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ITS 323

Assignment I

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Table of participation

section	Studen1	Studen2	Studen3
Zigbee	34%	33%	33%
Bluetooth	33%	34%	33%
Wireless Lan	33%	34%	33%
WiMax	34%	33%	33%
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Table A: Table of participation

ZigBee

Introduction

ZigBee is a wireless personal area network (WPAN) technology which under standard IEEE 802.15.4. ZigBee are used with small devices. So ZigBee consumes low energy or may use energy from solar energy. ZigBee are used for many applications.

Standard

Frequency	Data rate	Number of channel	Bandwidth	Range	Power Consumption
870 MHz	20 Kbps	1	-		**0 dBm (1 mW)**
900 MHz	40 Kbps	10	2 MHz	10 – 74 meters	(Very low)
2400 MHz	250 Kbps	16	5 MHz		Depend on Environment

Table 1Table 1.1 Standard of Zigbee

Layered stacks
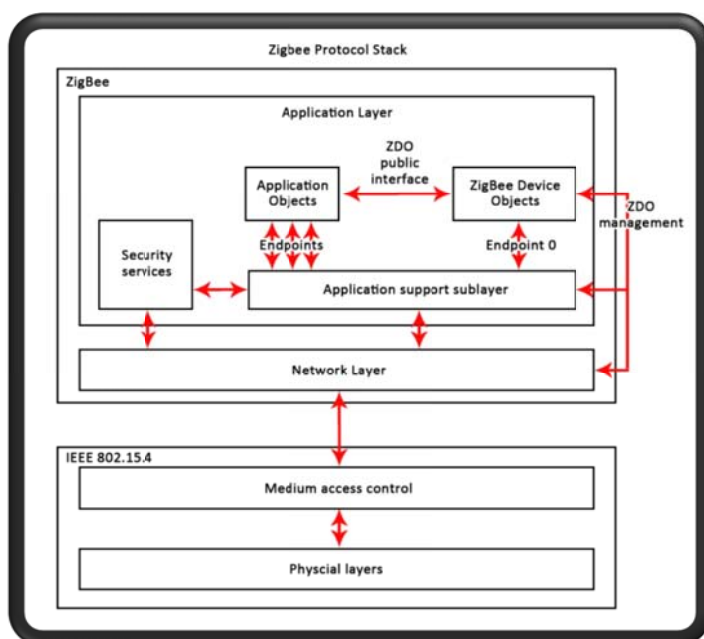
The Application Layer provides functions of the sensor node that defined by the manufacturer in order to achieve the goals it were designed. The Application consists of the Application Support Sub layer and ZigBee Device Object sub layer.

Figure 1.1: Zigbee Application Layer

The main role of Application Support sub layer is to maintain data to match with devices, to send data between connected devices, to map address 64 bit IEEE address form to 16 bit Network Layer address form The main role of ZDO is to define and to discover the devices on the network and determine which application services

The network layer provides functions to correct the operation of IEEE 802.15.4 MAC Sub layer and to provide a suitable service interact for application layer. And also define frame formats, correct data during transmission between network nodes

The MAC layer gives channel access to nodes

The physical layer active or deactivate transceivers to transmit and receive data.

Signal Encoding Techniques

Technique	802.15.4
Binary Phase-Shift Keying (BPSK)	√
Offset Quadrature Phase-Shift Keying (OQPSK)	√
8 Phase Differential Phase-Shift Keying (8DPSK)	-
Differential Quadrature Phase-Shift Keying (DQPSK)	-
Pi/4 Rotated Differential Quadrature Phase-Shift Keying (Pi/4-DQPSK)	-
Gaussian Frequency-Shift Keying (GFSK)	-
Amplitude-Shift Keying (ASK)	√
Direct-Sequence Spread Spectrum (DSSS)	√
Parallel-Sequence Spread Spectrum (PSSS)	√
Adaptive Frequency-Hopping Spread Spectrum (AFH)	-

Table 1.2: Zigbee Modulation and coding techniques

Technique	802.15.4
Phase-Shift Keying (PSK)	√
Frequency-Shift Keying (FSK)	-
Amplitude-Shift Keying (ASK)	√
Spread Spectrum (SS)	√

