect to the cluster-tree network as a leave note at the root of the node and FFD can be act as a coordinator to the other nodes

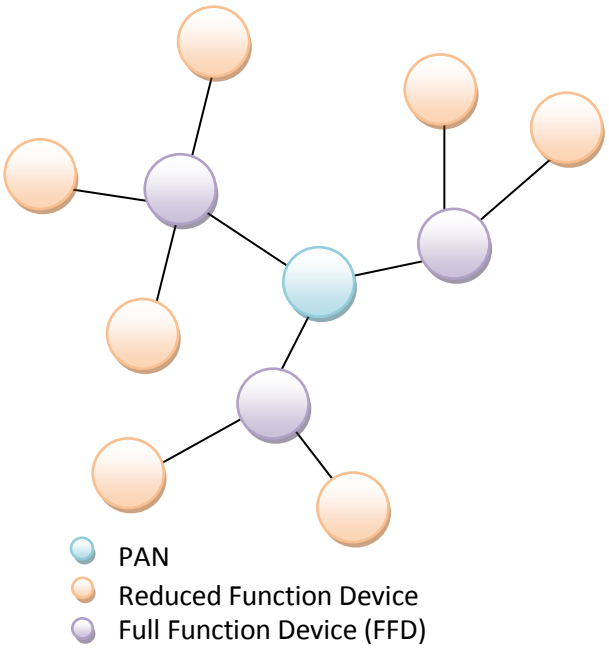


Figure 2.2 : Cluster-tree network diagram

3. Mesh Network

Similar to Cluster-tree Network but almost all non- RFD nodes will be connected together.

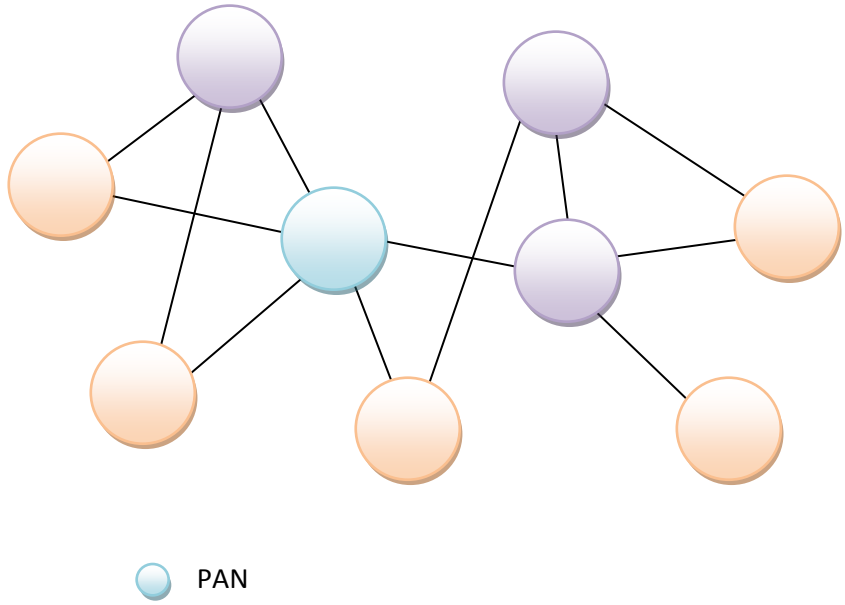


Figure 2.3 : Mesh network diagram

ZigBee Standard

ZigBee standard provides network, security, and application support services operating on top of the IEEE 802.15.4, which supports multiple network topologies including Star, Cluster-tree, and Mesh. And also include a medium Access Control (MAC) layer and Physical Layer (PHY).

Physical Address (PHY) layer:

The PHY service enables the transmission and reception of PHY protocol data units (PPDU) across the physical radio channel. And the main features of the IEEE 802.15.4 PHY layer are to Activate and deactivate the radio transceiver, energy detection (ED), transmit and receive the data, select a channel frequency, Link quality indication (LQI),clear channel assessment (CCA).

Media access control (MAC) layer:

The MAC service enables the transmission and reception of MAC protocol data units (MPDU) across the PHY data service. And the features of MAC are beacon management, channel access, frame validation, acknowledged frame delivery.

MAC Features	PHY Features
Associate/Dissociate ACK Frame delivery Beacon management Channel scan Low complexity Frame validation	Activation/Deactivation of the radio transceiver Energy detection within current channel Data transmission and reception Channel frequency selection Link quality indication for receive packets

Table 1 : Features of MAC layer and PHY layer

<u>Data Transmission</u>

The data rate is 250 kbps at 2.4 GHz, 40kbps at 915 MHz and 20kbps at 868 MHz. The higher data rate at 2.4 GHz is attributed to a higher order modulation scheme. Lower frequency provides longer range due to lower propagation losses. Low rate can be translated into better sensitivity and larger area. Higher rate means higher throughput.

PHY (MHz)	Frequency Band (MHz)	Spreading Parameter		Data Parameters		
		Chiprate (kchip/s)	Modulation	Bit rate (kb/s)	Symbol rate (ksymbol/s)	Symbols
868/915	868-868.6	300	BPSK	20	20	Binary
	902-928	600	BPSK	40	40	Binary
2450	2400-2483.5	2000	O-QPSK	250	62.5	16-ary Orthogonal

Table 2 : Characteristic of ZigBee

Operating sequence bands

There is only one channel between 868 -868.6 MHz which is Channel 0, 10 channels between 902-928 MHz which are channel 1-10, 16 channels between 2.4-2.4835 GHz which are channel 11-26 each channel requiring 5 MHz of bandwidth.

