ITS323

ASSIGNMENT 1

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Zigbee

Zigbee is a wireless technology that use very low power consumption and very low cost. The purpose of this technology is making wireless sensor network for communicate through small sensors which was embedded in buildings. Zigbee is developed by Zigbee Alliance, the name "Zigbee" comes from the behavior of bee's communication by bees fly zigzag and give information together about position, distance and direction of food what they find.

Protocol Architectures

Zigbee protocol architecture can divided into 2 sections. First section is based on standard IEEE 802.15.4 which consists of Physical layer and Media Access Control layer. And another section consists of network layer, application support sublayer, Zigbee device object, application framework and security service which are developed by Zigbee Alliance.

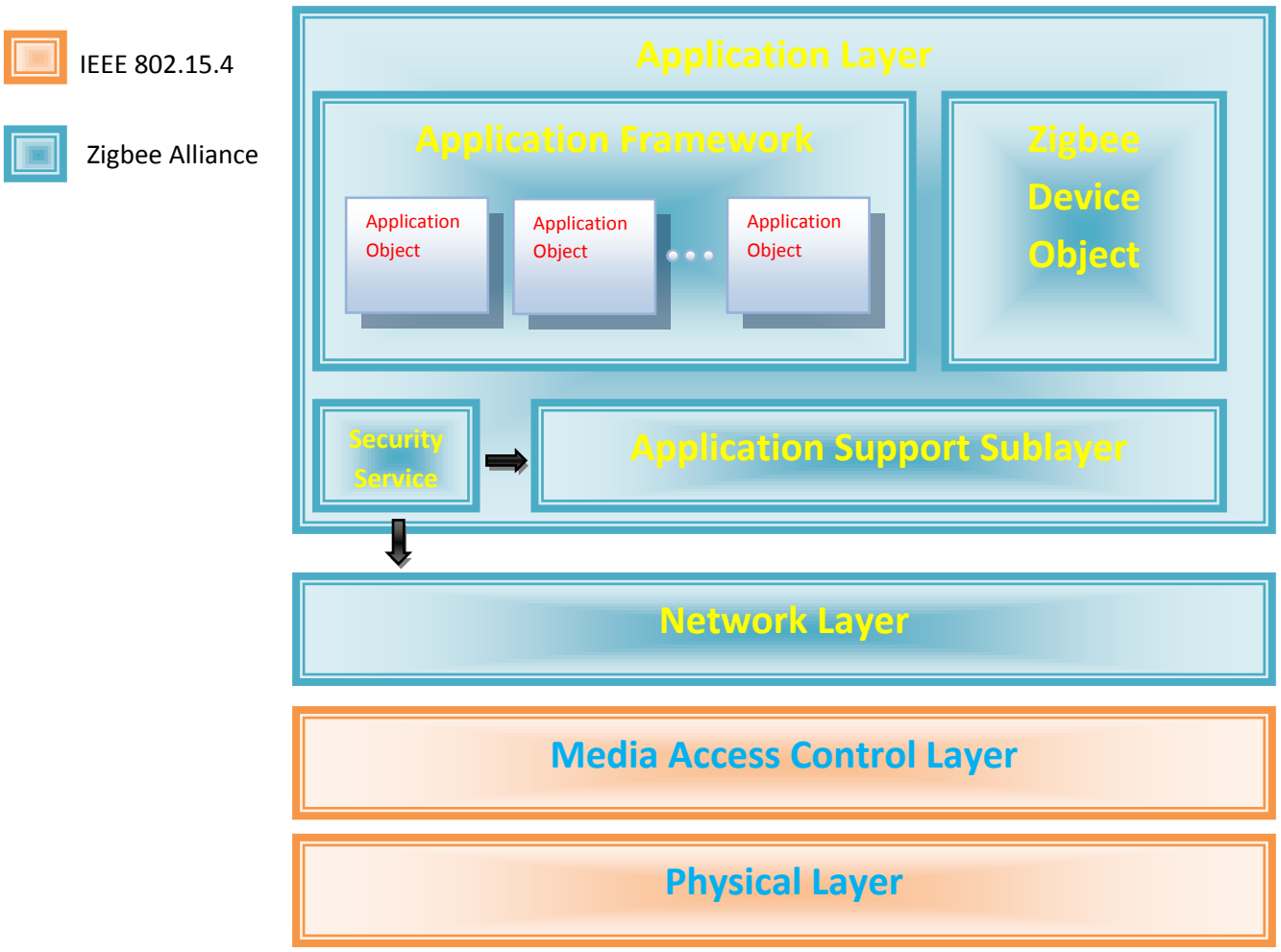

Figure 1 Zigbee protocol stack

Physical layer

The physical layer is responsible to activation or deactivation of the radio transceiver, Energy Detection , Link Quality Indication , channel selection , Clear Channel Assessment and receive packets through the mediums. It transmits information and receives information from a source.

Media Access Control layer

The functions of the MAC layer are access the network by using carrier-sense multiple access with collision avoidance (CSMA/CA), to transmit beacon frames for synchronization, and to provide reliable transmission.

