ITS323 Introduction to Data Communications Assignment 1

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Zigbee(Section 1)

⇨ Introduction

Zigbee, for about its name, is come from behavior of bee in the nature. When bee try to communicate with other, they will fly by zig-zag pattern. By doing like this, the data of position, distance and direction of meal that they are finding will be sending to each others. With wireless communication technology, Zigbee has occurred with significant advantage, low power consumption of batteries that take a part in some problem that Wi-Fi and Bluetooth are not suitable. There are some ad-hoc problems about wireless network that need specific attributes of Zigbee. Nowadays there is no private owner of Zigbee but there are consortiums of companies that called "Zigbee alliance" which has a main role in Observe and manage Zigbee's global standard.

⇨ Data Transmission

The frequency need in the unlicensed 2.4 GHz for worldwide. There have 16 channels. Data rate are about 250kbps.1 channel need bandwidth about 5 MHz. For America and some of Pacific Rim need 902-928 MHz. There have about 10 channels. Data rate are about 40 kbps. There are some countries in Europe that need 868 GHz. There has only 1 channel. Data rate is 20Kbps.they are using direct-sequence spread spectrum.From the below table showing that different of each country.

	CHANNEL NUMBER	CONVERAGE	DATA RATE	BAND
915 MHz	1-10	Americas	40 kbps	ISM
868 MHz	0	Europe	20 kbpd	
2.4 GHz	11-26	Worldwide	250 kbps	ISM

⇨ Signal Encoding

In the view of encoding signal, the structure of Zigbee start with physical layer, MAC layer, network or service provider then application. Zigbee implement IEEE 802.15.4 in lower layer. The higher layer is controlled by Zigbee alliance. End device is end point device which receive and transmit signal at its point to only their router or coordinator. End device can be RFD (reduced function device) or FFD(full function device). End device has no ability to transfer data to other devices. End device connected through router.

⇨ Error

In the view of error checking, Zigbee use acknowledgement frame. This algorithm will prove that there is no error of transmitted and considered it as complete frame transmission.

⇨ Transmission Media

In the view of transmission media, Zigbee's antenna is appropriate and has efficiency depends on the purpose of user. There are always use in 2.4 GHz. the minimum receiver sensitivity is -85 dBm for 2.4 GHz. For 900 MHz, it is -92 MHz. These are specified by the 802.15.4 standard. The variation about 10 dBm has a large amount of effect on system. The minimum output power also is specified by the 802.15.4 standard. it need to have -3dBm or 0.5mW.but nowadays, there are usually about 0dBm or 3dBm.the range of Zigbee is depend on receive power and transmit power. But the maximum range for real world is about 76 meters. The distance is between 10 and 76 meters for normal Zigbee and Zigbee pro can up to 1500 meters.

Comparison of different transmission media

Characteristics	Blue Tooth	ZigBee
Power Consumption	Medium	Low
Distance	100m	100m
Transfer Rate	1Mbps	250Kbps
Expansion	Medium	High

⇨ Protocol Architecture

In the view of protocol architectures, Zigbee's protocol is organized by Zigbee alliance for better wireless using focus on security and stability. This protocol gets Zigbee to be dominant on low cost and power consumption that can handle security with multiple nodes.

The structure of Zigbee starts with physical layer, MAC layer, network or service provider then application. Zigbee implement IEEE 802.15.4 in lower layer. The higher layer is controlled by Zigbee alliance. End device is end point device which receive and transmit signal at its point to only their router or coordinator. End device can be RFD (reduced function device) or FFD(full function device). End device has no ability to transfer data to other devices. End device connected through router.

Router is send and receives data on the path of network, monitor signal of incoming connection such as active channel then authorize that connection to send and receive with other. These actions of router happen on coordinator.

Coordinator has to communicate and link connection between end device and router, coordinator and coordinator or coordinator and router. Every device on network is managed by coordinator to not have any conflict address and routing path. If there is any unused channel, coordinator can start network on it. Digital radio has been send into data frame. There are frame-check procedures to verify that there are any errors or not.

Bluetooth(Section 2)

⇨ Introduction

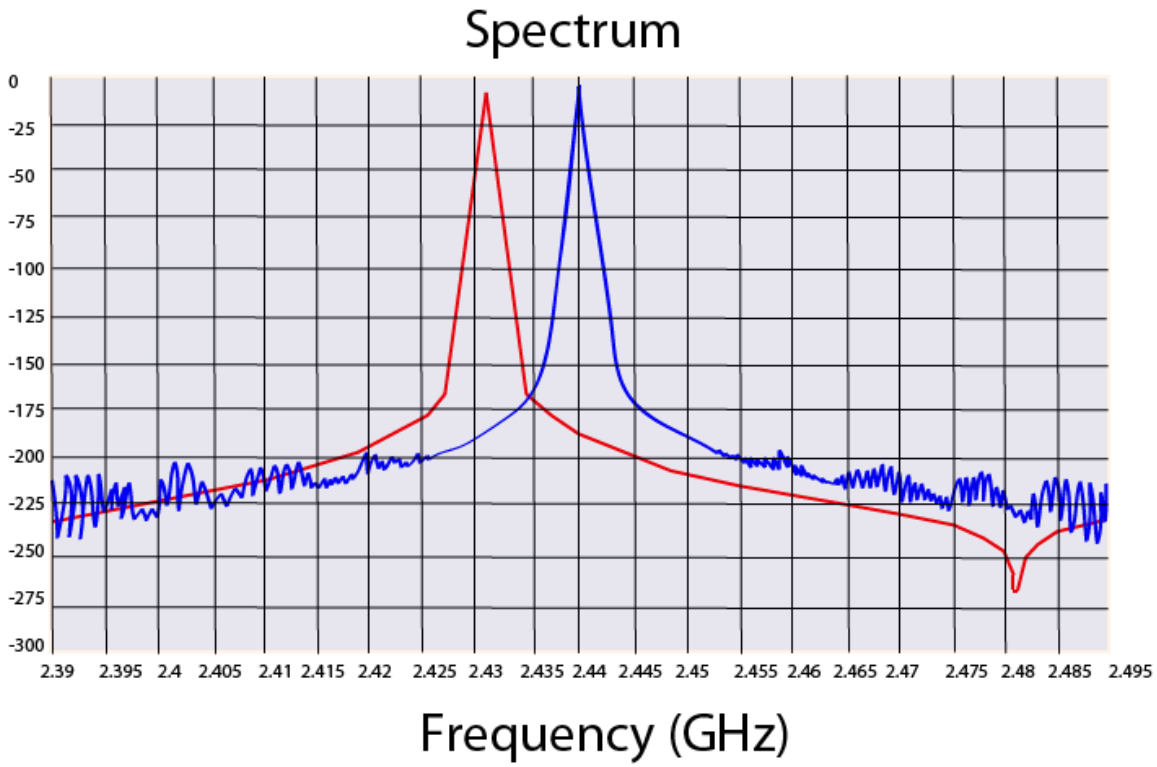
Bluetooth is kind of short-range wireless technology with have ability to decrease interference between Bluetooth devices. There is a small personal area network formed with each device not too far from each other within about 10 meters.