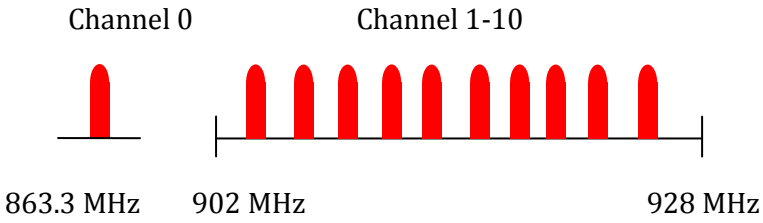
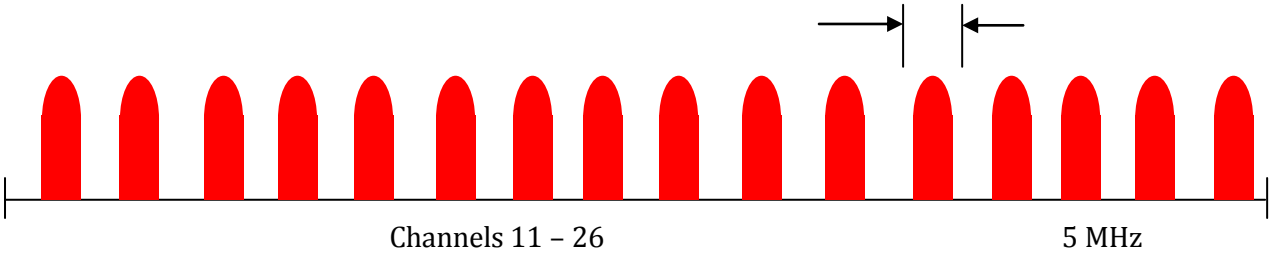


Figure 3.1 : 868 MHz / 915 MHz PHY



2.4 GHz **2.4835 GHz**

Figure 3.2 : 2.4 GHz PHY

Transmission media

There are many types of antennas which may use different kind of network. And the distance of each Transceiver is start from 10 meters up to 400 meters.

Transceivers - 1319x/1320x Families		
Production	**Description**	**Applications**
MC13191	2.4GHz transceiver, two timers and 125 Kbyte payload	Point-to-point and star networks
MC13201	Adds transmit/receive switch to MC13191	Point-to-point or star networks
MC13192	2.4 GHz transceiver, four timers and a 125 Kbyte payload	Point-to-point, star, IEEE 802.15.4 compliant, or ZigBee networks.
MC13202	Adds transmit/receive switch to MC13192	PHY Layer for point-to-point, star, IEEE 802.15.4 compliant and ZigBee compliant networks

Table 3 : Example of antenna and their significance

Signal Encoding

The radio use direct-sequence spread spectrum and mainly use 2 types of modulation. Binary phase-shift keying (BPSK) used in 868 – 928 MHz band and Offset QPSK (OQPSK) used in 2.4 -2.4835 GHz.

Bluetooth

Bluetooth

Bluetooth is a specification for Personal Area Network (PAN) that works in wireless technology. It's help the electronic machine like notebook or mobile phone connected to each other and exchange data over short distance. Nowadays, Bluetooth is managed by Bluetooth Special Interest Group (SIG) who created standards as IEEE802.15 and given the licensed of Bluetooth and trademark to manufacturing.

