

ITS323 – Assignment 1

Topic: ZigBee, Bluetooth, WLAN, WiMax

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Submitted to

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Academic Year 2010/1

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ZigBee	80	20
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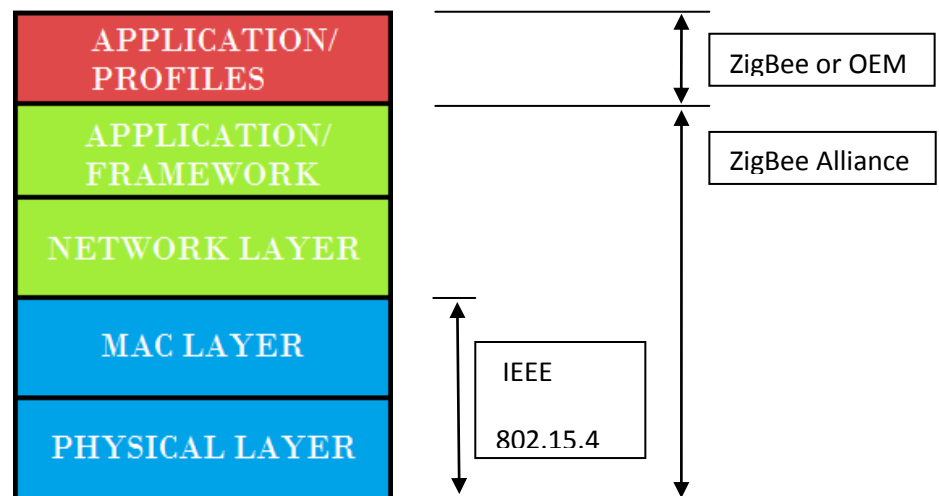
Note: Student 1 is Mr. Ariyachai Chaimanat

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ZigBee

Protocol Architectures (layered stack, protocols, standard, standard organizations)

ZigBee are built with based on the IEEE 802.15.4 low rate (LR-WPAN) standard that defines the physical layer and MAC layers for LR-WPANs but the ZigBee has defines the specific network layer and the application framework for the programming in the application layer.



An LR-WPAN are consists of a PHY that contains the radio frequency(RF) transceiver with low-level control mechanism and MAC sub layer to provides access to the channel by all types of the transfer

The Medium Access Control layer (MAC) is to control access to the radio channel by using of CSMA/CA channel access. The MAC layer can defines into four frames structure which is

1. Beacon Frame - used for transmitted beacons by the coordinator.
 2. Data Frame - used for transferred the all data.
 3. Acknowledgment Frame - used for confirm that the transmission of frame is successful on received the data.
 4. MAC Command Frame – used for handling of all MAC peer entity control transfer.
-
-

The MAC layer also has 2 functions which is the Reduced Function Devices (RFD) and the Full Function Devices (FFD)

FFDs - its can act as the network coordinator and network end devices that have ability to send the beacons, communicate and join services and offer synchronization

RFDs - Its can act only the end devices that have sensors/actuators and interact with a single FFD

The Application layer has responsibility to handle a huge number of nodes and this layer includes ZDO that is to replying and binding the requests and secure the relationship of the rest of devices, User-Defined Application Profiles that is refers to conforms to the ZigBee standard by the end devices and APS with the responsibility that to maintenance of tables between two devices, communication and discovery.

The Application profiles are the agreements for messages, message formats and processing an actions that the application to create an interoperable, distributed application

The Network layer has the responsibility to starting, joining, leaving a network, configuring a new device by assign the addresses to the devices that joining the network and has ability to discovery, record, report an information, routing the frames.

The ZigBee protocol has been created and ratified by the ZigBee Alliance Company follow by over 300 semiconductor manufacturers. The ZigBee protocol concept is an easy-to-use, stability and security by communicate data through RF environments with low latency that is not greater than 15ms and provides a long battery life to create a low duty cycle.

The communication of wireless devices in ZigBee has 2 kinds of network which are Star, Peer-to-Peer topology. The Star topology is the network that also similar to the "Piconet" network in Bluetooth technology. These communications is connecting through Personal Area Network Coordinator or Gateway Node for increase the network. The important for the Wireless network device is the low power consumption method that the devices sensor can create a time to sleep mode for reduce the power consumption. To doing this method, It's should requesting to the FFD for telling that, How much to become a sleep mode. When the other devices send the data to the sleep mode devices, The FFD also kept the data for temporary times and asks the all network for the data that has been transmit when the real receiver out of the sleeping mode. It will see the FFD asking for the real receiver and request for the data from the FFD and finally, it will completely receive the data to the real receiver.