In the view of transmission of data, Bluetooth use a technology in receiving and sending signal called FHSS(frequency hopping spread spectrum) .this technique make more efficiency for devices to use the radio spectrum and reducing probability of other devices disturbing Bluetooth devices. If this disturbing happens, it will be appear for a short seconds. Because of this technique, transmitter has to change its frequencies by called these action "hop" in the rate of 1,600 hops per second. It can be higher rate of hop if device as to page or inquire.79 individual channel frequencies will be randomly chosen. Therefore Bluetooth frequencies are in the range actually between 2.402 GHz to 2.480 GHz. This range of frequencies has been set by industrial, scientific and medical devices or ISM. Bluetooth has 2 types of connection, Asynchronous Connection less (ACL) and Synchronous Connection Oriented (SCO), with each has different data rate. For SCO, it designed for sending voice with point to point. It has a lot of packet types then the data rate is varying. For ACL, it designed for

sending normal data which can be symmetric or asymmetric. The bandwidth is about 24 kHz because range of frequencies using between 8 – 36 kHz. The data rate in Bluetooth is about 1Mbps.for higher technology, version 2.0, is about 3Mbps.for version 3.0 is about 24Mbps.

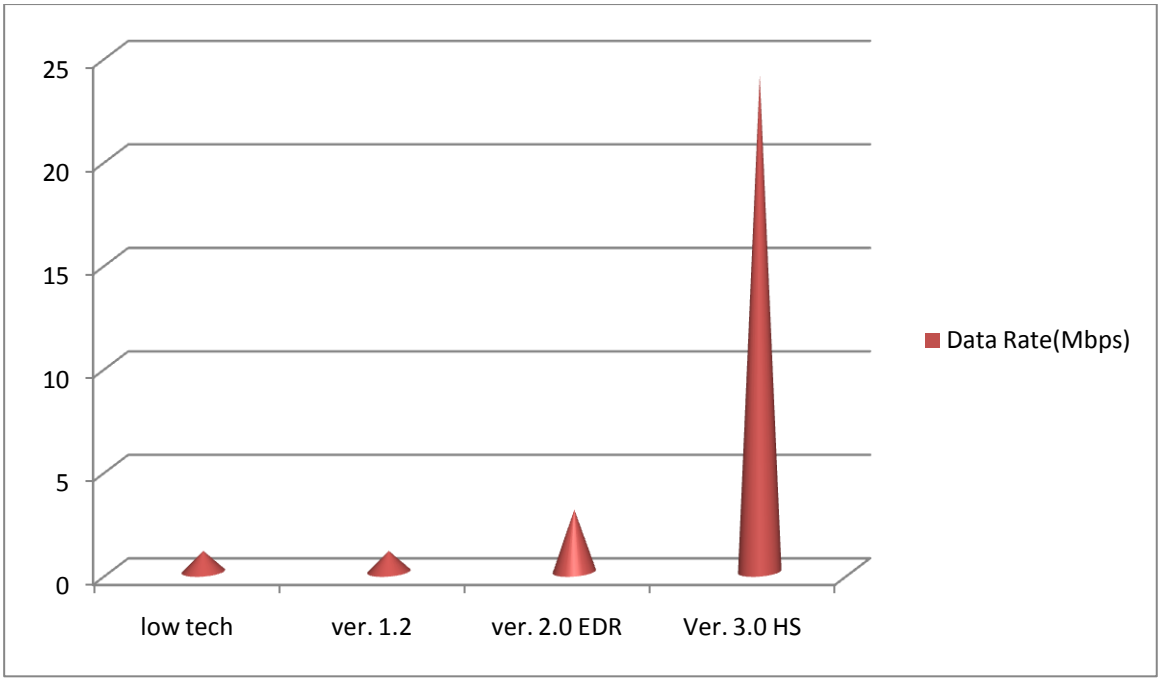
⇨ Spectrum

Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz, using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1600 hops/sec. The 2.4 GHz ISM band is available and unlicensed in most countries. Bluetooth spectrum use FHSS



⇨Data Rate

- 1 Mbps [low technology]
- 1 Mbps [version 1.2]
- 3 Mbps+ [version 2.0 EDR]
- 24 Mbps+ [Version 3.0 HS]



⇨ Transmission Media

In the view of transmission media, the range of Bluetooth is depend on each device designed and has no maximum limited. But it has the minimum has been created by the Core Specification. The minimum range is 10 meters or 30 feet. The manufacturers can set their product for appropriate range.

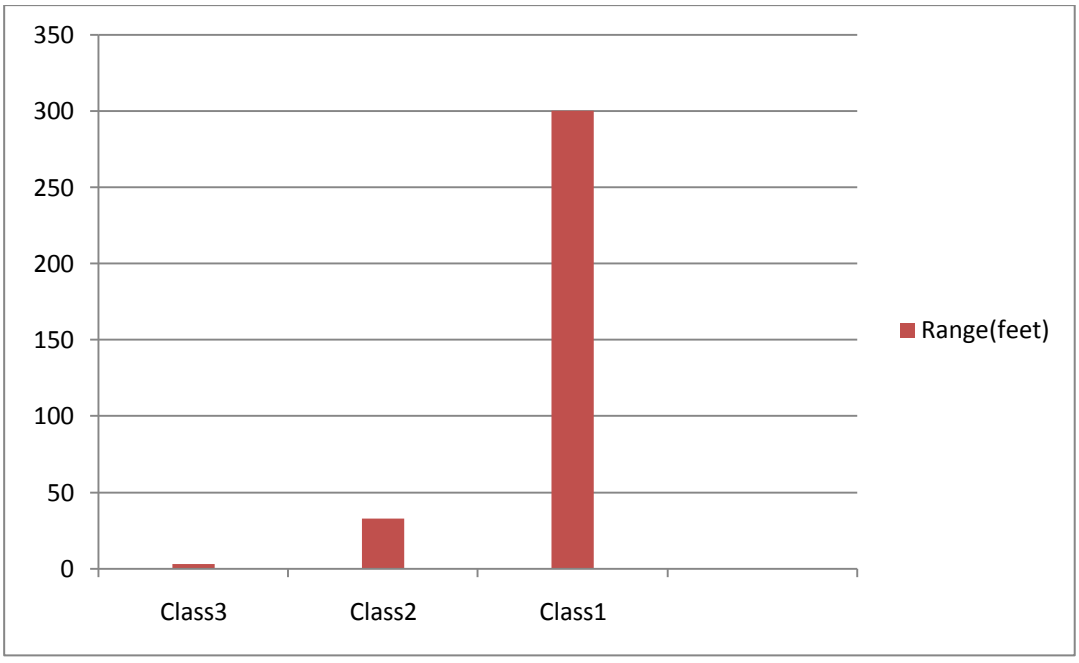
For power consumption, Bluetooth is designed by using low power technology. mobile devices type is use for worldwide then class 2 radios is use mostly. its power consumption is 2.5 mW or 4 dBm. For class 1 radios, its power consumption is 100 mW or 20dBm.for class 3 radios-its power consumption is 1 mW or 0 dBm. The receive threshold is about -70 dBm.

⇨ Range

Although a minimum range is mandated by the Core Specification, there is not a limit and manufacturers can tune their implementation to support the use case they are enabling.