Table 1.3: Simplified table of modulation and coding techniques
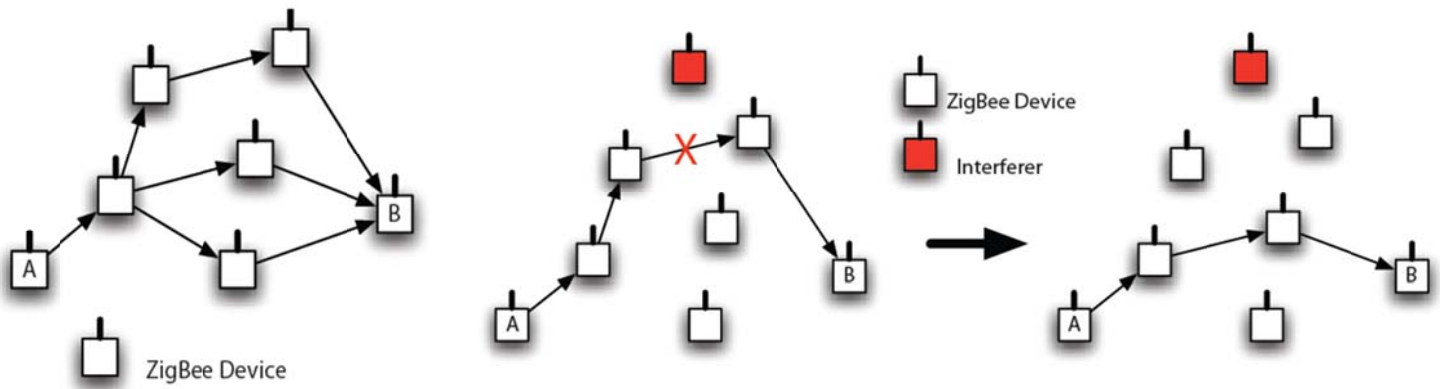
Figure 3.2: Zigbee mesh network

<u>Error</u>

For ZigBee let's consider the formation are connected in Cluster-Tree Network Mode. For the case of link failure, the child node can't send or receive data frames from parent node. So the child node will decide that parent node is dead. To recover the failure node, that node has to use appropriate recovery mechanism.

<u>Application</u>

ZigBee can use for

- Building automation
- Consumer electronics
- PC and peripherals
- Residential
- Commercial control
- Industrial control
- Personal health care

Cost and Used

For Zigbee cost is cheapest compare with other. But zigbee is hard to find device to support. Example Laptop, Mobile phone also not support Zigbee if you want to use Zigbee with you Laptop you have to buy a module for Zigbee. Zigbee is normally use in some device that design for Zigbee only like some traffic light control, some device in hospital.

Zigbee can use in almost country include Thailand.
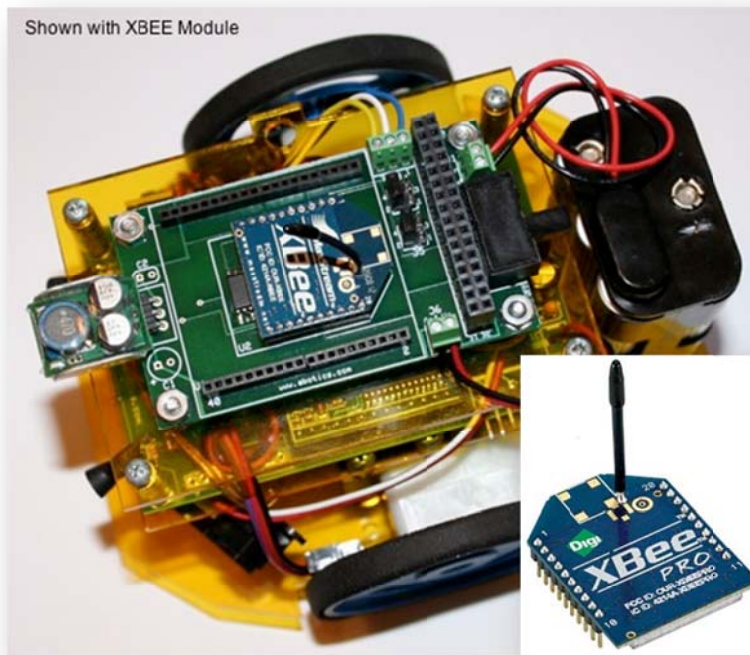
Figure 1.3: Zigbee in robot