ZigBee operates in two main modes which are non-beacon mode and beacon mode. Beacon mode is a fully coordinated mode in that all of the devices know when to coordinate with one another. In this mode, the network coordinator will periodically "wake-

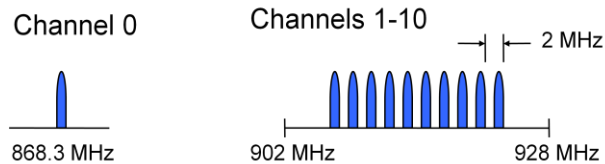
up" and send out a beacon to the devices within its network. This beacon subsequently wakes up each device, who must determine if it has any message to receive. If not, the device returns to sleep mode, as will the network coordinator, once its job is complete. Non-beacon mode, on the other hand, is less coordinated, as any device can communicate with the coordinator at will. However, this operation can cause different devices within the network to interfere with one another, and the coordinator must always be awake to listen for signals, thus requiring more power. In any case, ZigBee obtains its overall low power consumption because the majority of network devices are able to remain inactive over long periods of time

Data Transmission (spectrum, frequency, bandwidth, data rates)

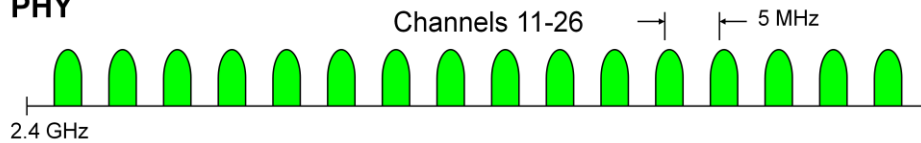
In the data transmission of ZigBee, its can separate into 2 PHYs frequency band with 868MHz/915MHz for 11 channels (1 channel for 868MHz and 10 channels for 915MHz) follow with the bandwidth of 2Mhz per channel and 2.4GHz for 16 channels with the bandwidth of 5MHz per channel and the data rates of these 2 frequency band can separate into 3 ranges of frequency band with 868MHz for 20kb/s, 915MHz for 40kb/s and 2.4GHz for 250kb/s by using direct sequence spread spectrum to prevent the noise signal with the spreading rate 0.3 Mchips/sec for the 868.0 – 868.6 MHz frequency band, 0.6 Mchips/sec for the 902.0 – 928.0 MHz frequency band and 2.0Mchips/sec for the 2.4-2.4835 GHz frequency band. The air interface is direct sequence spread spectrum (DSSS) that is faster acquisition than the frequency hopping by using binary phase shift keying (BPSK) with raised cosine pulse shaping for 868 MHz and 915 MHz and offset-quadrature phase shift keying (OQPSK) with half-sine pulse shaping for 2.4 GHz. The channel accesses of ZigBee are CSMA-CA and slotted CSMA-CA. The Carrier Sense Multiple Access/ Collision Avoidance (CSMA/CA) has a responsibility to control the transmission of the data.

Property Description	Prescribed Value	
	868/915 MHz	2.4 GHz
Data bit rate	20 kbps / 40kbps	250 kbps
Transmitter output power	1 mW = 0 dBm	
Receiver sensitivity (<1% packet error rate)	-92 dBm	-85 dBm
Tranmission Range	Indoors: up to 30; Outdoor: up to 100m	
Latency	15ms	
Channels	1 channel / 10 channels	16 channels
Channel numbering	1 to 11	12 to 27
Channel access	CSMA-CA and slotted CSMA-CA	
Modulation scheme	BPSK	O-QPSK

868MHz/ 915MHz PHY



2.4 GHz PHY



Channels

These three ISM frequency bands are only the 2.4 GHz band that operates worldwide by adding 4k to 2404MHz with k = 0-25 to assign to different countries. The 868MHz band only operates in Europe and the 915 MHz band is only for North and South America.

Transmission Media (transmit power, receive thresholds, antennas, distance)

The transmit power of ZigBee are -25dBm, -15dBm, -10 dBm, -7dBm, -5dBm, -3dBm, -1dBm and 0 that depends on the types of use by the users but in fact it's usually 0dBm and the receiver sensitivity is -85dBm for the 2.4GHz frequency band and -92 dBm for the 868/915MHz frequency band. The distance that can be transmitted in ZigBee product is usually about 10-75 meters and over 100 meters for the maximum transmission range. Antennas are in shape of chips.