Range may vary depending on class of radio used in an implementation:

- Class 3 radios – have a range of up to 1 meter or 3 feet
- Class 2 radios – most commonly found in mobile devices – have a range of 10 meters or 33 feet
- Class 1 radios – used primarily in industrial use cases – have a range of 100 meters or 300 feet



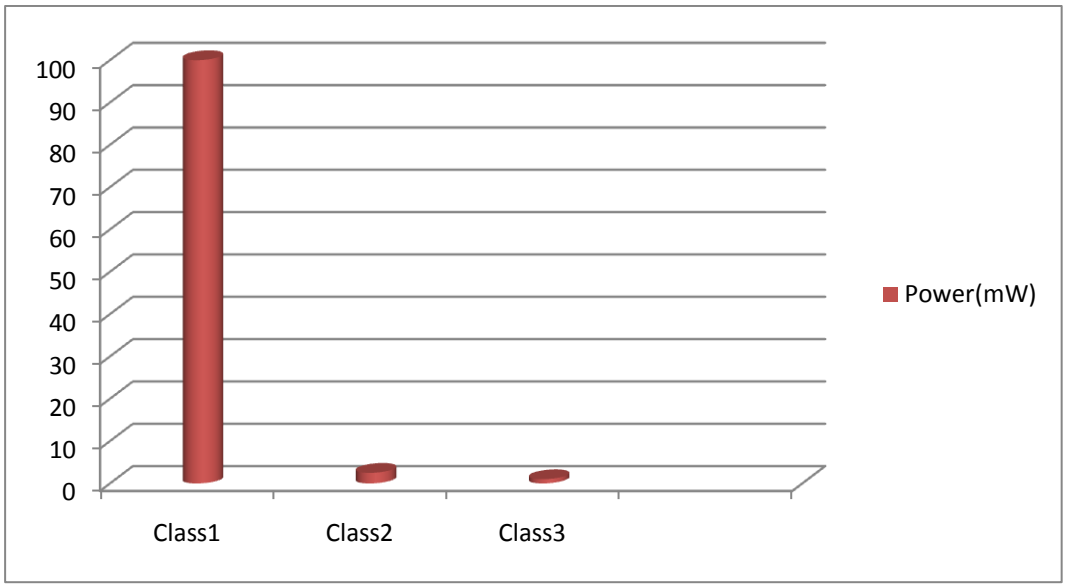
⇨Power

– Class 1: it is designed for high-range devices such as Bluetooth Access points (≈100 m), power characteristics: 20 dBm (100 mW)

– Class 2: for normal PCs and portable plugged devices (≈10 m), power characteristics 4 dBm (2.5 mW)

– Class 3: for low power devices (range less than 1 m), power characteristics: 0 dBm (1 mW)

These power values are measured at the input to the antenna. Nothing prevents a device to vary dynamically its power. The receiver should have sensitivity of – 70 dBm to detect far equipments.



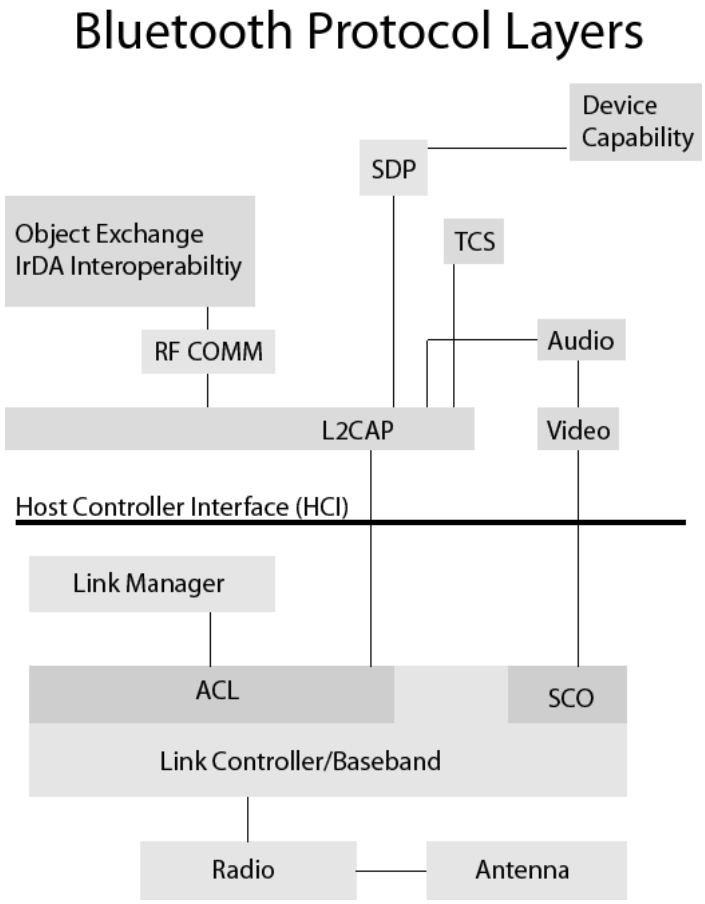
⇨ Protocol Architecture

In the view of Protocol Architectures and standard, Bluetooth is technology with low power consumption and transmission data in small range area by fewer disturbances. Architecture structure is like controller and follower.” Piconet” is a group of devices that has different duty, master and slave, by having 1 master and maximum 7 slaves. Piconet can be constructed a new network by joined with another slave called “scatter net” .node which is master will manage about slaves and their transmission. Connecting Bluetooth network doesn’t need to use IP. Then Bluetooth has no necessary to using network layer. Bluetooth use about physical layer and application layer. this physical layer will send data by using GFSK modulation. Sending zero value by negative frequency and sending one value by positive frequencies.

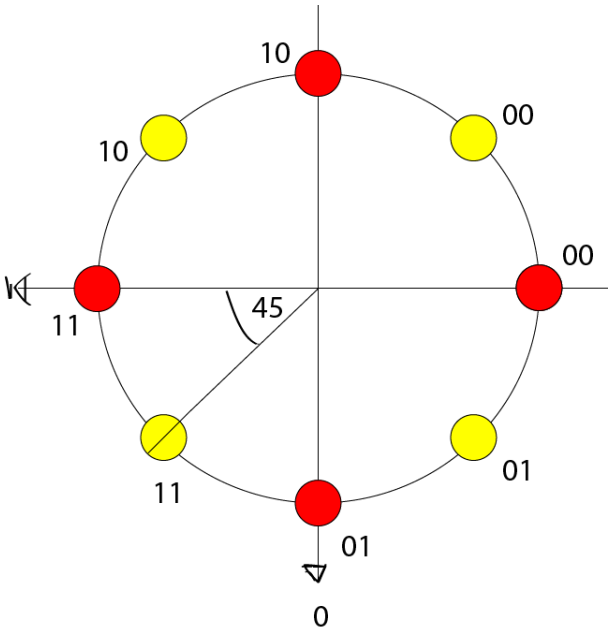
The stack of Bluetooth protocol is based by Bluetooth radio. The upper second layer is Bluetooth baseband.

Baseband is kind of physical layer that manage about security, error correction and detection,

Asynchronous and synchronous connection the upper layer from baseband is link manager. Link manager manage all process between 2 devices including establishing, controlling and transmission. Link manager will arrange data to send to application layer. The application layer is top of Bluetooth protocol stack.



This picture show that how PSK modulation determine value of data by look at phase of signal.For example,at $\pi/4$,it will decode the signal to be 00.at $3\pi/4$,it will decode the signal to be 01. At $-3\pi/4$,it will decode the signal to be 11. At $-\pi/4$,it will decode the signal to be 10.