Protocol Architecture

Layer stacks and Protocols

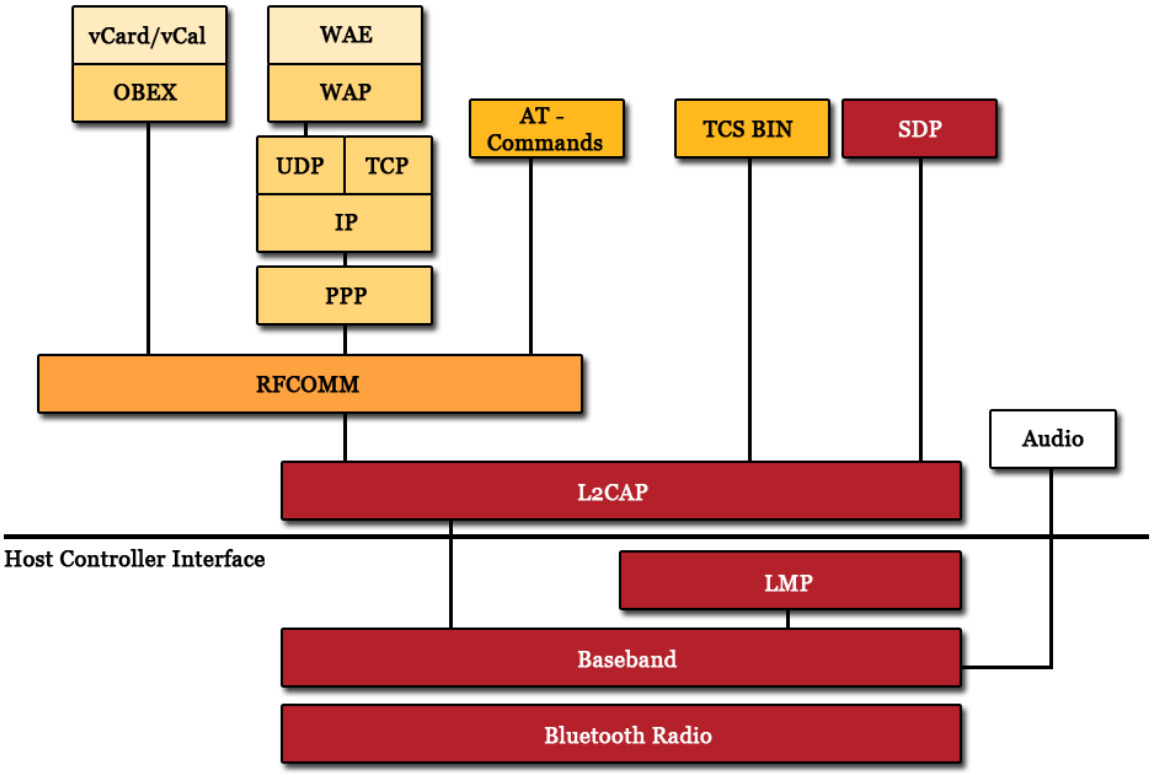


Figure 4 : Bluetooth Layer Stack

A Bluetooth Technology has protocol architecture like OSI Model and it's consist four layers. The layers, protocol and feature of them that summarized in Table 4

Protocol Layer	Member of the Protocol Stack	Feature
Bluetooth Core Protocols	Baseband	Enabled the physical radio frequency (RF) link between Bluetooth unit and Piconet. It is ad-hoc computer network linking a member group together
	Link Management Protocol (LMP)	Provide for setup link and control between Bluetooth device and control and manage sizes of baseband packet
	Logical Link Control and Adaptation Layer (L2CAP)	• Support higher level protocol to multiplexing, reassembly, packet segmentation and Quality of Service(QoS) • L2CAP is allow 64 kilobytes in length to transmission and receive in higher level of protocol and application
	Service Discovery Protocol (SDP)	• Quires a device information, services and special services. • Important element in Bluetooth frame-work
Cable Replacement Protocol	Radio Frequency Communication (RFCOMM)	• It's a emulation protocol which use in Global System for Mobile (GSM) • Emulation with RS-232 serial ports over L2CAP protocol • Only respect direct connection between Bluetooth device and connection with Bluetooth Device and Network
Telephony Control Protocols	Telephony Control Specification Binary (TCS BIN)	It's a bit-orient protocol that defines mobility management and call control signal that use with Bluetooth Devices for setting speech and data calls
	AT-Commands	It's defines how the various usage models are controlled by mobile phone and modem

Adopted Protocols	Point-to-Point Protocol (PPP)	
	User Datagram Protocol (UPD)/Transmission Control Protocol (TCP)/Internet Protocol(IP)	
	Object Exchange Protocol (OBEX)	Supporting the exchange objects that are simple and happen by itself
	Wireless Application Protocol(WAP)	It's a protocol that use in a small device for sending and reading internet content
	Content Formats • vCard • vCalendar	
	Infrared Mobile Communications (IrMC)	
	Wireless Application Environment (WAE)	

Table 5 : Feature of each Bluetooth protocols

Standard and Organization

A Standard of Bluetooth that has developed until today has 7 versions and all of versions now official by **Bluetooth Special Interest Group (SIG)**. And SIG is a group of companies; manufacture and consumer electronic to given licensed and develop Bluetooth technology. A standardization of Bluetooth technology current use as IEEE 802.15-2005.

Bluetooth v1.0 and v1.0B

- Many problem and incompatible with products

Bluetooth v1.1

- Use standardization as IEEE802.15-2002 and all problem that found in previous were solved

Bluetooth v1.2

- Use standardization as IEEE802.15-2005
- Introducing in flow control and retransmission mode for L2CAP

Bluetooth v2.0 + EDR

- Can compatible with old version
- In this version introducing of EDR (Enhancing Data Rate) for faster data transfer

Bluetooth v2.1 + EDR

- The SSP (Securing Simple paring) that improve the usage experience and higher security
- Near Field Communication (NFC) its allow user to connect device faster

Bluetooth v3.0 + HS

- The AMP (Alternate MAC/PHY) this function will be work by quantity of data and associated with 802.11(Wi-Fi)
- Improving in power control feature

Bluetooth v4.0

- High Speed associate with Wi-Fi
- Low Energy consumption: There are 2 types of mode in Bluetooth low energy are Dual and Single Mode

Data Transmission

Bluetooth technology is a license-free that no spectrum allocating before using and Bluetooth device can operates on ISM (Industrial,Scientific,Military) frequency band at 2.4 - 2.485 GHz used as global available and data rate is depends on version of Bluetooth and techniques that used to modulate signals. The bandwidth of a Bluetooth channel is less than 1 MHz. As you can see from Table 6

Version of Bluetooth	Data Rate
Bluetooth v1.2	1 Mb/s
Bluetooth v2.0+ EDR	Up to 3 Mb/s – approx. 2.1 Mb/s
Bluetooth v3.0+ HS	Up to 24 Mb/s
Bluetooth low energy (v4.0)	1 Mb/s

Table 6 : Show Data Rate Corresponding version of Bluetooth

From table Bluetooth technology continuous improvement in data rate but in version 4 is introducing new feature is low energy consumption, its use less than 15mA. And it widely use in healthcare, fitness or etc.