Network layer

The network layer is responsible for star, cluster tree and mesh networking. The network layer is located between the MAC layer and application support sublayer. It provides the following functions:

- **Starting a network:** The ability to successfully establish a new network
- **Joining and leaving a network**: The ability to gain membership or relieve membership a network
- **Configuring a new device:** The ability to configure the stack for operation as required
- **Addressing:** The ability of a ZigBee coordinator to assign addresses to devices joining the network.
- **Synchronization within a network:** The ability for a device to achieve synchronization with another device either through tracking beacons or by polling
- **Security:** applying security to outgoing frames and removing security to terminating frames
- **Routing:** routing frames from source to their intended destinations

The network layer also has command for security purposes like secure joining and rejoining. A secure join will avoid the situation where a ZigBee node without a Network Key first associates to the ZigBee Coordinator or ZigBee Router using an unsecured request.

Application Layer

The ZigBee application layer consists of the application support sublayer, the Zigbee device object, security service and manufacturer-defined application objects.

- **Application Support Sublayer**

The application support sublayer acts as a filter for the application running above it on endpoints to simplify the logic in those applications. The application support sublayer keeps a local binding table, a table which indicates the nodes or groups in the network that this node wants to speak to.

- **Zigbee Device Objects**

The Zigbee device objects are responsible for defining the role of devices within the network, discovering devices on the network and determining which application services they provide, and responding to binding requests and establishing a secure relationship between network devices.

- **Application Framework**

The application framework is an execution environment for application objects to send and receive data. Application objects are defined by the manufacturer of the ZigBee-enabled device.

Data Transmission

Zigbee has 3 frequency bandwidths based on IEEE 802.15.4:

1. Frequency 2.4 GHz has 16 channels, data rate 250 Kbps use in worldwide.
2. Frequency 915 MHz has 10 channels, data rate 40 Kbps use in United States.
3. Frequency 868 MHz has 1 channel, data rate 20 Kbps use in European countries.

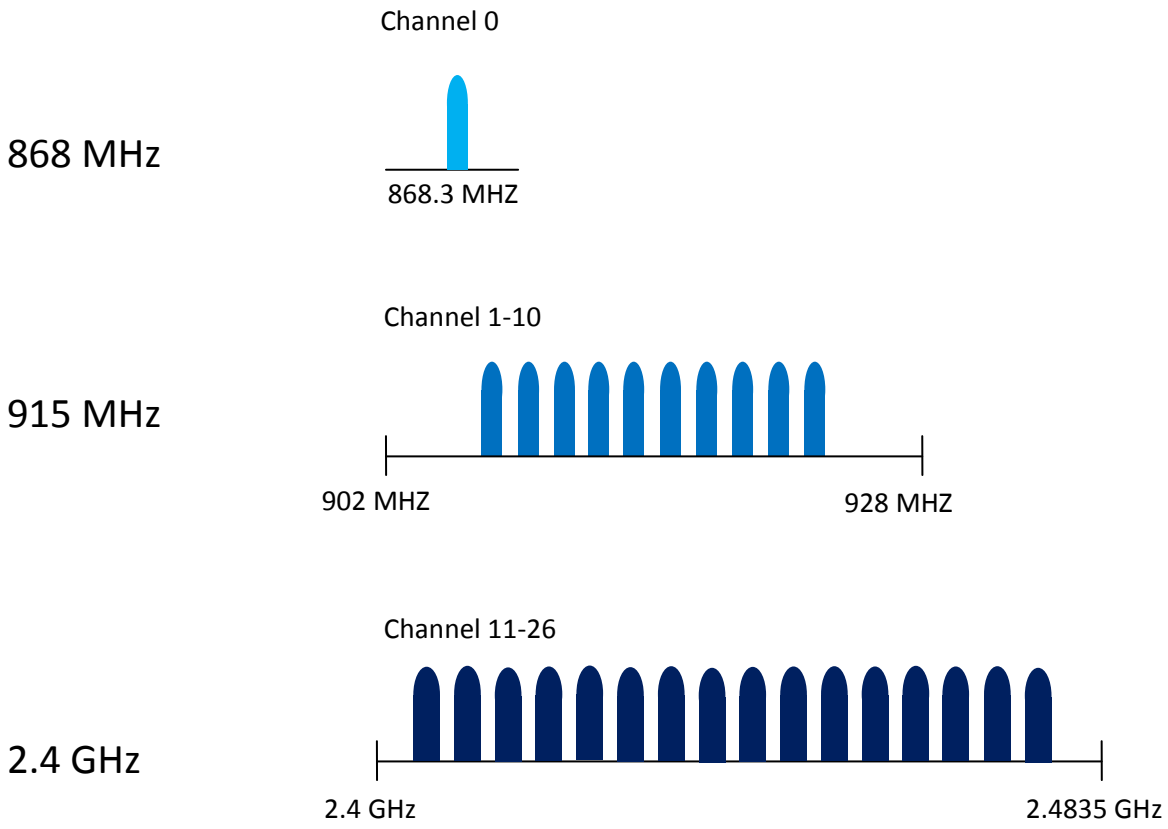

Figure 2 frequency bandwidth of Zigbee

Transmission Media

Transmission Power

802.15.4 sets the minimum amount of energy needed to transmit in **-3dBm**, (**0.5 mW**) and the minimum sensibility in the receiver is **-92dBm** (**$6.3 * 10^{-10}$ mW**).