⇨ Errors

In the view of error detection and correction, it occur in baseband layer. Bluetooth has a lot of packet when 1 data frames be transferred. It also has a lot of method to fix problem such as

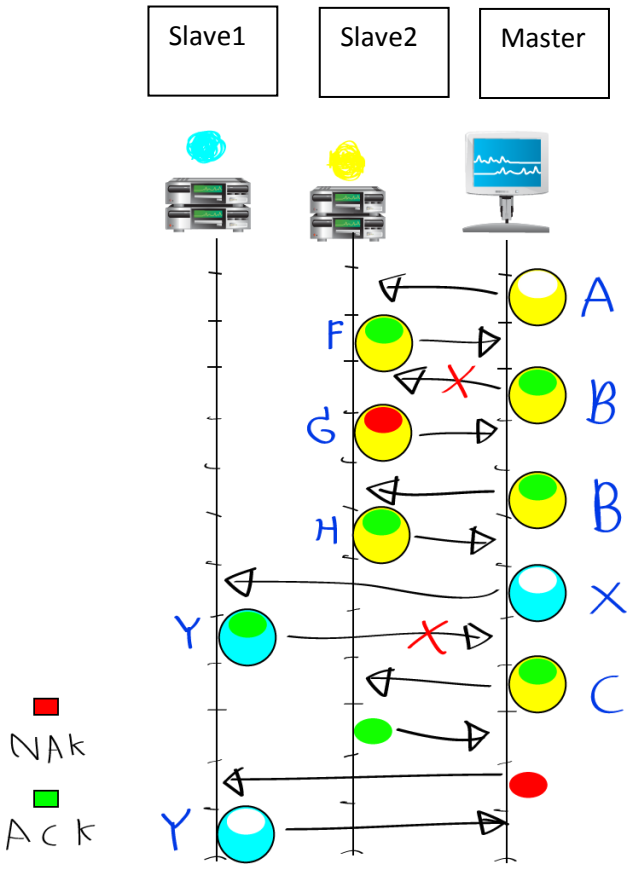
- Header error check by only detect whether there is error or not.

- CRC by calculating CRC code whether it sends correctly or have any errors.

- Automatic Repeat Request (ARQ) by check the data that sending is completely. If time of checking is expired. This table below shows the process.

- 1/3 FEC Coding by using header and packets. The algorithm is finding the average value of received 3 bits data and then decides whether the data is 1 or 0.

- 2/3 FEC Coding by using hamming distance algorithm.



ARQ scheme process

⇨ Signal Encoding

In the view of Signal Encoding Techniques, Bluetooth can use Pulse Code Modulation (PCM) or Continuous Variable Slope Delta Modulation (CVSD). These both techniques using 64 kbps. It received analog sound data and encode to digital signal. For CVSD, it determines the received data that it higher or lower than its average. If it is higher, it will return 1 to be output to the air interface. If it is lower, it will return 0 or -1 to be output to the air interface. For PCM, it will redraw input into graph that depends on amplitude then compare with quantization interval for checking error.PCM has 2 types of algorithm, the μ-law and the A-law.

Wireless Lan(Section 3)

⇨ Introduction

In the view of protocol architectures, wireless architecture in simple view is kind of connection through server, gateway and clients. Starting from internet server, there are wireless network to be a medium of connection between server and access points. Internet is connected through router. Access point or hot spots is a device for spread signal in its range. There is another of connection with wireless. This type enables clients to connect with other clients by not using router. It called ad hoc mode.

There are more than one standard that using for wireless lan. There are IEEE 802.11, a, b and g.

Each standard has its own maximum data rate and frequency. For IEEE 802.11, this standard has maximum bandwidth only 2Mbps and use frequency in 2.4 GHz band. Nowadays, there is no using or demand product for this standard. For IEEE 802.11a, this standard has developed for using more data rate. For IEEE 802.11b, this standard has developed for using less access points.

For IEE 802.11 g, this standard has better security and better data rate with lower frequency.(for more detail, see in Data Transmission)

To using IEEE 802.11b, there are Wi-Fi alliances who will verify standard. Wi-Fi alliance will give Wi-Fi certificate for proved products.

⇨ Data Transmission

In the view of data transmission, wireless using frequency between 2.4 and 5.0 GHz. Because of vary standard, properties of wireless is depends on its standard. briefly, wireless has data rate between 1 Mbps to 54Mbps.it can be maximum data rate with IEEE 802.11n standard about 540 Mbps. Bandwidth of wireless change by amount of obstacles between the path from transmitter to receiver.

It has many value of bandwidth, 20,22,25 Mhz. It is divided to an interval of 5 MHz wireless spectrum is limited by industrial, scientific and medical (ISM). It is use region of frequencies between 2450 MHz and 5800 MHz from ISM.

802.11 Network Standards

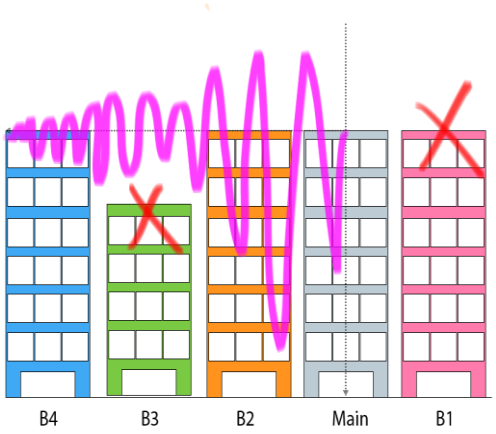
802.11 Protocol	Freq. (GHz)	Bandwidth (MHz)	Data rate per stream (Mbit/s)	Modulation	Appox. indoor (m)	Appox. Outdoor (m)
802.11	2.4	20	1.2	DSSS, FHSS	20	100
802.11a	5	20	69,121,824, 364,854	OFDM	35	120
	3.7				-	5,000
802.11b	2.4	20	1,2,5.5,11	DSSS	38	140
802.11g	2.4	20	1,269,121, 824,364, 850	OFDM, DSSS	38	140
802.11n	2.4/5	20	7.2,14.4,21.7,28.9,43.3,57.8,65,72.2	OFDM	70	250
		40	15,30,45,60,90, 120,135,150		70	250

⇨ Transmission Media

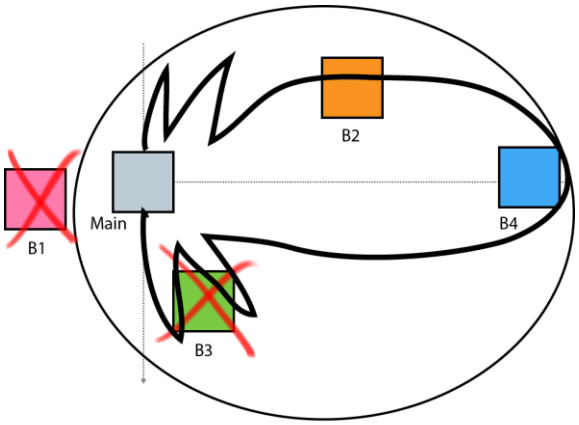
In the view of transmission media, like data transmission, wireless transmission power is depends on standard. Maximum transmission power is 1 watt or 30dBm.this value doesn't considered antenna gain. It can be different with other data rate. Higher data rate increasing, lower transmission power are receive threshold is depends on power of transmit and bit error rate.

Maximum distance for transmission is about 1.6 km. But for this long distance, receiver may not understand it. For the part that transmit signal wave, wireless using antenna to do this. Router antenna can be built-in antenna or external antenna. Wireless antenna has a lot of kind. It depends on purpose of user and nearby environment. Antennas are categorized by its radiated direction.

