ITS323

Introduction of Data Communications

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Group 15

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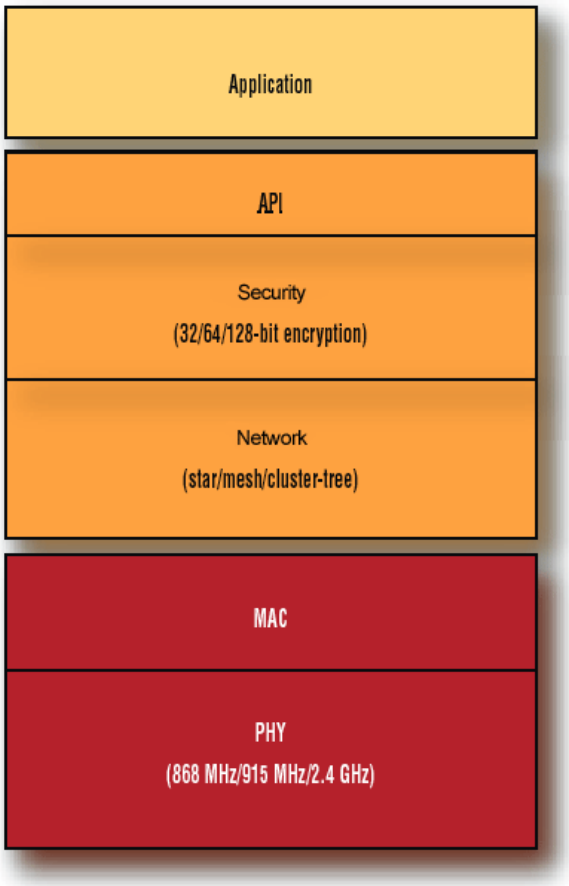
Wireless Technologies

The world of wireless telecommunications is rapidly evolving. Technologies under research and development promise to deliver more services to more users in less time. This paper presents the emerging technologies helping wireless systems grow from where we are today into our visions of the future. This paper will cover the applications and characteristics of emerging wireless technologies: Wireless Local Area Networks (WiFi-802.11n), Wireless Personal Area Networks (ZigBee) and Wireless Metropolitan Area Networks (WiMAX). The purpose of this paper is to explain the impending 802.11n standard and how it will enable WLANs to support emerging media-rich applications. The paper will also detail how 802.11n compares with existing WLAN standards and offer strategies for users considering higher-bandwidth alternatives. The emerging IEEE 802.15.4 (ZigBee) standard aims to provide low data rate wireless communications with high-precision ranging and localization, by employing UWB technologies for a low-power and low cost solution. WiMAX (Worldwide Interoperability for Microwave Access) is a standard for wireless data transmission covering a range similar to cellular phone towers. With high performance in both distance and throughput, WiMAX technology could be a boon to current Internet providers seeking to become the leader of next generation wireless Internet access. This paper also explores how these emerging technologies differ from one another.

ZigBee™

Protocol Architectures



1. The network layers in this ZigBee stack use the well-known Open Systems Interconnection (OSI) model. The IEEE 802.15.4 standard specifies the PHY and MAC layer. The ZigBee Alliance defines the network and security layers and the application programming interface (API). The user's application programs comprise the upper layers.

Physical Layer

PHY functionalities:

- Activation and deactivation of the radio transceiver
- Energy detection within the current channel
- Link quality indication for received packets
- Clear channel assessment for CSMA-CA
- Channel frequency selection
- Data transmission and reception

MAC Layer

Frame Types

- Data Frame
  used for all transfers of data
- Beacon Frame
  used by a coordinator to transmit beacons
- Acknowledgment Frame
  used for confirming successful frame reception
- MAC Command Frame
  used for handling all MAC peer entity control transfers

Data Transmission

ZigBee radios use direct – sequence spread spectrum. World Wide frequency is 2.4 GHz and have 16 channels. Over the air ,the data rate is 250 kbits/channel in 2.4 GHz band, for 915 MHz band the data rate is 40 kbits/channel and 20 kbits/channel for 868 MHz band. ZigBee require 5 MHz for Band width.

Transmission Media

Transmission range is about 10-75 meters and upto 1500 meters for ZigBee pro. Transmit power is 0 dBm. Received threshold is -85 dBm. Zigbee antennas is in a shape of chip. Sometimes it may come with a stick antennas

Signal Encoding Technique

On the 2.4 GHz frequency band, Offset-Quadrature Phase Shift Keying (OQPSK) is used. On the 868 MHz and 915 MHz frequency band, Binary Phase Shift Keying (BPSK) is used.