Example product about transmission power: Sensor Application Reference Design (SARD) 13192

Figure 3 SARD

The specification of SARD 13192 radio: It use 2.4 GHz radio-frequency transceiver, dipole antenna, interface RS-232 port, transmit power from -27dBm to 4dBm, receive threshold(receive sensitivity) of < -92dBm at 1% Packet Error Rate.

Antenna

For Zigbee, it can use many antennas like dipole antenna, chip antenna and F-antenna.

Example antennas for Zigbee

1. Fractus EZ Connect™ Zigbee Antenna is a chip antenna use for frequency range 902-928MHz. It has dimension 18x7.3x1 mm and peak gain > 0dBi. It is suitable for smarthome, security and other industrial devices
2. 2.4G Antenna is a inner antenna use for frequency range 2400 – 2483MHz. It has length 77.5mm and gain 3dBi. It is suitable for wireless router, Zigbee, transfer of wireless video & wireless date, using of wireless read-meter system.

Signal Encoding Technique

Zigbee devices use 2 modulation schemes depend on the frequency bandwidth which 2.4 GHz use O-QPSK with half-sine pulse shaping (MSK) and 868/915 MHz use BPSK with raised cosine pulse shaping.

- Binary phase-shift keying (BPSK) uses two phases which are separated by 180°
- Offset quadrature phase-shift keying (O-QPSK) use 4 different values of the phase to transmit

Errors

In Zigbee which based on standard 802.15.4, it can detect the error by using cyclic redundancy check but it does not have error correction. The error control that suitable for Zigbee is hybrid-ARQ.

Hybrid-ARQ

First, the message is encoded into a very low rate called “mother” code. Then the codeword is broken into many disjoint blocks. Blocks are transmitted one by one until the receiver is able to successfully decode and send back a positive acknowledgement (ACK).

Bluetooth

Protocol Architectures

Bluetooth is defined by IEEE 802.15 standard ,specifically a data link and physical layer. This can divide the Bluetooth to Bluetooth protocol divide into 4 main categories are Bluetooth Core Protocol, Cable Replacement Protocol, Telephony Control Protocol and Adopted Protocols.

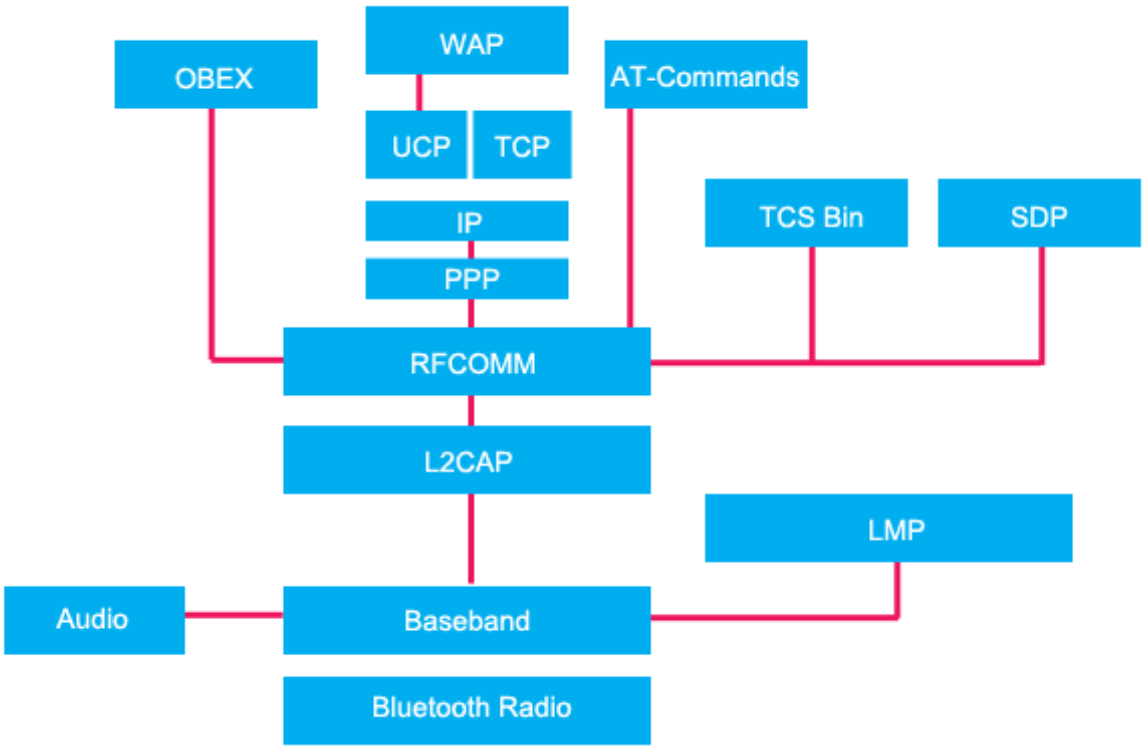

Figure 4 Bluetooth protocol stack

The core protocols plus the Bluetooth radio are required by most Bluetooth devices.