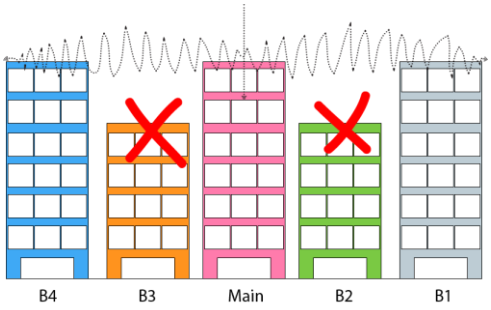
Omni directional is transmitting its signal in all direction. Its pattern like a candle emits the light. Semi directional is transmitting in specific directional radiation in small coverage area. This kind of antenna use with lamp to lighten into ground area. Highly directional is transmitting intensive signal in desired area like spotlight. if antenna are categorized in usage condition mode, it will has 5 kinds. Omni type is for outdoor environment with surrounding radiation. Panel type is for outdoor environment with specific direction radiation. Sector type is for outdoor environment with flat level radiation. Grid type is for outdoor environment with focus on horizon and vertical radiation. Yagi type is for outdoor environment with long range straight signal for connect with access point.



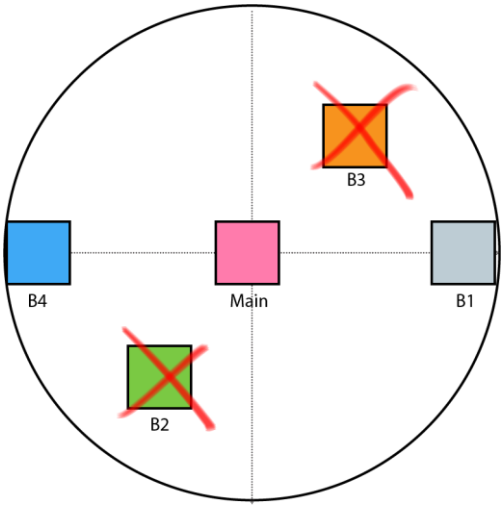
E-Plane / Vertical View
Grid Type



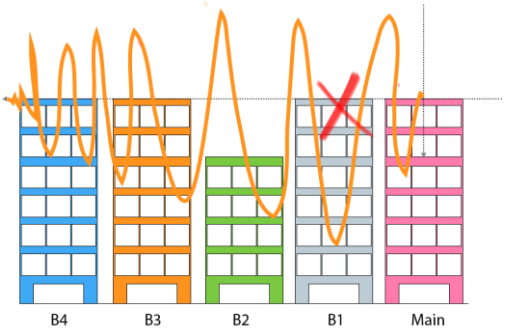
H-Plane / Horizontal View
Grid Type



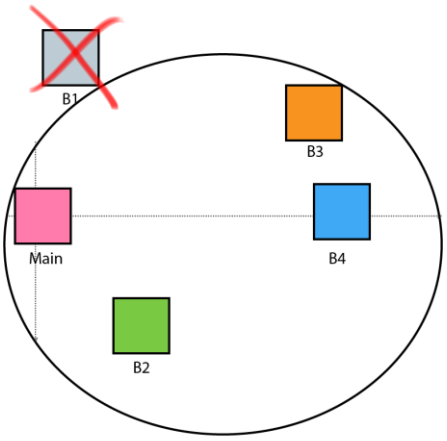
E-Plane / Vertical View
Omni Type



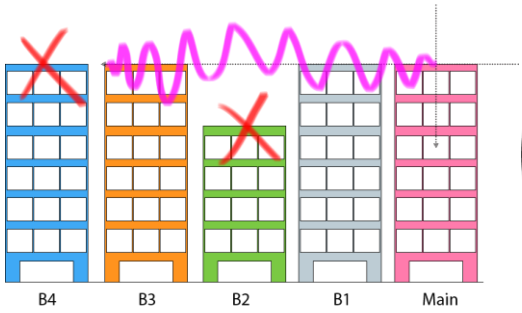
H-Plane / Horizontal View
Omni Type



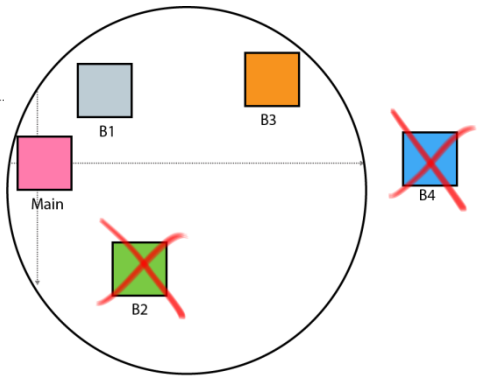
E-Plane / Vertical View
Panel Type



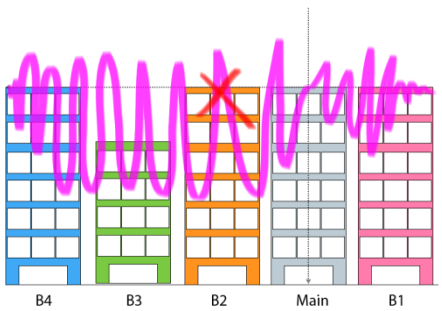
H-Plane / Horizontal View
Panel Type



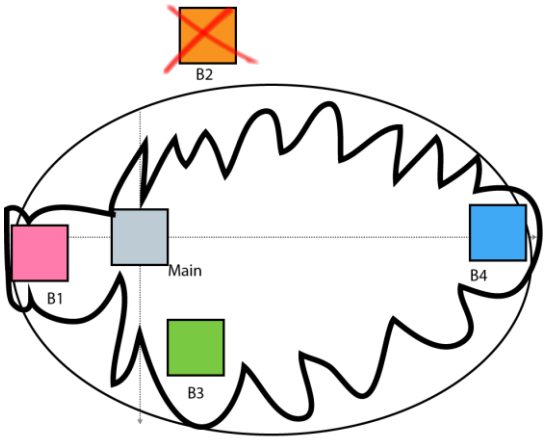
E-Plane / Vertical View
Sector Type



H-Plane / Horizontal View
Sector Type



E-Plane / Vertical View
Yagi Type



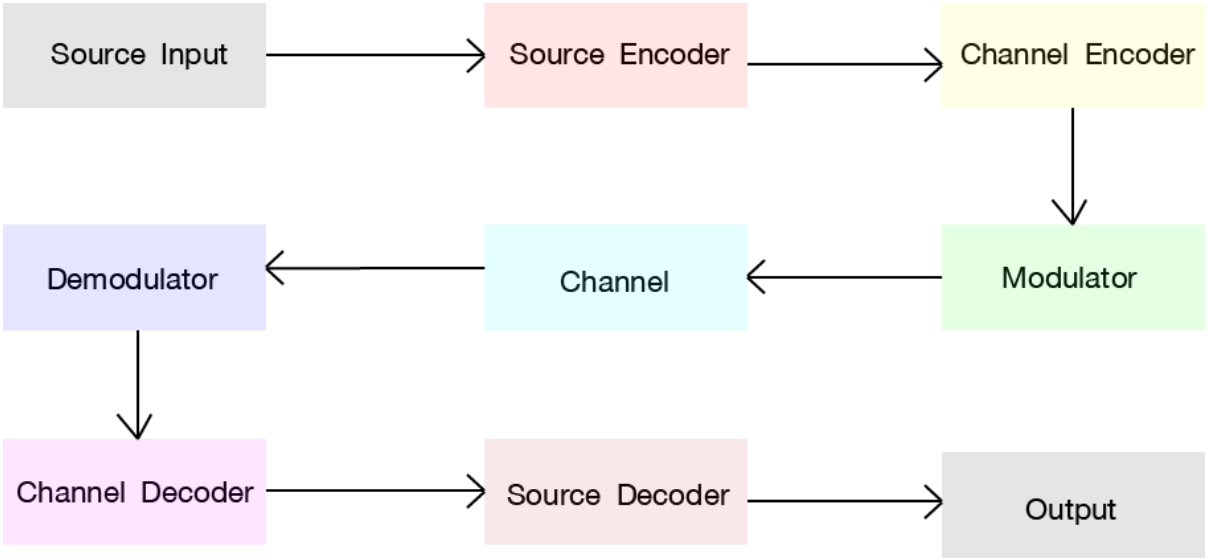
H-Plane / Horizontal View
Yagi Type

⇨ Error

In the view of error detection, wireless using acknowledgement frame to determine whether the frame has error between the sending paths. The access point will return ACK frame to its sender when there is no error occurs. When there is no ACK frame received by sender, it will assume that the error occurs and send the last data frame again. For correction error, wireless use forward error correction encoding (FEC).

⇨ Signal Encoding

In the view of Signal Encoding Techniques, wireless transmission is starting by receiving data. Then source encoder will prepare data to be digital for channel encoder. Channel encoder will add some header for error correction and destination. Its data will send to modulator. Modulator will encode digital data to be analog signal. Data from this process will be suitable with channel. This will be sent through wireless signal to receiver. Decoding modulator of receiver will decode analog signal to be digital data. The received data will has noise interrupt and error. Decoding modulator will optimize data for send to channel decoder. Error correction algorithm will be used to detecting and correcting error when data passing channel decoder. Source decoder will make the data to be same as the transmitted one from source.



WiMax(Section 4)

⇨ Introduction

WiMax is stand for Worldwide Interoperability for Microwave access. It is advanced wireless technology.This table below is showing comparison of Wi-Fi properties and WiMax properties.

Technology	Standard	Speed rate	Distance	Frequency
Wi-Fi	IEEE 802.11a	Max. 54Mbps	100m	5GHz
Wi-Fi	IEEE 802.11b	Max. 11Mbps	100m	2.4GHz
Wi-Fi	IEEE 802.11g	Max. 54Mbps	100m	2.4GHz
WiMax	IEEE 802.11d	Max. 75Mbps (20 MHz BW)	1.6 - 10 km	Sub 11GHz
WiMax	IEEE 802.11e	Max. 30Mbps (10 MHz BW)	1.6 - 5 km	2-6 GHz

⇨ Protocol Architecture

In the view of Protocol Architectures, WiMax use standard of IEEE 802.16.there are a lot of versions of this standard like IEEE 802.16a, IEEE 802.16e .for original standard, it is for supporting line of sight(LOS).it use in high frequency rate about 10 to 16 GHz. For IEEE 802.16a,it is support function of non line of sight (NLos) with lower frequency rate. It can send signal in point to multi point pattern. For IEEE 802.16d,it is called fixed WiMax because it cannot using when it is not in stationary. This standard

is use most for nowadays commercial products. For IEEE 802.16e, it is called mobile WiMax because it is enable to use when it is moving.