Signal Encoding Techniques (analog/digital data/ signals)

The signal encoding techniques in ZigBee technology are used Binary Phase Shift Keying (BPSK) for the 868/915MHz frequency band and Offset Quadrature Phase Shift Keying (O-QPSK) for the 2.4 GHz frequency band.

Errors (error detection, error correction, ARQ)

For the error when transmission the data of the ZigBee. It uses the ACK frame to confirm between the receiver and the transmitter than the data has been transmitted. In fact there is no error when transmit the data but if the receiver isn't sent the ACK frame back to the transmitter. The transmitter will send all of the data against to the receiver. There is no error that can be occurs between the transmitter and the receiver.

Application

Focus on the application of ZigBee, It's have many products with these technology like a Home Entertainment System(Home Theatre TV) in HID devices, the remote control in video conference equipment and another remote control for audio and video equipment and also in home appliances, sport clubs, mansions like a multi-player PC & video games, glass breakage monitoring (sensors), wireless keypads, smoke and flame detectors, lighting and remote control, fireplaces, pool/spa equipment, garage door openers.

Usage

The usage of the ZigBee product in Thailand is widely use in Thailand because in your everyday life such as in home appliances like a refrigerator and it's the most popular in Europe and North America which are The United States of America and Canada.

Cost

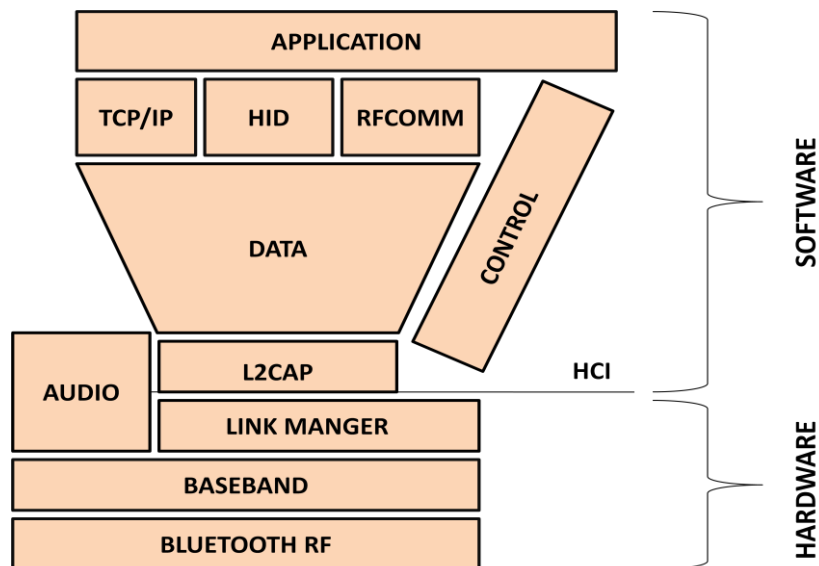
The cost of the ZigBee product is starts with \$1.5 – \$2.5. And another products is around \$5-\$10.

Bluetooth

Bluetooth is the wireless communication technology that utilizes wireless communications or radio wave communications. It is used for communications between small electronic or electrical devices such as mobile phones, Personal Digital Assistant (PDA), Pocket Personal Computer (Pocket PC), digital music player, and other small electronic devices. The devices that are in a personal area network (PAN), which radius of coverage area should be around 10 – 100 meters, and its can form a network and communication with each other.

Protocol Architectures (layered stack, protocols, standard, standard organizations)

Layered stack



Protocol

In the Bluetooth technology, its can categorized into many protocols which are

LMP (Link Management Protocol) is used for the link set-up, security and control. And also used for Authentication, pairing, encryption, exchanging clock/slot offset information, switching of master/slave roles and changing power modes. All of LMP messages are single slot packets.

L2CAP (Logical Link Control & Adaptation Protocol) defined for only ACL links. And provides protocol multiplexing segmentation & reassembly, QoS control with connection-oriented and connection-less service. Its use for transfers the data between higher layer protocols and lower layer protocols by signaling with peer L2CAP implementation.

Service Discovery Protocol (SDP) provides an attribute based searching of services, browsing through available services, discovering new services and also removal of unavailable services.