- **Bluetooth Radio**

  Bluetooth system operates in the 2.4 GHz Industrial Scientific Medical (ISM) band. This frequency band is 2400-2483.5 MHz. This are two modulation modes are defined. Basic Rate is a mandatory mode. Enhanced Data Rate is a optional mode.

This core Protocols consist of 4 in protocol stack Baseband, Link Management Protocol, Logical link control and adaptation Layer and Service Discovery Protocol

- **BaseBand Layer**

This is a physical layer of Bluetooth. It manage physical channels and links form other services like error correction, data whitening, hop selection and Bluetooth security. Baseband manages asynchronous and synchronous link. Baseband applies a time-division duple(TDD) , so the time is also slotted. In the connection , the master always start at even numbered slot and slave transmission always start at odd numbered slot. SCO (Synchronous Connection-Oriented) which is symmetric point to point link between the master and a single slave. ACL (Asynchronous Connection-Less) which is point to multipoint link between the master and all the slave participating.

- **Link Manager Layer**

This layer is used to control and negotiate the operation of the Bluetooth.This layer have set-up control logical transports and logical links, and for control of physical links. The important thing that this layer do is used to communicate between the Link Managers (LM) on two devices.

- **L2CAP Layer**

This supports high level protocol multiplexing, packet segmentation and reassembly, and the conveying of quality of service information. The L2CAP provides logical channels, named L2CAP channels. Each channel is separate by channel identifier (CID) . CID is relative to a particular device . A device can assign CID independently from other devices. This layer can operate in one of three different modes as Basic L2CAP Mode , Flow Control Mode and Retransmission Mode.

- **Service Discovery Protocol (SDP)**

This layer is important element in the Bluetooth Frame that it provide the basic of all usage models. The user can may select from SDP, device information, services and the characteristics oft the services. Then Bluetooth devices can be established.

- **Cable Replacement Protocols**

This protocol is a part of two protocols that control signaling over wireless links. It consist of Radio Frequency Communication (RFCOMM).

- **RFCOMM**

  This is provides emulation of RS-232 serial ports over the L2CAP protocol. RFCOMM support applications that use serial port. It concern with the connection between Bluetooth device in the direct connect case or between the Bluetooth device and modem in the network case. RFCOOM can support another configurations.

- **Telephony Control Protocols (TCS)**

This protocols is a bit-oriented protocol that control signaling for set up speech and data calls between Bluetooth devices.

- **Adopted Protocols**

This is a protocols to allows older application to work with Bluetooth technology and to ensure smooth operation these applications with the new version application for Bluetooth devices.

Data Transmission

Basic radio channel is 1Mbps with average 723.2 kbps to a single user. Bluetooth scientific and medical (ISM) band at 2.4 to 2.485 GHz .It use spread spectrum, frequency hopping. The Bluetooth chops up the data being sent and transmits it on up to 79 bands (1 MHz each) in the range 2402 – 2480 Mhz.

	International Standard	Operating Frequency	Maximum Data Rate	Maximum Distance	Power Consumption Rate
Bluetooth 3.0	IEEE 802.15.1	2.4GHz	22 Mb/s	100m	Hours/days
Bluetooth 2.1	IEEE 802.15.1	2.4 GHz	3 Mb/s	100m	days

Table 1 Bluetooth specification

From table 1 we can see that the Bluetooth 3.0 is the newest version of Bluetooth that we can know it can transfer data at higher rate than the older version although it have the same standard as IEEE 802.15.1

Signal Encoding Techniques

The Bluetooth have the method to modulation or encoding data is digital to analog. It use modulation is GFSK (Gaussian Frequency Shift Keying) which it has data rate is 1Mb/s . The binary FSK is minimizes transceiver complexity to the Gaussian-shaped. The positive frequency is represent by one and negative frequency is represent by zero. In the one slot data can change value in every 1us.

Transmission Media

Bluetooth is considered to be a transmission media in the same OSI layer as Ethernet, Token Ring, Atm, etc. When we compare Bluetooth with another wireless technologies it transmission is slow (less than 3MB/s) but bluetooth has major benefit that other wireless technologies doesn't have that it consume low power consumption than 802.11 WiFi radio signal.

Frequency offset	Transmit Power
± 500kHz	-20 dBc
2MHz (|M-N| = 2)	-20 dBm
3MHz or greater (|M-N| ≥3)	-40 dBm

Table 2.1

This table show the transmit power that use for the frequency in the Bluetooth

Product Name	Frequency range	Gain	Bandwidth
Lanbowan	2400 to 2483.5 MHz	9dBi	83.5Mhz
Lanbowan ANT2400Q29	2400 to 2483.5MHz	2dBi	83.5MHz
Lanbowan rubber Duck	824 to 894 or 1850 to 1990MHz	2.15dBi	70/140MHz

Table 2.2

This Table show the example of the Bluetooth antenna it compare the frequency range, Gain and Bandwidth.