Transmission Media

The Bluetooth have classified transmission power into three classes depends on transmission equipment. It's shown as Table 7

Transmission Power	Range(Distance)
20dBm (100mW)	100 meters (328 feet)
4dBm (2.5mW)	N/A
0dBm (1mW)	Approximately up to 10 meters (30 feet)

Table 7 : Show Transmission power that corresponding distance

From the Table 7 Transmit Power at 4dBm not available cause of it has a power control to adjust power level appropriate with distance. And as you can see it from the table that evens more transmission power that have more than distance. Bluetooth is technology use low power consumption and powered is goes down when it's inactive mode.

And Range can classified into another one by class or radio that used to implement its. There is not limited in range and manufacture can adjust or tuning them by implementation.

Class	Range
Class 1	100 m. or 333 ft.
Class 2	10 m. or 33ft.
Class 3	1 m. or 3 ft.

Table 8 : Show a range depending in class

As you can see from Table 8, it's shown that class 1 is most used in industrial so, it must use in large area, and Class 2 is very popular because it can found in most mobile device, and class 3 is use in smallest area like Bluetooth headset cause of class 3 has a lowest range and power of Class 2 that commonly uses only 2.5mW

Signal Encoding Techniques

A Bluetooth Technology is using digital coding technique called Spread Spectrum. There is transmits all signal over a bandwidth and greater than that required for standard narrowband and mode of spectrum that used in Bluetooth Technology is Frequency Hopping that spread its signal over the entire radio as a function of time.

A modulation that used in Bluetooth technology has three types.

- **Gaussian frequency-shift keying(GFSK)**
  - Use **Gaussian filter** that use a Gaussian function to filter the impulse response and its make smooth frequency
  - Refer to Bit Rate (BR) mode
  - Data Rate can go up to 1Mb/s

When Bluetooth v2.0 is introducing new feature that is extended data rate (EDR) for transfer data in faster and modulation uses in Bluetooth with EDR are π/4-DQPSK that give 2 Mb/s and 8DPSK has data rate is 3 Mb/s

Errors

The error correction in Bluetooth is divided into three types. This First type is 1/3 rate forward error correction (FEC) and second is 2/3 FEC. And the third is Automatic repeat-request (ARQ).

The difference the first and second type is that 1/3 is a repeat 3 times of each info bit. But 2/3 is (15,10) shortened a Hamming code and each block has a 10 information and encode it into15-bit codeword that use to correct all single error and correct double errors. And both of them help recovering a data packet lost and FEC corrects receive errors. Another technique is ARQ its use for detection an error. So, FEC and ARQ are a couple and work together. ARQ is detection errors whereas FEC is correction an error.

Application, Cost and Usages

The applications that used with Bluetooth Technology have a lot of applications because it's very popular wireless technology in the world today, easy to use and equipment has cheap cost since $0.01 to $300. An application that use in modern world that use in widely range like mobile phone to transfer file , MP3 and images between mobile phone, wireless Bluetooth headset or wireless controller in Game Console like PS3, etc.

Wireless LAN

Wireless Local Area Network (Wireless LAN or WLAN)

A Wireless Local Area Network (WLAN) is the linking two or more devices via using some wireless distribution method, and usually connect through an access point to the internet. This gives users can move around within a local area that covered by signal and still be connected to the network.

Protocol Architectures

Layer stack of WLAN refer to The Open Systems Interconnection model or OSI Model. OSI model consists of 7 layers that are Application layer, Presentation layer, Session layer, Transport layer, Network layer, Data link layer and Physical layer.

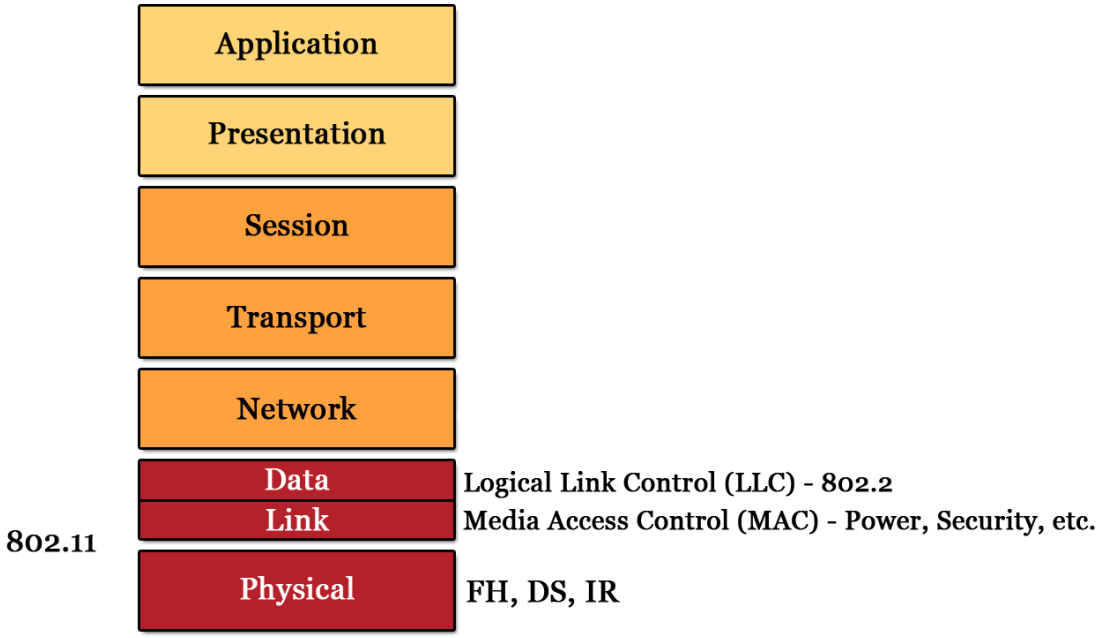


Figure 5 : Wireless LAN Layer Stack

An international standard describing the characteristics of WLAN is IEEE 802.11 specification. The 802.11 standard reserves the low levels of the OSI model for a wireless connection that uses electromagnetic waves, i.e.:

- The Physical layer which offers three types of information encoding that are FHSS, DSSS and Infrared.
- The Data Link layer is separated to two sub-layers: Logical Link Control (or LLC) and Media Access Control (or MAC).

Data Link layer	LLC – 802.2		
	MAC – 802.11		
Physical layer	FHSS	DSSS	Infrared

Table 9 : Data Link layer and Physical layer

The 802.11 specification designed to minimize collisions, because two mobile units may both be in range of a common access point, but out of range of each other.

Hardware devices that use the 802.11 standard is called Wi-Fi (Wireless Fidelity)that corresponds to the name of the certification given by the Wi-Fi Alliance, formerly WECA (Wireless Ethernet Compatibility Alliance). Hardware devices certified by the Wi-Fi Alliance are allowed to use this logo:

The IEEE 802.11 standard is the earliest standard. There are amendments standard making from original standard to optimize bandwidth or to better specify components in order to ensure improved security or compatibility. This table shows the various amendments to the 802.11 standard and their significance

Name of standard	Name	Description
802.11a	Wi-Fi 5	The 802.11a standard (called Wi-Fi 5) allows higher bandwidth (54 Mbps maximum throughput, 30 Mbps in practice). The 802.11a standard provides 8 radio channels in the 5 GHz frequency band.
802.11b	Wi-Fi	The 802.11b standard is currently the most widely used one. It offers a maximum throughput of 11 Mbps (6 Mbps in practice) and a reach of up to 300 meters in an open environment. It uses the 2.4 GHz frequency range, with 3 radio channels available.
802.11c	Bridging 802.11 and 802.1d	The 802.11c bridging standard is of no interest to the general public. It is only an amended version of the 802.1d standard that lets 802.1d bridge with 802.11-compatible devices (on the data link level).
802.11d	Internationalization	The 802.11d standard is a supplement to the 802.11 standard which is meant to allow international use of local 802.11 networks. It lets different devices trade information on frequency ranges depending on what is permitted in the country where the device is from.
802.11e	Improving service quality	The 802.11e standard is meant to improve the quality of service at the level of the *data link layer*. The standard's goal is to define the requirements of different packets in terms of bandwidth and transmission delay so as to allow better transmission of voice and video.

Name of standard	Name	Description
802.11f	Roaming	The 802.11f is a recommendation for access point vendors that allow products to be more compatible. It uses the *Inter-Access Point Roaming Protocol*, which lets a roaming user transparently switch from one access point to another while moving around, no matter what brands of access points are used on the network infrastructure.
802.11g		The 802.11g standard offers high bandwidth (54 Mbps maximum throughput, 30 Mbps in practice) on the 2.4 GHz frequency range. The 802.11g standard is backwards-compatible with the 802.11b standard, meaning that devices that support the 802.11g standard can also work with 802.11b.
802.11h		The *802.11h* standard is intended to bring together the 802.11 standard and the European standard (HiperLAN 2, hence the *h* in 802.11h) while conforming to European regulations related to frequency use and energy efficiency.
802.11i		The *802.11i* standard is meant to improve the security of data transfers (by managing and distributing keys, and implementing encryption and authentication). This standard is based on the *AES* (Advanced Encryption Standard) and can encrypt transmissions that run on 802.11a, 802.11b and 802.11g technologies.
802.11r		The *802.11r* standard has been elaborated so that it may use infra-red signals. This standard has become technologically obsolete.
802.11j		The *802.11j* standard is to Japanese regulation what the 802.11h is to European regulation.

Table 10 : The various amendments to the 802.11 standard and their significance

Note: The 802.11a, 802.11b and 802.11g standards, called "physical standards" are amendments to the 802.11 standard

Data Transmission

This table shows the various standards and their characteristic.

Standard	Spectrum	Frequencies	Bandwidth	Data rates (Mbit/s)
802.11	Operated without a license	2.4 GHz	20 MHz	1, 2
802.11a	Operated without a license	5 GHz	20 MHz	6, 9, 12, 18, 24, 36, 48, 54
802.11b	2.4 GHz (In US)	2.4 GHz	20 MHz	1, 2, 5.5, 11
802.11g	Operated without a license	2.4 GHz	20 MHz	1, 2, 6, 9, 12, 18, 24, 36, 48, 54

Table 11 : The various standards and their characteristic

Transmission Media

An 802.11 network interface operating in the 2.4 GHz band has a wavelength of just 12.5 cm, so an antenna can be incorporated into a PC card or the top of laptop computer.

The transmit power and receive thresholds depend on each antenna. In this case, this table shows significance of WaveBlade Wi-Fi product.