HCI (Host/Controller Interface) is used to communicate between the host stack and the controller

BNEP (Bluetooth Network Encapsulation Protocol) is used for transfers an another protocol stack data by an L2CAP channel with the responsibility to transmission of IP packets.

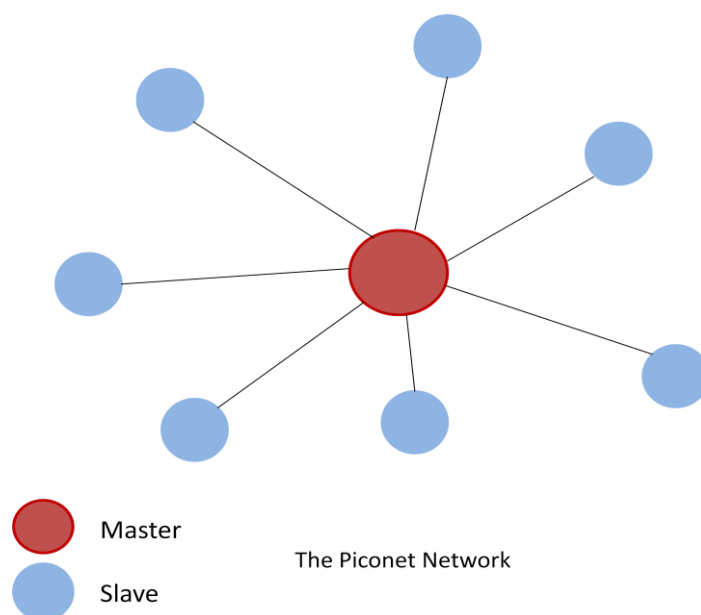
Telephony control protocol is defines the call control signaling for the establishment of voice and data calls between Bluetooth device

Adopted protocols

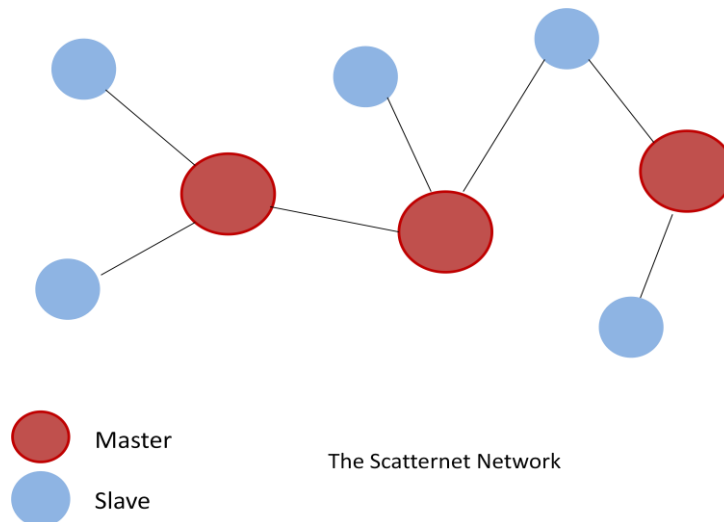
- Point-to-Point Protocol (PPP)
- Object Exchange Protocol (OBEX)

The Bluetooth network has 2 structures which are the Piconet and Scatternet network.

The “Piconet” network needs to has a Bluetooth devices that act as an the parent of the network or master that has a responsibility to connecting to the other devices in the network that are the child or slave by the rules that the master can connect to the slave not greater than 7 slaves.



The “Scatternet” network is the network that is piconet network with the increasing in numbers of the master and slaves that make a bigger network by the Bluetooth devices that act as the master on one piconet network can also maybe a slave in another piconet network.



Standard

Bluetooth has built with based on IEEE 802.15.1 standard and there has many update on the IEEE 802.15.1 standard such as IEEE 802.15.1-2005 in Bluetooth v1.2

This Bluetooth technology was formalized by the Bluetooth Special Interest Group (SIG) that has a membership over 13000 companies.

Data Transmission (spectrum, frequency, bandwidth, data rates)

Spectrum

Bluetooth uses a radio technology to communicate that is called “Frequency-hopping spread spectrum (FHSS)” that switching a carrier with many frequency channels by using a pseudo random hopping sequence to the transmitter and the receiver.

Frequency

The Bluetooth globally operates on the 2.4 GHz unlicensed ISM band and the radio spectrum spreading by frequency hopping in 79 hops frequencies from $f = 2402+k$ MHz with $k = 0 - 78$ MHz in the range of 2402 – 2480 MHz by hopping sequence determined by the address of the piconet master. The master starts transmissions in even slot while slaves start in odd slots with the packet transmission that can extend to 5 slots with a single hop frequency for each transmission.