For WiMax's protocol architectures, the base of protocol's stack is physical layer. This layer has to encoding and decoding signal from transmission. The upper stack from physical layer is medium access control layer or MAC. Error detection is processed on this layer. It will handle data in frame form when transmit or receive according to its address. The upper stack from here is convergence layer. This layer is map an address into suitable form for transmits to next layer. The upper layer stack is application layer. This layer helps about security system. This layer also providing a connection to internet.

⇨ Data Transmission

In the view of Data Transmission, WiMax its maximum data rate is about 75Mbps theoretically. Its maximum distance that it can send data is 31 miles with line-of-sight pattern. When sending with line-of-sight, it has no physical obstacles, just only atmosphere .With non-line-of-sight, it will be lower than line-of-sight because it will have some undefined obstacles depends on its environment. Its frequency is varying depending on its standard. Its spectrum is allocated into 3 ranges such as 2.3, 2.5 and 3.5 GHz. Nowadays, we using different value around the world. America use 2.5 GHz band. Asia use 2.3 GHz band. Bandwidth is about 200MHz

⇨ Transmission Media

In the view of Transmission Media, WiMax has 2 type of station, stationary and mobility. For stationary station, its transmission power is usually about 20 W (43dBm). For mobility station, its transmission power is usually about 200mW (23dBm). Maximum distance of WiMax signal is about 30 miles. WiMax’s antenna has 3 types such as Omni directional, sector and panel antenna. Omni directional pattern of sending signal spread to every direction. Its signal does not intensive but can receive in any direction. Sector directional is pattern of sending amplified signal into specific direction. This signal cannot be sent in all direction. Panel directional is pattern of sending intense signal throughout for nearby area.

⇨ Error

In the view of Errors detection and correction, WiMax using Forward Error Correction (FEC) for checking error in transmitter and receiver. When transmitter sending frame of data, algorithm will calculate the data bits for create code. This code will be attached with header and data. When receiver receiving data frame, it will check error from the code. Its algorithm is convolution encoding, reed Solomon fec and interleaving algorithm. Convolution method will create convolution code for detect error when its data is received. This algorithm is efficiency when single bit has an error. Reed Solomon method will create code for detect a lot of random error bits by calculate from combination of its created code. Interleaving algorithm will distributes detecting error codes through several frames. If these algorithms cannot detect and correct error, Automatic Repeat Request (ARQ) will be used for sending the error frame again. All of this procedure is for reducing bit error rate (BER) and packet loss rate (PLR)

Wi-Fi vs. WiMax

	WiFi	WiMax
Coverage	Small Limited area	Vas,Broader Area
Quality of service (Qos)	Unreliable, Does NOT support Multimedia Applications	Support Multimedia Application
Speed	Limited Speed	Higher Speed
Mobility	Limited to Hotspot locations	Anywhere,Anytime
Spectrum	Unlicensed	Licensed

From this graph we can see WiMax is the new technology that will replace the Wi-Fi because the efficiency and speed is higher than Wi-Fi. The important thing is WiMax is very wide and can support more multimedia application. In the future the streaming technology will come to actual life and WiMax can be the answer.

⇨ Comparison of application, cost and usage (Section 5)

Scenario#1

For household technology, we can use these for

-Zigbee

- Home Control Lighting by using zigbee devices that can detect that if there is movement of human, it will trigger lighting at that point. We can use this with domestic lighting such as switcher or sensors.

- Air conditioner temperature sensor or Planting humidity sensor.
We need tools for complete control system.(suppose that we already have a new computer).there are

-Zigbee device price 20.00 $/1 module.
-Computer with board to connect with zigbee devices.