Bluetooth

Introduction

Bluetooth is wireless technology which uses short range radio links to connect between two equipment at least 10 meters. Power consume 1mW-100mW (Depend on length)

Standard

Standards of Bluetooth which is IEEE 802.15.1 there are many versions of Bluetooth each of them has different specifications and features

Class	Maximum Power	Range (Approximate)
Class 1	100 mW / 20 dBm	100 metre
Class 2	2.5 mW / 4 dBm	10 metre
Class 3	1 mW / 0 dBm	1 metre

Table 4.1: Class of Bluetooth

Version	Frequency	Data rate
Bluetooth 1.0	2.4 GHz	1 Mbps
Bluetooth 1.1	2.4 GHz	1 Mbps
Bluetooth 1.2	2.4 GHz	1 Mbps
Bluetooth 2.0 + EDR	2.4 GHz	3 Mbps
Bluetooth 2.1 + EDR	2.4 GHz	3 Mbps

Table 2.2: Version of Bluetooth

Protocol Stack
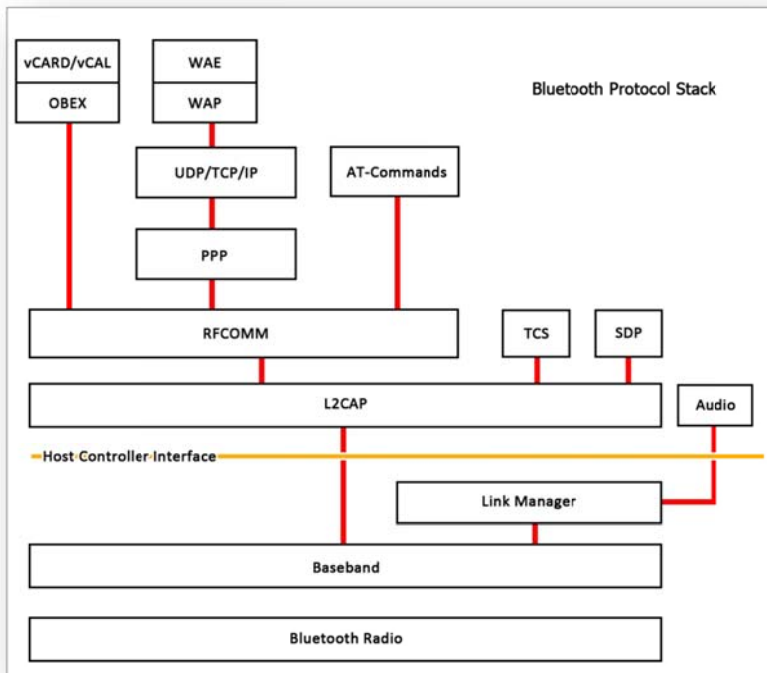
Figure 2.1: Bluetooth Protocol Stack

Object Exchange Protocol (OBEX) provides a model for representing objects and operations.

RFCOMM is a visual protocol which makes applications detect Bluetooth as common serial port for Service Discovery Protocol (SDP) is a protocol which find Bluetooth equipment in nearly area. Telephony Control Specification (TCS) controls signaling to create a speech and data calls between BD.

Logical Link Control and Adaptation Protocol (L2CAP) makes data from above that may has many applications work in the same time into packages.

Host Control Interface (HCI) is protocols that connect with applications and make them know Bluetooth commands.

Link manager translates received commands and send to bottom layers.

Link controller controls all of Bluetooth connections.

Baseband main purpose of this one is to control circuit to transmit and receive Bluetooth radio by choose the same frequency channel between the source and destination.

Bluetooth Radio transmits and receives radio wave which is controlled by Baseband. Transmission Media Transmission media of Bluetooth is considered in the same OSI layer.