Data Rate

The data rates of Bluetooth technology are

1Mbits/s for version 1.2

Up to 3Mbits/s supported for version 2.0 + EDR

Up to 24Mbits/s supported for the version 3.0 + HS

Transmission Media (transmit power, receive thresholds, antennas, distance)

In the Bluetooth technology, we can categorize to the 3 main classes which are Class 1, Class 2 and Class 3

Class 1 is refers to the next generation of the Bluetooth technology that used primarily in many industrials covered with the range to communicate up to 100meters and It has the transmit power for 20dBm (100mW).

Class 2 is refers to the current generation of the Bluetooth technology that used most commonly in the real world like a mobile phones devices covered with the range to communicate up to 10meters and It has the transmit power for 4dBm (2.5mW).

Class 3 has the transmit power for 0dBm (1mW) and covered with the range to communicate up to 1 meters.

Signal Encoding Techniques (analog/digital data/ signals)

Pulse Code Modulation (PCM) is a method that used to represent sampled analog signals.

Errors (error detection, error correction, ARQ)

The Bluetooth technology used 3 ways to detect and correct the error that can happen by

1. 1/3 rate Forward error correction
2. 2/3 rate Forward error correction
3. ARQ – Automatic Repeat request

Note: FEC = Forward Error Correction

The Bluetooth technology use the FEC and ARQ to fix the errors that can be occurs in progressing from the transmitter to the receiver. For the forward error correction the transmitter encrypt the data with the error-correcting code and send the data message that has been encrypted to the receiver. The receiver has to decrypt the data message and compare to the data table and get the real data that the transmitter actually sent to. For the automatic repeat request the transmitter send the data and the check code for the receiver

to check on the failure in data transmission if the receiver not even found any kinds of failure in the data it will send the ACK (acknowledgment) signal back to the transmitter to confirm that the data is already transmit to. But in case of the transmitter is not receive the ACK signal it will try to send the same data back against to the receiver.

Application

Focus on the application of Bluetooth, There have many products with these Bluetooth technologies like a mobiles phone that can send the data by using Bluetooth. And also to equipments in the mobile phones that can make the user easier to use the mobile phones such as a hand free.

Usage

In Thailand, Bluetooth technology is widely used in many places. In the view of mobile phones people can share the data to each other by using Bluetooth. And same as the laptop, it has the Bluetooth devices in it also, that can sharing to other through Bluetooth technology.

Cost

They started price of the Bluetooth chips are under \$3. And another products that used the Bluetooth devices is about around \$10-\$20.

Compare between the ZigBee and the Bluetooth technology

To compare the ZigBee technology to the Bluetooth technology, that was served very different applications to the Bluetooth, Here are some key protocols of both technologies.

ZigBee

- Long battery life, Very low duty cycle
- Static and dynamic star and mesh networks with greater than 65,000 nodes with static low latency.
- Direct Sequence Spread Spectrum allows devices to sleep without the requirement for close synchronization.

Bluetooth

- Moderate duty cycle, secondary battery lasts same as master,
- Very high QoS and very low, guaranteed latency,
- Quasi-static star network up to seven clients with ability to participate in more than one network,
- Frequency Hopping Spread Spectrum is extremely difficult to create extended networks without large synchronization cost.