Errors

In the Bluetooth technology , Baseband layer in the protocol layered stack it provide ARQ protocol. For err-detection,Bluetooth uses varios checksum-calculations. The Baseband use forward error correcting (FEC) coding to correct the error by using receiver and a header error check (HEC) to detect errors d remain after correction. But it have some packet error that have probability are undetected. To correct this bluetooth have L2CAP layer to addition high level of error control . This will reduce probability of undetected error .

Wireless LAN

A wireless LAN (WLAN) is one that makes use of a wireless transmission medium. WLAN use radio waves for transmitting data in local area network. WLAN technology is defined by the IEEE 802.11 standard, this standard defines physical and medium access control (MAC) layers, specifically devoted to WLAN.

Protocol Architectures

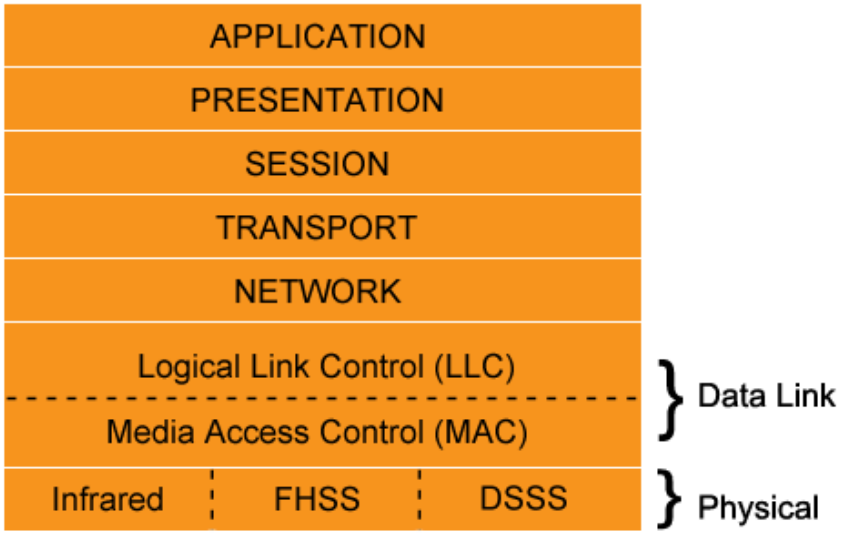

Figure 5 IEEE 802.11 protocol stack

An IEEE 802.11 protocol stack in OSI model is shown in Figure 5, The IEEE 802.11 includes Direct Sequence Spread Spectrum (DSSS), Frequency Hopping Spread Spectrum (FHSS), and Infrared in physical layer.

The data link layer is split into two sublayers, the MAC sublayer determines how the channel is allocated and who gets to transmit next. Logical Link Control (LLC) sublayer is to hide the differences between the different 802 variants and make them indistinguishable as far as the network layer is concerned. Data link layer uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). CSMA/CA attempts to avoid collision by using explicit packet acknowledgement (ACK) , which means an ACK packet is sent by the destination to confirm that the data packet arrived.

But nowadays IEEE 802.11 Working Group improves performance, security and develops standard of IEEE 802.11 in many version. They are commonly used today in their 802.11a, 802.11b, 802.11g and 802.11n

Data Transmission

IEEE 802.11 standard is defined in many version to improve performance, security, etc. The data rates, bandwidth, and frequency are also different in each version. Table 3 provides some details.

	802.11	802.11a	802.11b	802.11g	802.11n
Maximum Data rate	1,2 Mbps	54 Mbps	11 Mbps	54 Mbps	600 Mbps
Frequency	2.4 GHz	5 GHz	2.4 GHz	2.4 GHz	2.4 or 5 GHz
Bandwidth per channel	20 MHz	20 MHz	20 MHz	20 MHz	20 MHz or 40 MHz

Table 3 Maximum data rate, frequency, and bandwidth of IEEE 802.11 family

IEEE 802.11a provides much higher data rates than 802.11b and the same maximum data rate as 802.11g, but 802.11n provides the highest data rates, there is the option to double the bandwidth per channel to 40 MHz which provides more than double data rate. 802.11n operates in both the 2.4 GHz and 5 GHz. The 5 GHz band has substantial capacity due to many non-overlapping radio channels and less radio interference as compared to the 2.4 GHz band. 802.11n achieve the maximum efficiency when uses in 5 GHz.

The IEEE 802.11 allows three transmission techniques in physical layer. The infrared method and the other two use radio frequency, using techniques called direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS). Both of these operate in the 2.4 band, which is an unlicensed spectrum.

Transmission Media

WLAN use broadcast radio(unguided media) as transmission medium. In WLAN, commonly used antennas are omnidirectional antenna and directional antenna. The size of antenna used depends on the frequency. Table 4 describes information of both antennas.

Antenna type	Description	Example antenna	Device
Omnidirectional antenna	360 degree coverage pattern, cover large area, used for point-to-multi-point	Dipole	PCMCIA wireless card, wireless USB adapter, wireless router, access point
Directional antenna	Focused signal to direct energy in certain directions, used for point-to-point	Patch, yagi, dish	Wireless bridge

Table 4 omnidirectional antenna and directional antenna

But in 802.11n uses Multiple Input Multiple Output (MIMO) antenna.