Signal Encoding Techniques

Technique	802.15.1
Binary Phase-Shift Keying (BPSK)	-
Offset Quadrature Phase-Shift Keying (OQPSK)	-
8 Phase Differential Phase-Shift Keying (8DPSK)	√
Differential Quadrature Phase-Shift Keying (DQPSK)	√
Pi/4 Rotated Differential Quadrature Phase-Shift Keying (Pi/4-DQPSK)	√
Gaussian Frequency-Shift Keying (GFSK)	√
Amplitude-Shift Keying (ASK)	-
Direct-Sequence Spread Spectrum (DSSS)	-
Parallel-Sequence Spread Spectrum (PSSS)	-
Adaptive Frequency-Hopping Spread Spectrum (AFH)	√

Table 2.3: Modulation and coding techniques

Technique	802.15.1
Phase-Shift Keying (PSK)	√
Frequency-Shift Keying (FSK)	√
Amplitude-Shift Keying (ASK)	-
Spread Spectrum (SS)	√

Table 2.4: Simplified table of modulation and coding techniques

Error

Bluetooth uses threes error corrections

• **1/3 rate Forward Error Correction (FEC)**

Use with high quality voice packets by send 3 copies of each bit. Each received triple bits is mapped with the bit of data.

• **2/3 rate Forward Error Correction (FEC)**

Use with data or voice packets by use Hamming code to correct all of errors.

• **Automatic Repeat Request (ARQ)**

Use with data or voice packets by use cyclic redundancy check (CRC) to detect errors in packages.

If there is error the destination will send negative acknowledgement (NACK) to tell the source has to retransmit the package which is error.

Application

Bluetooth usually uses with equipment that want to link in short range (about 10 Meters) like mobile phone, head set, Personal Digital Assistant (PDA),Home theater etc.

Cost and Used

For Bluetooth, cost is cheaper than Wireless Lan and WiMax but higher than Zigbee a little bit but Bluetooth is normally in market and almost device have built-in module support Bluetooth like mobile phone,Laptop,etc.

Bluetooth can use almost country include Thailand and easy to find device that support Bluetooth in market at very cheap price.

Figure 2.2: Bluetooth Devices

Introduction

Wireless LAN is a communication system which is connected via radio frequency. There are two connection types of wireless LAN which are computer to computer and access point to computer

Standard

Standards of wireless LAN which is using there are IEEE 802.11a, IEEE 802.11b, and IEEE 802.11g each of standards has different data rate and frequency.

	Data Rate	Range	Frequency	Bandwidth	Hot-spot Access	Power useage	Interference Risk	Cost
802.11a	54 Mbps	100 Feet	5 GHz	20 MHz	Poor	High	Low	High
802.11b	11 Mbps	150 Feet	2.4 GHz	20 MHz	Excellent	Moderate	High	Low
802.11g	54 Mbps	150 Feet	2.4 GHz	20 MHz	Excellent	Moderate	High	Moderate

Table 3.1: Wireless Lan Standard in Thailand

IEEE 802.11a has maximum data rate 54 Mbps at frequency 5 GHz. This standard can change data rate for change transmit range (Example 54, 48, 36, 24, and 11 Mbps). The advantage is IEEE 802.11a has low noise because most equipment is working at frequency 2.4 GHz. So there is low chance to get noise from another which is working at the same frequency.

IEEE 802.11b has maximum data rate 11 Mbps at frequency 2.4 GHz, and also has encrypted data in WEP 128 bits. This standard prefer to use in many countries they are usually use in public place, school, industrial, and household

IEEE 802.11g has maximum data rate 54 Mbps at frequency 2.4 GHz. This standard can change data rate according where are they using? In the future IEEE 802.11g will replace IEEE 802.11b**.**

Transmit media

Wireless LANs do not require any cables for data transmission. Radio waves and Infrared signals are used to send communication signals through air or space. Wireless LAN uses radio frequency between 1 GHz to 10 GHz.