-Bluetooth

-car kits like hands-free.
-ear phone by using bluetooth's technology connect with mobile phone. User can walk anywhere in the house by not losing connection.
-speaker at door to sending voice for short range.
We need only Bluetooth devices.(suppose that we already have a new computer and mobiles phone)
-bluetooth devices price 25.00$/1 earset .(for standard, we use NOKIA)

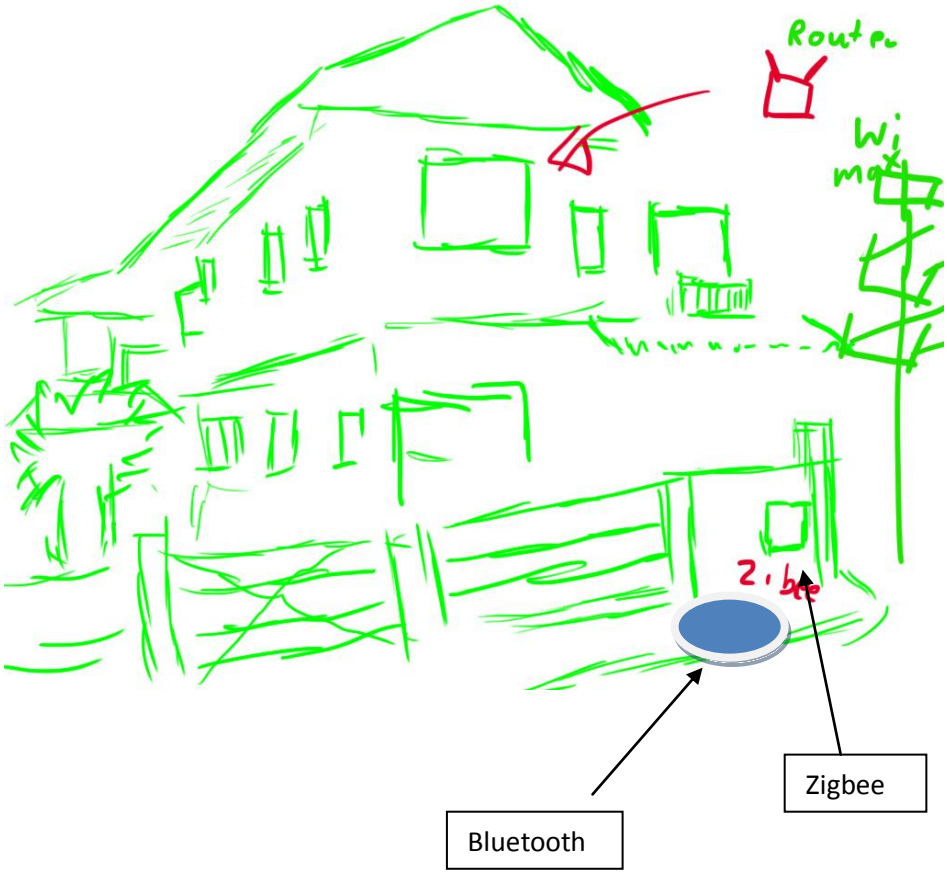
-Wireless and WiMax

-Router for internet by using wireless or wimax.

We should not use wimax because it doesn’ t have to use this much data rate and signal. We just only walk in the house. Wireless is good enough for household.

In the view of user, normal people without programming knowledge can use this technology. They just only know how to install and use. Zigbee device and router is easy to maintenance. Higher level user can use ability of Zigbee more efficiency.

In Thailand, we can rarely see zigbee devices because it still needs some knowledge to use it. Bluetooth and wireless technology is used by almost of people. But in the future, zigbee will be more popular because it has a lot of advantage that can help people’s daily life.



Scenario#2

For business office technology, we can use these for

-Zigbee

-lighting check for each floor without human checking.

-locking door checked.

-personal identity checking by user's device to eliminating to insert card.

We need tools for complete control system.(suppose that we already have a new computer).

-zigbee device price 20.00 $/1 module.

-computer server for collecting data. We only know that Price is expensive.

-Bluetooth.

Bluetooth can build network from smalldevices together called personal area etwork(PAN).it likes household using.but with more people connect with,we may face the limited of blutooth technology.it may occur some confliction.

-wireless

-sharing printer.

-Internet connection.

-server between each floor to sharing data.

We should consider a lot of factor to choosing type of bandwidth effectively. More transmission power, higher cost of devices. Some important factor are the thick of wall, number of floor, number of access point and number of user. It is better for not using LAN and no wire.

We may need

-G type wireless router price 30.00-200.00$(we are not choose N-type because it is small area suitable price and efficiency. We should care about antenna but we will tell detail later in scenario 3).the price is vary on brand and property.

- access point at each floor price 150.00-900.00

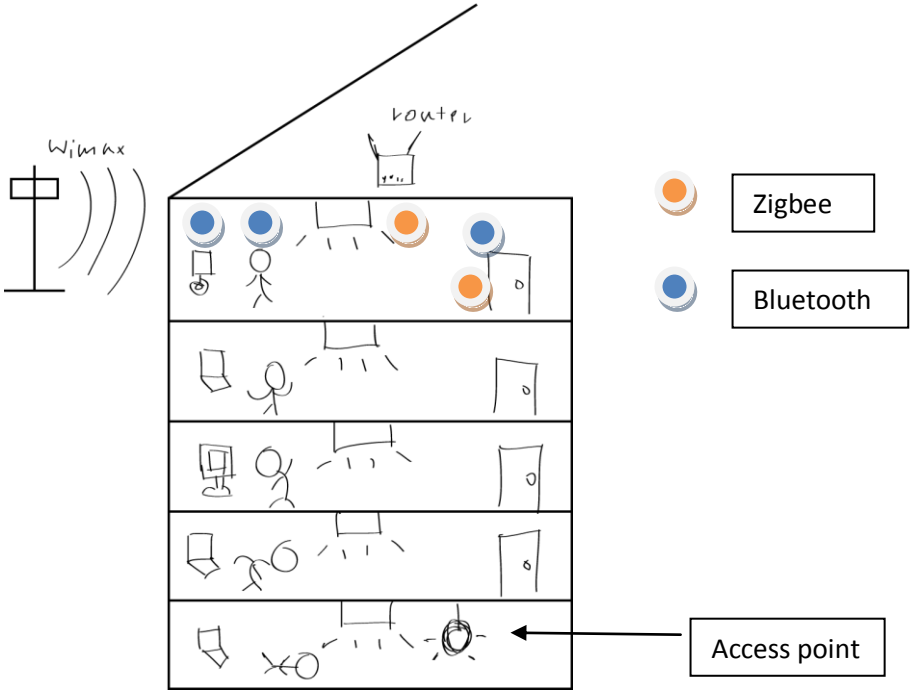
-hot spot

-wimax

We should not using wimax in this case because the high cost of infrastructure is not suitable for office user.

In the view of user, we need some technician for manage server, maintenance hardware and allocate proper signal for each floor.

In office in Thailand, this kind of system is used widely because it is very simple and easy to use.But we still can’ t see wimax using in office because there are no wimax infrastructure cover business region.



Scenario#3

For cross building technology, we should not use Zigbee and Bluetooth because it is too far for these both technologies to work effectively.

-wireless

-sharing data between 2 companies

We should consider type of wireless and antenna type depending on how far from each distance and different of height from transmitter and receiver. For example, if both companies is in the same floor and far from another 200 meters. We should use G type router with Omni type antenna because they both are not too far and in same floor is easily for Omni type to send signal. it is cheaper for using Omni type than sector type and more efficiency. if there are 3 companies in same floor and not too much distance apart. We should use G or N type router and Sector Type antenna because we now need higher data rate and channel and sector type has advantage in amplify signal in flat level.