Some example of wireless device specification is shown below in table 5

	receive sensitivity	Antenna type	Transmit power
TP-LINK TL-WN321G Wireless USB adapter	54M: -68dBm@ 10% PER 11M: -85dBm@8% PER 6M: -88dBm@10% PER 1M: -90dBm@8% PER	Internal omnidirectional	15dBm (Typical)
TP-LINK TL-WA601G Wireless Access Point	108M: -68dBm@10% PER 54M: -68dBm@ 10% PER 11M: -85dBm@8% PER 6M: -88dBm@10% PER 1M: -90dBm@8% PER 256K: -105dBm@8% PER	3dBi detachable omnidirectional	20dBm (MAX)

Table 5 some example of wireless device specification

The maximum distance of WLAN is shown below in table 6.

	802.11	802.11a	802.11b	802.11g	802.11n
Maximum distance (indoor)	~20 meters	~35 meters	~38 meters	~38 meters	~70 meters
Maximum distance (outdoor)	~100 meters	~120 meters	~140 meters	~140 meters	~250 meters

Table 6 maximum distance of WLAN

Signal Encoding Techniques

WLAN transmits digital data using analog signals. IEEE 802.11 uses binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), Gaussian frequency shift keying (GFSK), and complementary code keying (CCK).

Errors

WLAN uses Cyclic Redundancy Check (CRC) technique for error detection. For error correction, WLAN uses Forward Error Correction (FEC) technique. For error control, WLAN uses Stop-and-Wait ARQ technique.

WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless digital communications system. WiMAX provides the missing link for the "last mile" connection in metropolitan area networks where DSL, Cable and other broadband access methods are not available or too expensive. WiMAX technology is defined by IEEE 802.16 standard which provides specification of the medium access control (MAC) layer and physical (PHY) layer.

Protocol Architectures

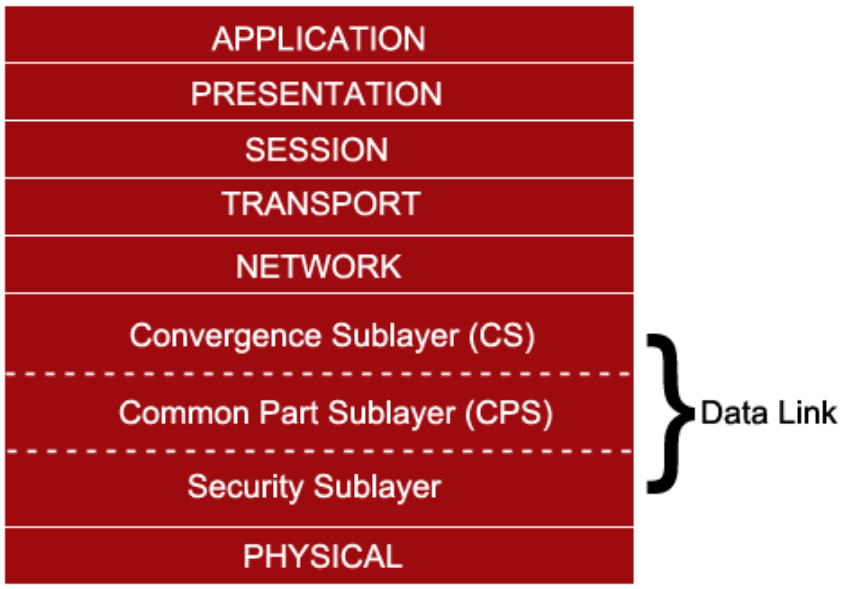

Figure 6 IEEE 802.16 protocol stack

An IEEE 802.16 protocol stack in OSI model is shown in Figure 6, The physical layer of this technology is responsible for data transmission and reception.

The MAC layer is divided into three sublayers are convergence sublayer(CS), common part sublayer(CPS), and security sublayer.

- **Convergence Sublayer (CS)** ,The CS transform incoming data received from the CS service access point (SAP) into MAC data packets. The CS can divided into two specifications ATM CS and packet
- **Common Part Sublayer (CPS)** , The CPS provide for access control functionality , bandwidth allocation, connection establishment, and maintenance
- **Security Sublayer** is responsible for authentication, key exchange, and encryption.

But nowadays IEEE 802.16 Working Group improves performance, security and develops IEEE 802.16 standard in many versions. However, They are commonly used today in IEEE 802.16-2004(Fixed Broadband Wireless) and IEEE 802.16e(Mobile Broadband Wireless).

Data Transmission

Spectrum bands of WiMAX have unlicensed band and licensed band

- **Unlicensed band:** 5.8 GHz, this includes the 5150-5350 MHz and 5725-5825 MHz band
- **Licensed bands:**
  3.5 GHz, this includes the band within 3400-3600 MHz
  2.5 GHz, this includes the 2500-2690 MHz band; 2305-2320 and 2335-2350 MHz are also available in North America.
  Sub 1 GHz, this includes the 700-800 MHz bands

Different bands are available for WiMAX applications in different parts of the world. The frequencies band commonly used are 3.5 and 5.8 GHz for 802.16-2004 and 2.3, 2.5 and 3.5 GHz for 802.16e but the use depends upon the countries.