Wireless LAN has many types of antennas each of them has different specification following table below

Type	Frequency Range	Gain	Voltage Standing Wave Ratio (50 Ohm)	Polarization
Panel	2.4-2.5 GHz	10-18 dBi		
	4.9-5.8 GHz	12-26 dBi		
Sector	2.4-2.5 GHz	10-18 dBi		
Parabolic	2.4-2.5 GHz	18-24 dBi		
	4.9-5.8 GHz	20-34 dBi		
Omni-directional	2.4-2.5 GHz	6-15 dBi	≤ 1.5	Vertical
	4.9-5.8 GHz	8-12 dBi		
Wall mount	2.4-2.5 GHz	8 dBi		
	4.9-5.8 GHz	10 dBi		
Ceiling mount	2.4-2.5 GHz	2-3 dBi		
Yagi	2.4-2.5 GHz	7-15 dBi		

Table 3.2 Type of Wireless Athena
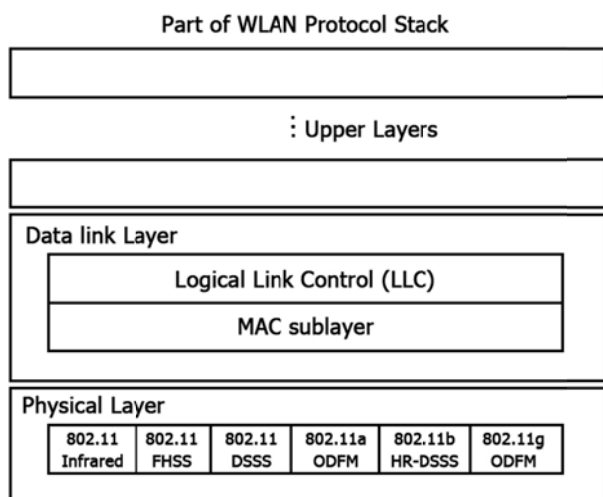
Protocol Architecture

Figure 3.1: Protocol Architecture

This figure show a part of the 802.11 protocol stack. upper layers are the complex layer (Example application layer, presentation layer, session layer, transport layer etc.)

The data link layer is split into two sub layers or more.

The Logical Link Control sub layer (LLC sub layer) has to hide the different and make 802 standards be in harmony with the network layer.

The Medium Access Control sub layer (MAC sub layer) allocates the channel. The physical layer corresponds to the OSI physical layer.

Signal Encoding Techniques

Technique	802.11a	802.11b	802.11g
Binary Phase-Shift Keying (BPSK)	√	-	-
Quadrature Phase-Shift Keying (QPSK)	√	-	-
Differential Binary Phase-Shift Keying (DBPSK)	-	√	√
Differential Quadrature Phase-Shift Keying (DQPSK)	-	√	√
16 Quadrature Amplitude Modulation (16-QAM)	√	-	√
64 Quadrature Amplitude Modulation (64-QAM)	√	-	√
Complementary Code Keying (CCK)	-	√	-
Orthogonal Frequency-Division Multiplexing (OFDM)	√	-	√
Direct-Sequence Spread Spectrum (DSSS)	-	√	-

Table 3.3: Modulation and coding techniques

Technique	802.11a	802.11b	802.11g
Phase-Shift Keying (PSK)	√	√	√
Quadrature Amplitude Modulation (QAM)	√	-	√
Complementary Code Keying (CCK)	-	√	-
Orthogonal Frequency-Division Multiplexing (OFDM)	√	-	√
Spread Spectrum (SS)	-	√	-

Table 3.4: Simplified table of modulation and coding techniques

Error

At the physical layer of Wireless LAN it prepares data frames before transmit to target by using forward error correction technique to detect and correct the error data frame after receive data frames.

Application

In Thailand has allowed everybody to use wireless LAN at frequency 2.4 GHz that mean in Thailand has used the access point for standard 802.11b and 802.11g only.now in Thailand we use Wireless Lan in organizer like school or university network system and some public WIFI hotspot.

Cost and Used

For Wireless Lan cost is higher than Zigbee and Bluetooth but if compare with WiMax interm of client Wiless Lan is few different WiMax but if look at provider cost WiMax is cheaper than Wirless LAn because a Station of WiMax can provide many service for client and greater rang than Wiless Lan. But currently WiMax station equipment is high cost than Wiless Lan and use in Some country. Now a day, it easy to find device that support both WiMax and Wiless Lan in market.