Wireless LAN

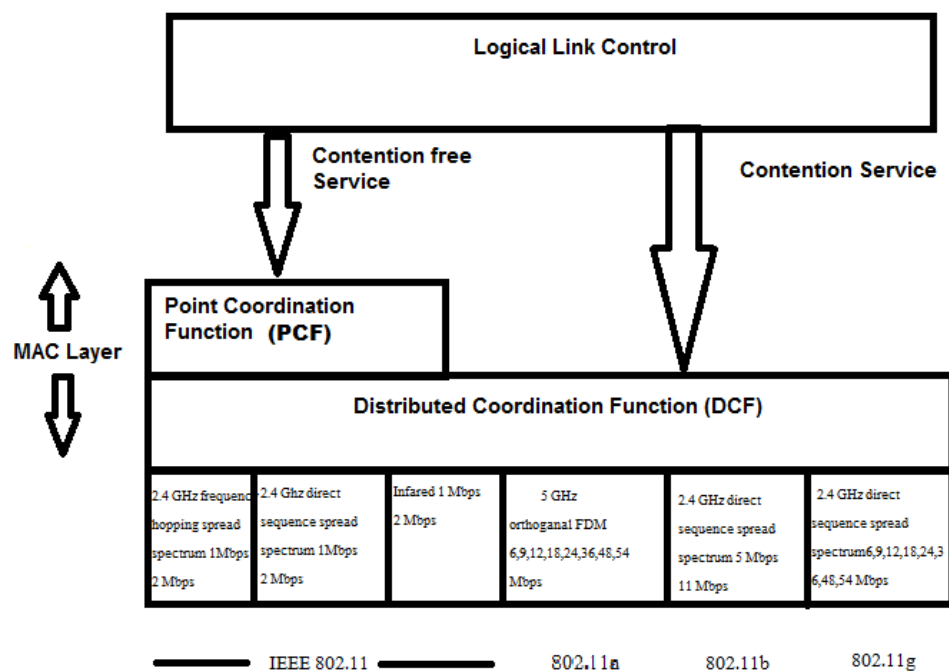


Wireless LAN or wireless local area network (WLAN) that doesn't use wired connection. Use WLAN is more flexibility. And allow user to move while keeping computer connected

Protocol Architectures (layered stacks, Protocols, Standard, Standard Organization)

The network that connect into wireless called station and all station connect with wireless network set interface cards(WNICs). And wireless station is divided into two part : Access Point(AP) and Clients.

And the set of all station that communicate with other is called Basic Service Set (BSS).And BSS is separate into two type independent BSS (IBSS) and infrastructure BSS. All BSS has ID called BSSID. And Mac address of AP serves the BSS. Ad-hoc network have no AP is an IBSS. So it can't connect with another BSS. An infrastructure can connect with other station it connect by AP. Extended Service Area (ESA) is multiple BSAs connected with AP. Extended Service Set(ESS) is set of stations in ESA.



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Data Transmission (Spectrum, Frequency, Bandwidth, Data rate)

WLAN Bandwidth

Standard	spectrum	maximum data rate	Layer 3 data rate	compatible with
802.11	2.4 GHz	2 Mbps	1.2 Mbps	NONE
802.11a	5.0 GHz	54 Mbps	32 Mbps	NONE
802.11b	2.4 GHz	11 Mbps	6-7 Mbps	802.11
802.11g	2.4 GHz	54 Mbps	32 Mbps	802.11/ 802.11b due to narrow spectrum

The IEEE(Institute of Electrical and Electronic Engineers) released the 802.11. And then additional standard 802.11a, 802.11b, 802.11g, 802.11n

- 802.11a the data transfer rate up to 54 Mbps it is faster than 802.11b and use 5 GHz frequency . And the shortest range of these three standard. And bandwidth is 20 MHz. approximate indoor range is 35m and outdoor is 120 m

- 802.11b the data transfer rate up to 11 Mbps and use 2.4 GHz frequency It's better than 802.11a at penetrating physical barriers but doesn't support many connection. And bandwidth is 20 MHz. Approximate indoor range is 38m and outdoor is 140 m.

- 802.11g the data transfer rate up to 54 Mbps and use 2.4 GHz frequency. It has a little bit shorter range than 802.11b. And bandwidth is 20 MHz. Approximate indoor range is 38m and outdoor is 140m.

- 802.11n the data transfer rate over 100 Mbps and use 2.4/5 GHz frequency. And bandwidth is 20/40 MHz. Approximate indoor range is 70m and outdoor is 250m

Transmission Media (Transmit Power, receive thresholds, antennas, distance)

There are 2 types of antennas that use for 802.11 first is directional second is omni directional. Directional antenna sums energy in a narrow conic path while send and reject signal. An omni directional antenna transmits in a 360 arc mean all direction. And first has router contain with antenna. And the receiver likes a pc mobile or laptop

Signal Encoding Techniques (analog, digital data, signals)

The wireless transmissions have Decoding Moderator for transform analog signal and digital signal. When you send the data it transform analog signal to digital signal. So at the receiver station decoder will transform digital signal to analog signal.