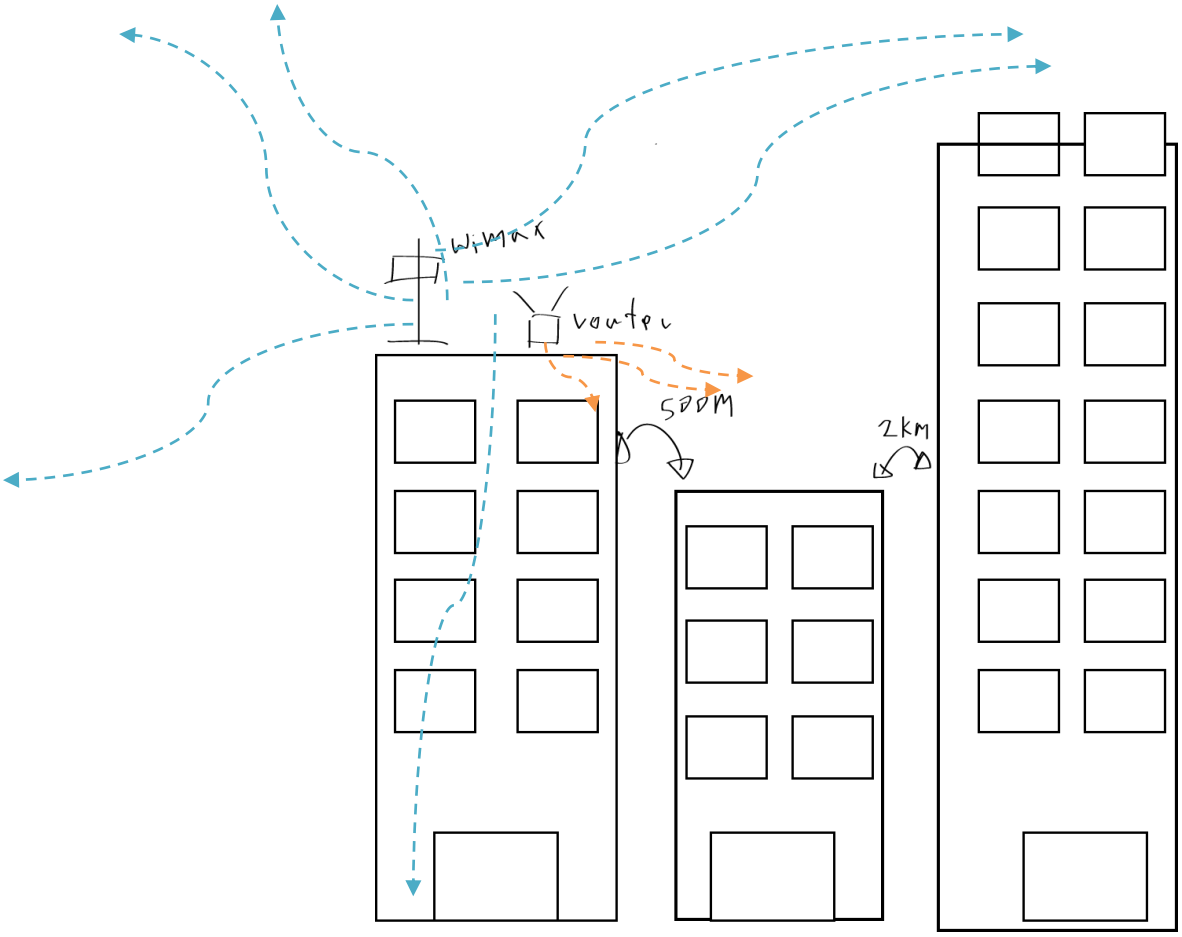
-wimax

-voice over internet protocol(VoIP)

-internet connection without using wireless system.

The factor of wimax is as same as wireless but it has less concerning because it is too short for limited of wimax.

In the view of user, it likes user of office. The different is wimax. We need infrastructure to connect wimax. The location of building must in area of services of wimax.



Scenario#4

For Metropolitan Area Network (MAN), we consider only wimax and wireless that is used in household connection.

-wimax

-stationary points

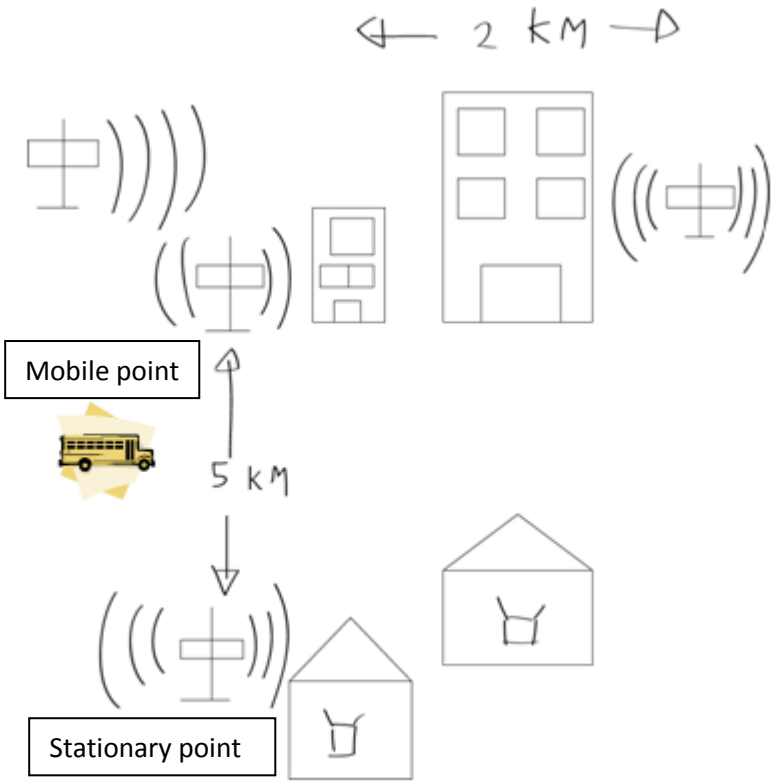
- Mobile points

We have to choose type of wimax transmitter because we have 2 situations that is mobility and stationary. Each device must be chosen for proper usage.

-wireless

-Access point to house. Wireless system can be used for access points in the house.

In the view of user, we need advanced technician and engineering to determine how far for each transmitter, what kind of atmosphere, obstacles, geography and who is a user. We can use line of sight (Los) pattern when the area is plain and no big obstacle. if we has a lot of obstacles through the path, we should use non line of sight(NLos) pattern



⇨ Overview for globe’ s wimax

In the view of global’s wimax, the future is bright for Asia. There are needs in distance urban that normal technology is not accessible. There are some regions that far away from city. The demand will be much greater for this developing region. The graph below showing that Asia has the highest growth revenue because a lot of developing country in this region has no infrastructure for wimax .it will have high revenue for investment. But in EU, there are a lot of developed countries with advanced technology. There has been far developed.

802.16 a/ d /e WiMax
2004 - 2008 WW Forecast
Revenue Share by Region

Region	2003	2004	2005	2006	2007	2008
SE Asia	19	25	29	28	26	26
China	8	9	16	20	20	19
NAM	31	23	18	18	20	19
EU	17	17	16	14	14	13

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