Wireless Lan are normally use in almost country include Thailand but for Thailand we use 2.4 GHz only by the communication rules.

Figure 3.2: Wireless Lan access point

Figure 3.3: Wireless Lan receiver card

Introduction

Worldwide Interoperability for Microwave Access (WiMAX) is hi-speed wireless technology that has standard on IEEE 802.16

Standard

WiMAX technology has three standards which are IEEE 802.16. The standard 802.16 has many versions and each of versions has different specification.

| Version	Spectrum	Channel Condition	Maximum data rate	Bandwidth	Range
802.16	10 – 66 GHz	Line of sight only	134 Mbps	28 MHz	1.6 – 4.8 Km
802.16d	Less than 11 GHz	None line of sight	75 Mbps	20 MHz	1.6 – 4.8 Km
802.16e	Less than 6 GHz	None line of sight	15 Mbps	5 MHz	1.6 – 4.8 Km

Table 4.1: Version of WiMax

Protocol stack

This figure show a part of the 802.16 protocol stack. upper layers are the complex layer (Example application layer, presentation layer, session layer, transport layer etc.)

The data link layer contain MAC sub layers which are

The service specific Convergence Sub layer (CS) sets protocol to make it harmony with upper layers and lower layers.
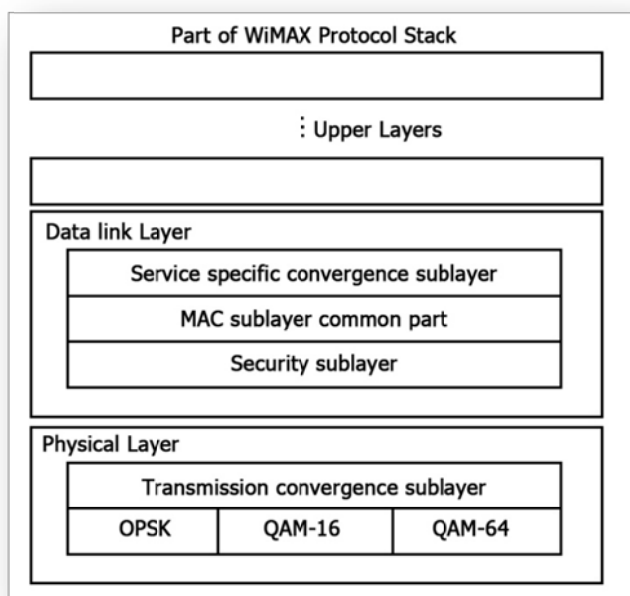
Figure 4.1: Protocol stack of WiMax

The Common Part Sub layer control all of WiMAX features.

The Security Sub layer encrypt data before transmit to the receiver.

The Transmission Convergence Sub layer encodes data to analog signal by use Signal Encoding Techniques (Example OPSK, 16-QAM, 64-QAM)

Transmission Media

WiMAX has many types of antennas each of them has different specification following table below

Type	Frequency Range	Gain	Voltage Standing Wave Ratio (50 Ohm)	Polarization
Panel	2.3-2.7 GHz	14-18 dBi		
	3.3-3.8 GHz	15-21 dBi		
Sector	2.3-2.7 GHz	10-18 dBi		
	3.3-3.8 GHz	10-18 dBi		
Parabolic	2.3-2.7 GHz	18-29 dBi	$\leq$1.5	Vertical
	3.3-3.8 GHz	18-30 dBi		
Omni-directional	2.3-2.7 GHz	6-15 dBi		
	3.3-3.8 GHz	5-12 dBi		
Wall mount	2.3-2.7 GHz	8 dBi		
Ceiling mount	2.3-2.7 GHz	2-3 dBi		