Standard	Transmit Power	Receive Thresholds	Distance	
			Indoor	Outdoor
802.11	0 to -50dBm in 1dB steps	65dBm	20 m	100 m
802.11a	0 to -50dBm in 1dB steps	65dBm	35 m	120 m
802.11b	0 to -50dBm in 1dB steps	65dBm	38 m	140 m
802.11g	0 to -50dBm in 1dB steps	65dBm	38 m	140 m

Table 12 : Significance of WaveBlade Wi-Fi product

Signal Encoding Techniques

Modulation techniques used in the IEEE 802.11 series of specifications include binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), Gaussian frequency-shift keying (GFSK) and CCK

Gaussian Frequency-Shift Keying (GFSK) is a type of Frequency Shift Keying modulation that uses a Gaussian filter to smooth positive/negative frequency deviations, which represent a binary 1 or 0.

Complementary Code Keying (CCK) is used to achieve data rate higher than 2 Mbps at the expense of shorter distance.

Error

Wi-Fi used Forward Error Correction (FEC) for reducing the effective packet loss rate from the propagation. This Technology use stop-and-wait ARQ technique.

Applications, Cost and Usages

There are 3 devices requirement for WLAN. The first thing is Wire Network. Before you can have your WLAN network, you need a wired network of some sort in place. The wired network can consist of many things. It may connect to other devices, as well as to private networks and to the Internet. Residential wired networks tend to just be with whatever your local ISP (Internet Service Provider) gives you, be it DSL, cable, or other, e.g. ISP signal from telephone-signal wire. The second thing is Wireless Access Point, to get information from the wired network *to* your wireless enabled device, have to create some sort of wireless access point, or WAP. This is defined as any device that allows other wireless communication devices, including Wi-Fi-enabled devices like laptops, printers or cellphones, to connect to a wired network. The third thing is Wireless Adapter, to be able to connect to them with other devices. These devices thus need some sort of wireless adapter. Wireless adapters can take many forms for example USB wireless adapter, embedded serial to Wi-Fi module.

WLAN make users can connect the network without wire, so users can connect to the network anywhere and can be move around in the local area that be covered by WLAN signal. If we want to connect a lot of computer to the network, can be use WLAN instead of use a lot of wire. WLAN help to reduce the cost and make a simpler installation.

WiMAX

WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is a name that created by WiMAX Forum that is a new telecommunication protocol with 802.16 family Standards that divided into fixed and fully mobile communication.

Protocol Architecture

Layer stacks and Protocols

IEEE 802.16 Protocol Stack Layers is divided into two main parts that refer to OSI Model. The First is Data Link Layer and another one is Physical Layer. And Upper Layer is contains services such as transfer IP, Broadcast of Digital audio and video that have one way like television or radio and other is two way such as video conference or teleconference or Bridged LAN is transfer data between Network (LANs) . As you can see from Figure 6

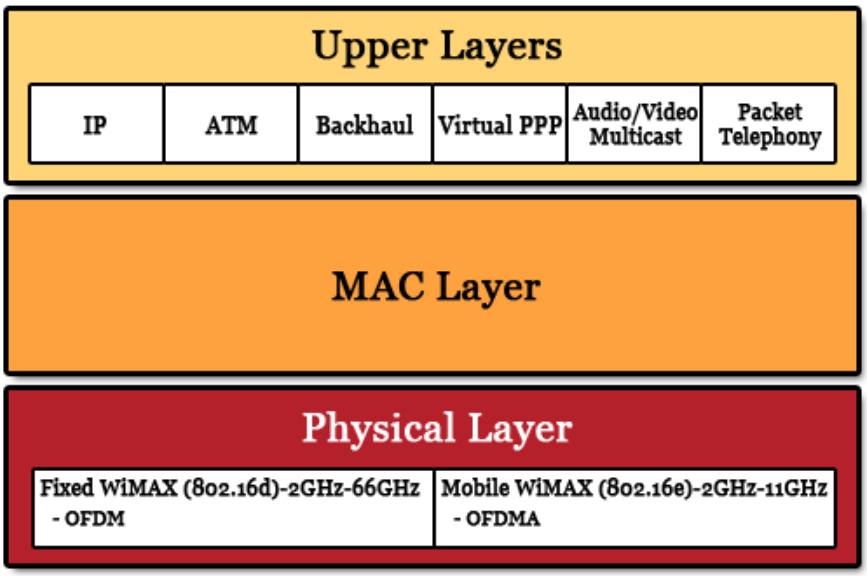


Figure 6 : WiMAX Protocol Layer Stack

Physical Layer

The Physical Layer are contain two sub layer that are Transmission sub layer and Physical sub layer that are used to encoding and decoding of signals, data transmission and reception. It's use define to Frequency Band, Channel of Bandwidth or Modulation.

Data Link layer (MAC Layer)

In Data Link Layer are divided into three sub layer that are Service-Specific Convergence sub layer(CS), MAC Common part sub layer(CPS) and Security sub layer.

- **Service-Specific Convergence sub layer (CS)**
  - Change data that come from the CS into data packets.
- **MAC Common part sub layer (CPS)**
  - Control functionality, PHY Control, Bandwidth Allocation, Data Maintenance and Connection Establishment.
- **Security sub layer**
  - Authentication, Encryption and Key Exchanged

Standard and Organization

Figure 7: A Images of WiMax

The "WiMax" is a Commercial Name that given by industry alliance to promoted products and services compatible with same Standard that use WiMax Technology called WiMAX Forum that represented series of wireless Broadband of 802.16 standards that publish by IEEE (Institute of Electrical and Electronics Engineers).