Application

Now wireless LAN technology is very popular in many countries. Wireless LAN application is used in many public area around people such as small size (internet cafe) or large size (airport) or in education that help the student to access the data easier faster. And sometime it used in business for connecting or meeting or e-commerce



Usage

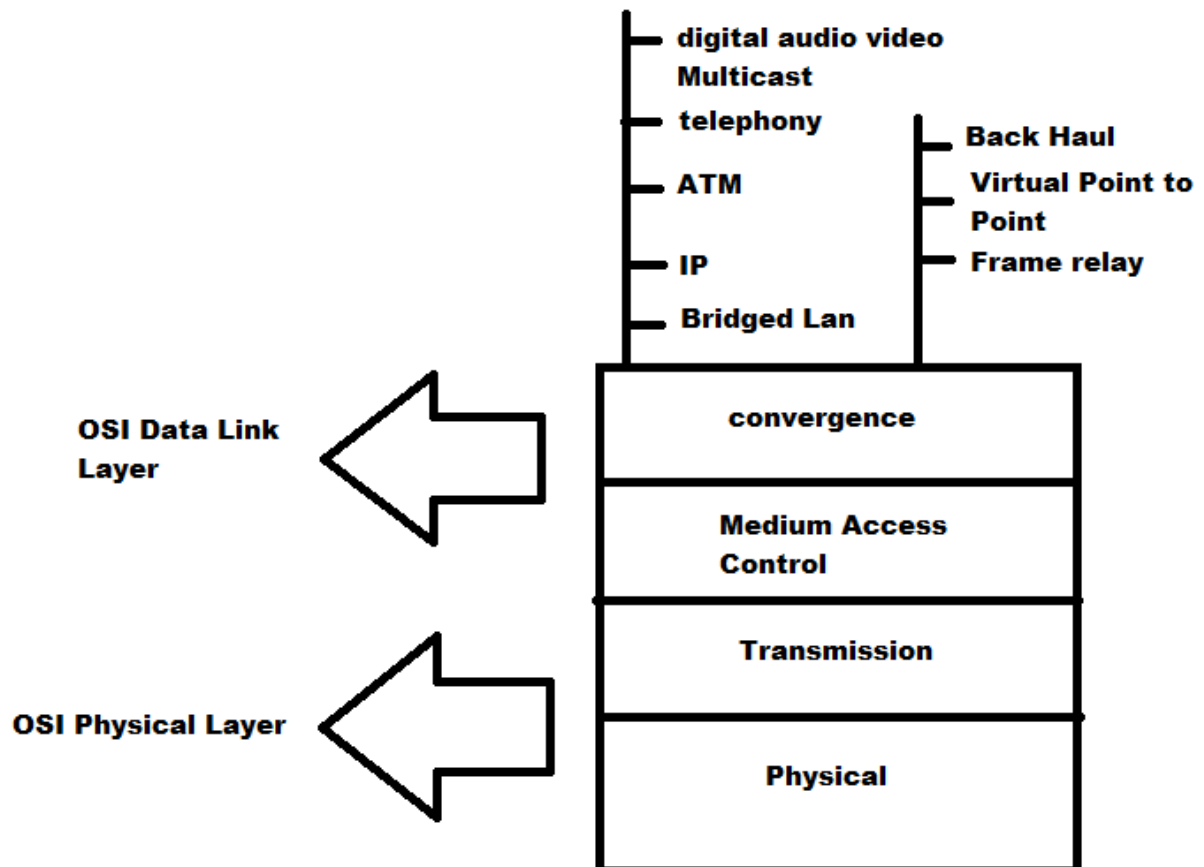
In our country wireless LAN is very popular it can apply in many place such as in hospital. Imagine you are in hospital and the hospital use WLAN for guest or such as patient monitor lifeline and life care application.

WiMAX(Worldwide Interoperability for Microwave Access)



WiMAX is the currently one of the hottest technology of wireless technology. It is high speed mobile internet access used notebook, PCs, smart phones.

Protocol Architectures (layered stacks, Protocols, Standard, Standard Organization)



IEEE 802.16 Protocol Architecture includes 4 layers

-Convergence -MAC -Transmission -Physical

And can be separate to 2 OSI Layer: Physical, Data Link

For standard of WiMax has developed in 3 models

WiMax IEEE 802.16

Standard that provide the distance just 1.6 - 4.8 km and Light of sigh(LOS)transmission and point to point delivery. Air interface on 10-66 GHz licensed bands

WiMax IEEE 802.16a

Operation on 2-11 GHz licensed/non-licensed bands Non-Light-of-sigh(NLOS)transmission and point to multipoint delivery. And provide the distance 48-50 km