Table 4.2: Type of WiMax Athena

Signal Encoding Techniques

Technique	802.16	802.16d	802.16e
Quadrature Phase-Shift Keying (QPSK)	√	√	-
16 Quadrature Amplitude Modulation (16-QAM)	√	√	-
64 Quadrature Amplitude Modulation (64-QAM)	√	√	-
Orthogonal Frequency-Division Multiplexing (OFDM)	-	√	-
Orthogonal Frequency-Division Multiple Access (OFDMA)	-	-	√

Table 4.3: Signal Encoding Techniques of WiMax

Error Correction

The error correction technique that WiMAX uses are Automatic Repeat re-Quest (ARQ) and Hybrid Automatic Repeat re-Quest (HARQ)

For the ARQ error correction at the data link layer operates on accumulation or selection of basis, or combination of the above layers. The receiver checks the block of data in the link layer data and report the result back to the sender by using a standalone or encapsulated acknowledgment.

For the HARQ, the mechanism in the PHY-MAC cross layer is a combination of Forward Error Correction (FEC) with retransmission techniques. According to a multi-channel stop-and-wait approach where the sender must wait for the receiver done the operate at the physical layer.

Application

WiMax use in network that require very wide range and need high data transfer rate. Like Mobile phone VoIP, internet service in some country.

Cost and Used

For WiMax client side is a few different from Wireless Lan but for provider cost of WiMax station equipment is higher than other but Now a day, WiMax are not currently use.

Wimax is used in some country only like in EU, now Thailand unable to use WiMax by communication rules about frequency the WiMax work.

Figure 4.2: Type of WiMax Athena

Figure 4.3: WiMax Equipment

CONCLUSION

In concludtion zigbee, Bluetooth, Wireless Lan, WiMax there are different technic but all of them concept are transmit data wirelessly (Noncable). There are designs for using in different purpose. Then they have different data rate, size of equipment, range, Cost and power consume. But in Thailand we are familiar with Bluetooth, Wireless Lan than Zigbee and WiMax, because Zigbee is design to use in specific purpose and WiMax is not exit in Thailand.
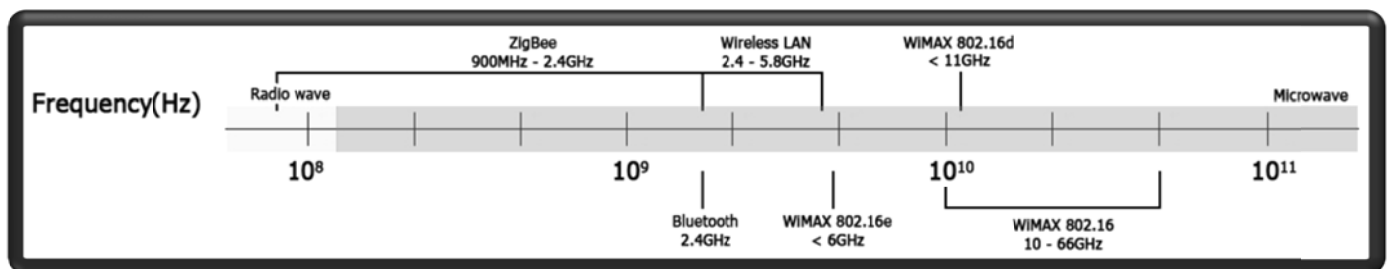

Figure 5.1: Spectrum of Signal

Wireless Technology	Data rate	Range	Cost
Bluetooth(Class1)	1–3 Mbps	100 m	> ZigBee
Wireless LAN(G)	11–54 Mbps	38 m	> Bluetooth and ZigBee*
WiMAX	15–134 Mbps	4800 m	> Bluetooth and ZigBee*
ZigBee	20–250 Kbps	74 m	Lowest

Table 5.1: Compare Table

*Note Wireless Lan cheaper than WiMax in term of client but for base station WiMax cheaper than Wireless Lan because a station of WiMax greater range than Wireless Lan and support more user to connect to the station.

In Thailand Market

WiMAX is not available in Thailand yet.

Bluetooth usually found in many portable products (Example mobile phones, USB devices, Printers etc).Wireless LAN is available in Thailand for 2.4GHz most of Wireless LANs are used with

Access points. ZigBee is hard to find in common markets because ZigBee are used with specific devices like patient monitoring, blood pressure, heart rate

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