Nowadays, the standard of IEEE 802.16 has two types.

- IEEE 802.16-2004 (802.16d) which is **Fix BWA**(Broadband Wireless Access)
- IEEE 802.16-2005 (802.16e) which is **Mobile BWA**(Broadband Wireless Access)

Data Transmission

Spectrum Allocation

The Spectrum Allocation has work associated with WiMAX Forum to manipulate worldwide spectrum allocation that makes WiMAX equipment has a lower prices for consumers.

To Specification we consideration in three factors. The First is usages in Frequency are Licensed and Unlicensed. Second, frequency use in Line of Sight(LOS) and Non Line of Sight(NLOS). Finally, frequency uses in Mobility are Fix and Mobile Broadband Wireless Access.

A Spectrum Allocation defines by Standard IEEE 802.16 into 3 Spectrum. Follow Table 13

Frequency Band	**10-66 GHz**	**Below 11 GHz**	**Below 11 GHz**
Allocation	Licensed	Licensed	Unlicensed

Table 13 : Licensed allocation of each frequency

A frequency band shown in Table 1.1 A Licensed allocation of use frequency to protected interference of radio waves. But, Unlicensed not protected use in radio waves that interference signals may be happened.

Frequency, Bandwidth and Data Rate

Parameter	**IEEE802.16 (First version of 802.16 Standard)**	**IEEE802.16d (802.16-2004) Fix WIMAX**	**IEEE802.16e (802.16-2005) Mobile WIMAX**
Channel Bandwidth	20, 25 and 28 MHz	1.25 -28 MHz	1.25 -20 MHz
Frequency Band	10-66 GHz	2-11 GHz,10-66 GHz	2-6 GHz
Data Rate(Bit Rate)	32-134 Mbps	Up to 75 Mbps	Up to 15 Mbps

Table 14: A comparison between two standard IEEE802.16e and IEEE802.16d and IEEE802.16 in Frequency, Bandwidth and Data Rate

As you can see from Table 14 Compare IEEE802.16, IEEE802.16d, IEEE802.16e that can see from first row shown channel bandwidth is variation value cause of bandwidth in IEEE802.16 standards are flexible bandwidth and its help interference problem in 2-11 GHz and eliminate interference of unlicensed spectrum. A frequency band is a range depend on frequency allocation that set up by IEEE Standard Organizations.

Transmission Media

Transmit Power

A WiMAX works in coverage large area, So we must to optimize appropriated power from base station. Then High transmit power is very important for long range. To optimize power must to ensure consume use low power but efficiency of WiMAX properties such as data rate, throughput is stable. And we use technique to transmit power long ranges is adaptive modulation

- WiMAX Base Station(Fix) : transmits power at +43 dBm (20 W)
- Mobile Station : transmits power at +23 dBm (200 mW)

As you can see from Fix Base Station and Mobile Station has a large difference Power Level that use in transmit. And a big number of difference make mobile easily receive transmission from base station and low transmits power make base station difficult to receive transmission from mobile.

Antennas

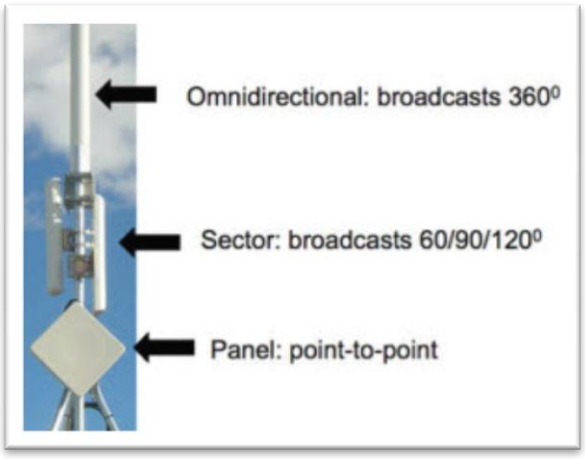


Figure 8 : Different Antenna types WiMAX Antennas

A WiMAX antenna just like other like Mobile Phone or Television. It's have a three main components as you can see from figure 8

- Omni Directional
  - use point to multipoint, good for subscription that near base station.
  But limits of this component is signal strength and ranges

- Sector
  - help to focus more area, increase throughput and ranges

- Panel Antenna
  - use with point to point application and power is given by Ethernet that
  we known as PoE (Power of Ethernet)

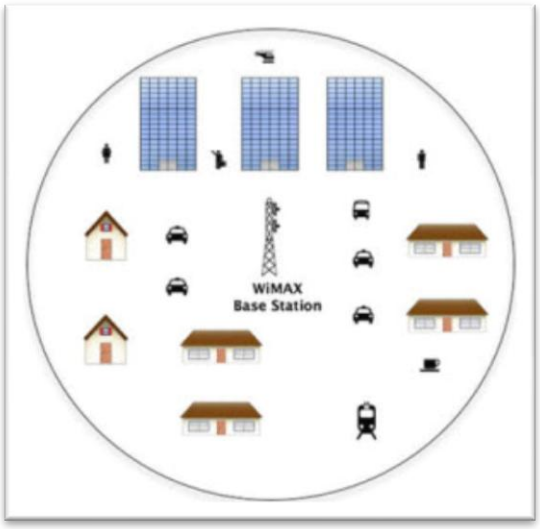


Figure 9: Show Omni Directional coverage in 360 degree but it use with subscribers near base station and it common use in small ranges cause of longer distance make decrease signal strength