WiMax IEEE 802.16e

Operation on 2-6 GHz licensed bands and also support mobility. And provide the distance 1.6-4.8 km

Data Transmission (Spectrum, Frequency, Bandwidth, Data rate)

	802.16	802.16a	802.16e
spectrum	10-66 GHz	2-11 GHz	< 6 GHz
configuration	Line of Sight	Non Line of sight	Non Line of sight
Bit rate	32-134 Mbps (28 MHz Channel)	<70 or 100 Mbps (20 MHz Channel)	up to 15 Mbps
Modulation	QPSK,16-QAM, 64-QAM	256 Sub-carrier OFDM using QPSK,16-QAM, 64 QAM,256-QAM	same as 802.16a
Mobility	Fixed	Fixed	<75 MPH
Channel Bandwith	20,25,28 MHz	selectable 1.25-20 MHz	5 MHz(Planned)
Typical cell Radius	1-3 Miles	3-5 Miles	1-3 Miles
Complete	Dec,2001	Jan,2003	2nd Half of 2005

Transmission Media (Transmit Power, Receive thresholds, Antennas, Distance)

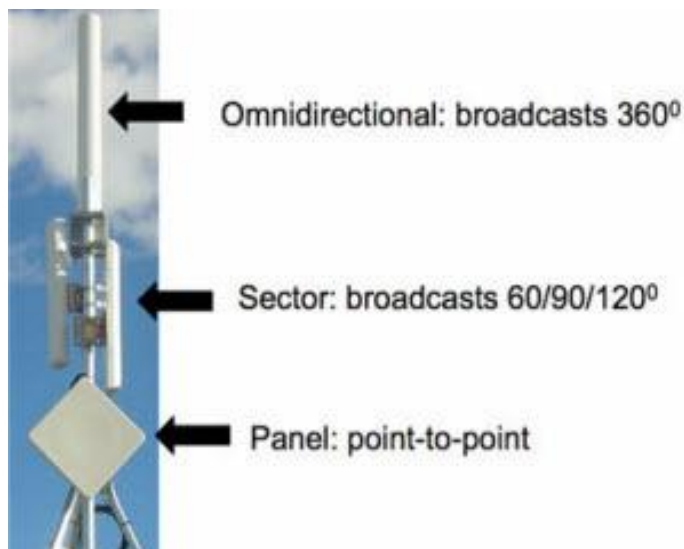
WiMax base stations transmit at power levels of approximately +43dBm (20W). And A WiMAX mobile station (MS) typically transmits at +23 dBm (200mW).

And three main types of antennas used in WiMax: Omni directional, sector and panel antenna

Omni directional antennas are used point-to-multipoint. And transmit in a 360 arc. Omni directional antennas good for locate in closely to base station

Sector antenna is greater range and throughput with less energy. By focus more area.

Panel antenna often used for point-to-point applications. And WiMax is communication over maximum distance 30 miles.



Error (Error Detection, Error Correction, ARQ)

WiMax have error detection techniques to reduce signal noise ratio (SNR).And interleaving algorithms are used to identify or correct error to increase throughput. The strong error correction techniques help to recovery frames lost cause have missing to frequency selective fading. And remove the errors Automatic Repeat Request (ARQ) is used for error that can't be corrected by FEC So Send data again.

Application

WiMax is the most effective today. Provides the service for example video, voice, mobile and internet access. There are various profits of Wimax technology such as cost saving, high speed data transfer. Use in broadband internet.

Usage

Nowadays WiMax is new technology that be eye-catching in Thailand. Because WiMax is high efficiency. And most widely for access broadband. And reduce the space for learning or education for long distance service that people who far from the technology. I believe when WiMax in Thailand is completed. This technology will popular in Thailand. But in other country such as USA or Japan the WiMax technology is widely used and very popular.



WLAN VS WiMax

Wireless local area network or WLAN is provides users move from one location to another without thinking about wire. It grow up in popularity of increasing of notebook or laptop. WiMax is provide the high speed internet access to area that the WLAN can't reach

WiMax is a new technology that is still not very popular but it is gaining widespread attention. WLAN is for short range application while WiMax is for long range applications. Compared to WLAN WiMax provides a better method of bandwidth distribution compared to WLAN.

Conclusion

The demand for data service make WiMax is a better choice because it's increasing in terms of usage from around the world. WiMax technology provides more flexibility and scalability. So I think WiMax is the future of broadband wireless.

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