IEEE 802.11 standard is defined in many version to improve performance, security, etc. The data rates, bandwidth, and frequency are also different in each version. Table 7 provides some details.

	802.16-2004	802.16e
Maximum Data rate	75 Mbps	30 Mbps
Frequency	2-11 GHz (3.5 GHz in Europe)	2-6 GHz
Range	10 km	3.5 km

Table 7 Maximum data rate, frequency, and range of IEEE 802.16 family

Transmission Media

Transmit power and receiver sensitivity

WiMAX has 2 transmit powers is typical WiMAX basestation and mobile station. A typical WiMAX basestation use power to transmit in approximate 43dBm, and mobile station use power to transmit in 23dBm. The receiver sensitivity of WiMax is defined in IEEE 802.16 to be −91dBm for a 1.5 MHz channel using 1/2 coding rate QPSK, and −65dBm for a 20 MHz channel using 3/4 coding rate 64-QAM.

Antenna

WiMAX has many shapes of antennas like diamond shaped antenna, sector antenna, etc.

Example antennas for WiMAX

1. 3.3-3.8 GHz Subscriber Antenna for WiMAX applications is a diamond shaped antenna. It has dimension 600 x 600 x 22 mm and gain 28dBi for frequency range 4.9 - 5.15 GHz
2. 3.5 GHz Sector Antenna for WiMAX Applications, 60° is a base station antenna. It has dimension 805x 115 x 49 mm and gain 17 dBi.

Signal Encoding Techniques

WiMAX transmits digital data using analog signals. WiMAX uses three modulation techniques, there are QPSK(quadrature phase shift keying), 16QAM(quadrature amplitude modulation), and 64QAM.

Errors

For error detection and correction, WiMAX uses Forward Error Correction (FEC) technique. For error control, WiMAX uses Hybrid ARQ .Hybrid ARQ is a combination of FEC coding and error detection using the ARQ error-control method.

Comparison:

Application, usage, and cost

	Zigbee	Bluetooth	WLAN	WiMAX
Maximum data rate	250 Kbps	22 Mbps	up to 600 Mbps	up to 75 Mbps
Distance (indoor)	60m	~100 m	~70 m	-
Distance (outdoor)	750m	~100 m	~250 m	~10 km

Table 8 comparison in each technology

Advantages/Disadvantages

WiMAX

Advantages

- Single station can serve hundreds of users.
- Much faster deployment of new users comparing to wired networks.
- Speed of 10 Mbps at 10 kilometers within line-of-site.
- It is standardized, and the same frequency equipment should work together.

Disadvantages

- Line of sight is needed for more distant connections.
- Bad weather conditions such as rain could interrupt the signal.
- Other wireless equipment could cause interference.
- Multiplied frequencies are used.
- WiMAX is a very power-consuming technology and requires significant electrical support.
- High installation and operational cost.

Bluetooth

Advantages

- Widely used
- Simplicity
- Free of Charge
- Can control easy when sent data or exchange

Disadvantages

- Consume much more battery which it use with cell phone
- When connect to internet it very low speed

ZigBee

Advantages

- Low power consumption
- Low cost
- Flexible reliable, and self-healing network
- Large number of nodes
- Fast, easy deployment
- Security
- Ability to be used globally
- Product interoperability

Disadvantages

- Short range
- Low complexity
- Low data rate speed
- To make it better it use to pay high cost.

Wireless LAN

Advantages

- It is easier to add or move workstations.
- It is easier to provide connectivity in areas where it is difficult to lay cable.
- Installation is fast and easy, and it can eliminate the need to pull cable through walls and ceilings.
- Access to the network can be from anywhere within range of an access point.
- A WLAN can avoid the need to drill holes in walls.
- Long-term cost benefits can be found in dynamic environments requiring frequent moves and changes.

Disadvantages

- As the number of computers using the network increases, the data transfer rate to each computer will decrease accordingly.
- As standards change, it may be necessary to replace wireless cards and/or access points.
- Lower wireless bandwidth means some applications such as video streaming will be more effective on a wired LAN.
- Security is more difficult to guarantee and requires configuration.
- A wired LAN is most likely to be required to provide a backbone to the WLAN, a WLAN should be a supplement to a wired LAN and not a complete solution.
- Long-term cost benefits are harder to achieve in static environments that require few moves and changes.

Applications

Zigbee Applications

Zigbee can use for many applications. The applications of Zigbee can be classified as follows:

Advanced metering infrastructure

Applications for two-way communications of metering data and energy management to provide more efficient and reliable energy usage.

Commercial building automation

Applications in the commercial, industrial and institutional domain for control, management and monitoring of buildings of up to 100,000 sq. ft. per floor.

Home automation

Applications for the residential automation market to allow OEMs to produce products that will meet the needs of customers ranging from DIY homeowners to professional installers.