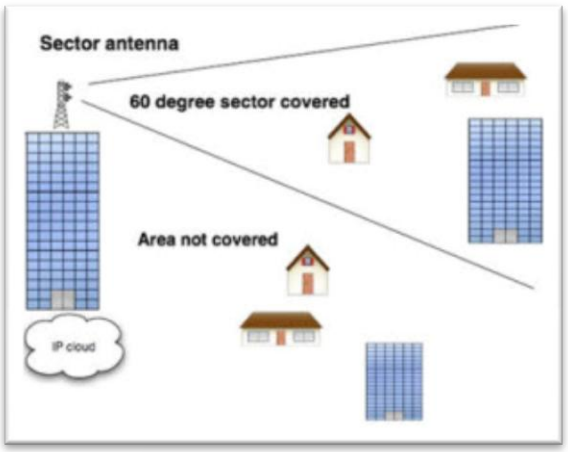


Figure 10 : Show Sector of Antennas that cover in vertical depends on sectors that chosen to used. Commonly in operators use antenna sector to cover 360 degree Omni directional service area.

Distance

Standardization	IEEE802.16	IEEE802.16d	IEEE802.16e
Distance	Up to 31 Miles	Maximum is 30 Miles on basic antenna gain, antenna height and transmit power	Up to 31 Miles

Table 15 Show distance in IEEE802.16, IEEE802.16d, IEEE802.16e

A distance in IEEE802.16 standards family that coverage area following Table 15 is IEEE802.16 and IEEE802.16e both of standards have same distance but IEEE802.16d has a maximum coverage area is 30 miles depends on antenna height, antenna gain.

Signal Encoding Techniques

In 802.16 Standard family uses digital modulation scheme that have a benefit than analogue modulation are resistance of noise or high performance, etc. They are many digital modulation that use in IEEE802.16 Standards are BPSK(Binary Phase Shift Keying), QPSK (Quadrature Phase shift Keying), 16-QAM(Quadrature Amplitude Modulation) and 64-QAM. All of digital modulation used in IEEE802.16 is OFDM in Fix WiMAX and OFDMA in Mobile WiMax. Both OFDM and OFDMA used in Physical layers. Another one is Adaptive Modulations which is high efficiency to receive difference frequency. This is one to adapt its corresponding environment.

The OFDM(Orthogonal Frequency Division multiplexing) is in Physical Layer of Fix WiMAX that allow two direction high-speed data transmission. This modulation separated from Spread Spectrum Technology and modulate which is Multi-Carrier Modulation(MCM) this technique separate data into multiple sub channels (carriers) like fast Fourier transform(FFT) that used by OFDM. The OFDM convert data into multiple channels are 256 sub channels and each channel is independent to each other and transmits into parallel.

Errors

The technique is uses in Error Detection and Error Correction is FEC (Forward Error Coding).The 802.16e that used encoding to find and solve the errors. Encoding used to increase reliable and efficiency of transmit and receive data.

The ARQ used in IEEE802.16 is Hybrid-ARQ. It's support only OFDMA Physical interface. It's uses in error control code and Hybrid ARQ had benefit more than ARQ that is Hybrid ARQ retransmission and combine the receive error that improve a reliable.

Application, Cost and Usages

Nowadays, we using broadband services via Cable and DSL that is wired broadband access that have a high cost to installation and quality of broadband service depends on access network, local access point and backbone network.

But in urban area that have a low population and if we investment in wired broadband access that higher cost than investment in wireless broadband access and WiMAX is the best choice of wireless broadband access because its low cost but high efficiency like large area coverage, higher data rate, etc. And WiMAX can be used in small or medium sized of business to help them reduce the operation cost.

In Thailand, WiMAX is a technology that compatible because Bangkok is a Big City that used both wired and wireless broadband service. But in urban area or far province which don't have broadband service in some area. Investment in WiMAX is the best choice cause of Thailand has a large area of urban and WiMAX is the answer for wireless broadband services

Summary

Summary

From the information that given by Table 16 shown a comparison among Zigbee, Bluetooth, Wireless LAN and WiMAX that based in six topics. Concluded that in distance which WiMAx is appropiate use in large area like connect across city and use a Wireless use as sub-network like use its in office or across building. But Zigbee and Bluetooth that for personal use cause of both of them use for shortend**.**

Characteristic	ZigBee	Bluetooth	Wireless LAN	WiMax
Distance • Indoor • Outdoor	 10 – 100 m Up to 400 m	 10 m 100+ m dep. on radio	 20 - 40 m 100 – 140 m	 - Up to 31 Miles
Data Rates	20-250 Kbps	< 1 Mbps	Up to 54 Mbps	(Fix) 15 Mbps (Mobile)75 Mbps
Frequencies	868-868.6	2.4 GHz	2.4 GHz	10-66 GHz
Bandwidth	5 MHz	1 MHz	20 MHz	Up to 28 MHz
Number of devices per network	2 - 65,000	8	10 - 100	1,000
Cost	$10 - $100	$1 – $50	$300 - $2,000	About $60,000
Usages (In Thailand)	not widely use	widely use	widely use	during in System Testing

Table 16 : The comparison between ZigBee, Bluetooth, Wireless LAN and WiMAX

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