Personal, home and hospital care

Applications for personal exercise or medical equipment, or hospital equipment for monitoring health and well being.

Telecom applications

Applications for telecom value added services including information delivery, mobile payment,P2P data sharing, location services & mobile gaming.

Wireless sensor applications

Environmental monitoring, asset tracking and structural monitoring.

Nowadays, typical users use Zigbee technology in many ways like home automation devices, pda controller, occupancy sensor, etc. The types of devices are required in Zigbee:

- **ZigBee coordinator (ZC)**: The most capable device, the coordinator forms the root of the network tree and might bridge to other networks.
- **ZigBee Router (ZR)**: while running an application function, a router can act as an intermediate router, passing on data from other devices.
- **ZigBee End Device (ZED)**: Contains just enough functionality to talk to the parent node. It cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time, so it make Zigbee give long battery life.

Bluetooth Applications

A few other possible applications are as follows:

- Data synchronisation need never again be a problem as your Bluetooth enabled PDA, PC or laptop all talk to each other and update their respective files to the most recent ones.

- Travelling in a plane, a person may write but not send e-mail. When the plane touches down the Bluetooth enabled laptop will communicate with the user's phone and will automatically send them.

- Mice and keyboards will identify themselves to the computer without intervention, or could also be used to command TVs, videos or hi-fis at the touch.

Wireless LAN Applications

WLAN can connect multiple devices to each other, to audio, video content, and to the internet. Users can connect a family's computer, media to share hardware and media resources such as printers, audio files, and internet access. Companies, Universities, etc. use WLAN to communicate in their business like meeting rooms, classrooms, auditoriums, etc. The following list shows example of WLAN applications:

- Students at universities use wireless connectivity to facilitate access to information, information exchanges, and learning.
- Doctors and nurses in hospitals deliver patient information instantly by using hand-held or notebook with WLAN capability
- Waiters provide faster order to kitchen in restaurant by using hand-held with WLAN capability.

Wi-Fi is a standard developed by the Wi-Fi Alliance who certifies vendor products to ensure 802.11 products on the market follow the various 802.11 specifications. The product has Wi-Fi logo, it guarantees for compatible with WLAN, but the lack of Wi-Fi logo does not necessarily imply a product is incompatible with WLAN. The following components are required in WLAN:

- **Wireless adapters** allow devices to connect to a wireless network. These adapters connect to devices using various external or internal interconnects such as PCI, USB, router.
- **Wireless access point (WAP)** connects a group of wireless devices to an adjacent wired LAN. An access point resembles a network hub, relaying data between connected wireless devices in addition to single connected wired device, most often an ethernet hub or switch, allowing wireless devices to communicate with other wired devices.
- **Wireless bridge** is a networking bridge used to connect two or more separate networks. A wireless bridge functions in the same way but can be used in situations in which running a wire or cable would be impractical or expensive, such as creating a 10-mile point-to-point link.

WiMAX Applications

One of WiMAX's potential uses is to cover the so-called "last mile" (or "last kilometre) area, meaning providing high-speed Internet access to areas which normal wired technolgies do not cover (such as DSL, cable).

According to WiMax Forum, it supports 5 classes of applications:

1. Multi-player Interactive Gaming.

2. VOIP and Video Conference

3. Streaming Media

4. Web Browsing and Instant Messaging

5 . Media Content Downloads

Usage

In four technologies that we give information the most usage in Thailand is Wireless LAN because now in Thailand it easy and simple to set up and use about wireless. It can access to the internet every time and every where within the signal that wireless land sent. The important thing that it use is it scalability, it can manage to apply to work efficiency to many application. In other country wireless LAN is more popular so. In other country Bluetooth and zigbee use in worldwid. WiMax is use in most country but not popular when compare with other technology.

Cost

Wireless Technology	WiMAX	WLAN	Bluetooth	Zigbee
Equipment	**Cost (USD)**			
Proxim Wireless Tsunami MP.16	800			
Zyxel MAX-100 WiMAX IEEE 802.16e PCMCIA Card	570			
Zyxel MAX-200M1 WiMAX IEEE 802.16e	800			
Netgear WG511 WLAN Wireless Laptop Card		60		
Zyxel ZyAIR B-2000 v.2		170		
WDA-1320 Wireless G Desktop Adapter		40		
DBT-120 Wireless Bluetooth 2.0 USB Adapter			30	
CM-BT Bluetooth Neckloop			150	
Motorola T215 Bluetooth In-Car Speakerphone			60	
SN250 ZigBee Wireless Networking chip(7 x 7mm)				5
ZMN2405-R Zigbee OEM Module				22
Rainsun AN7638 Multilayer Chip Antenna				0.88

Table 9

From the table, it shows the price of product for each wireless technology. The cost of WiMAX product is the highest (500-800USD), cost of WLAN product is more expensive than cost of Bluetooth product a little bit and the cost of Zigbee product is the lowest (0.5-50). The other costs that associated with using wireless technology are installation cost, power consumption cost, and it may have managing and upgrading wireless network cost if distance to receive signal is more over than the equipment range.

References

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