Error

ZigBee use ACK frame. Ideal of ACK frame make the ZigBee system cannot detect the error, Because the algorithm of ACK frame is prove that there is no error.

Application

Consumer Electronics

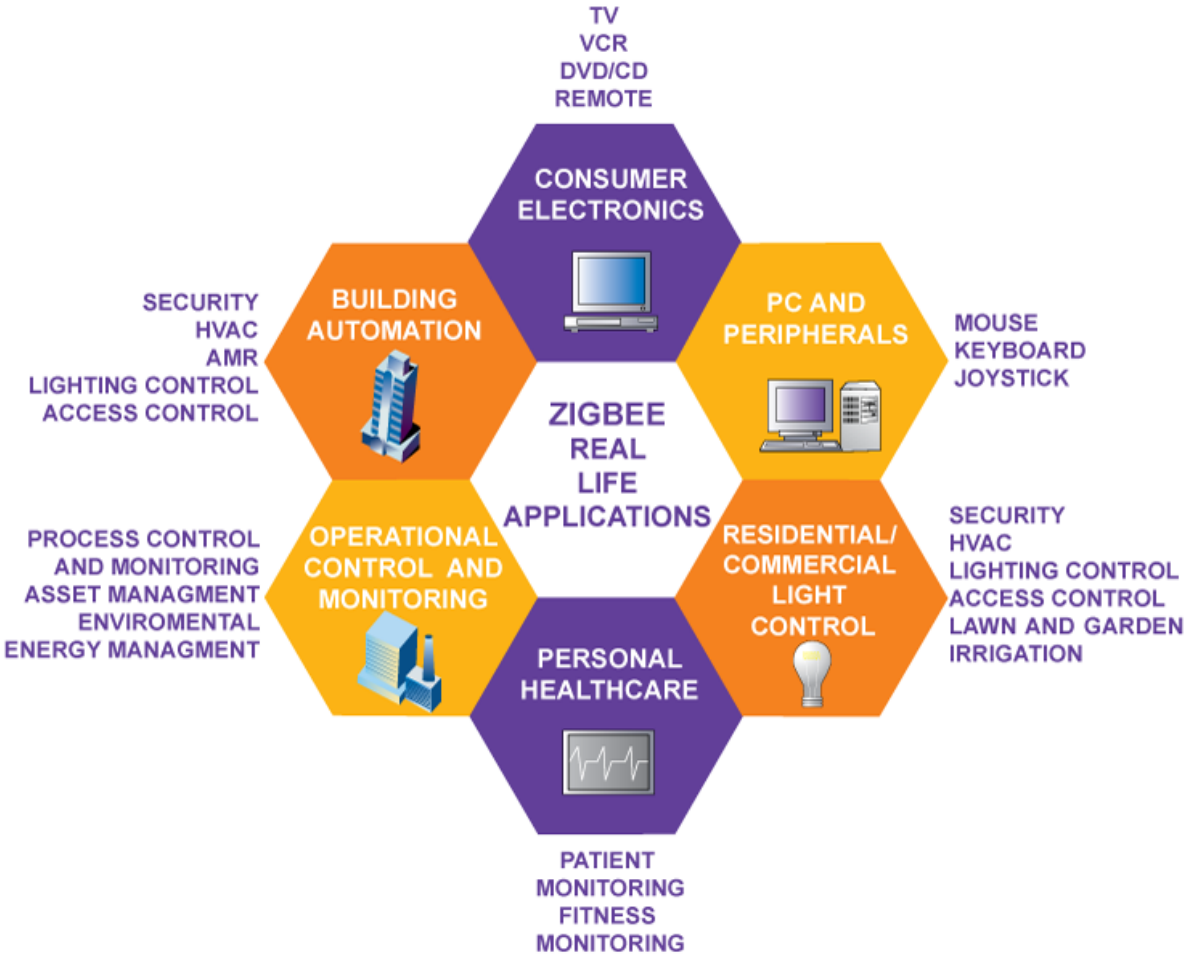
Building Automation

PC and Peripherals

Operational Control and Monitoring

Residential/Commercial Light Control

Personal Healthcare



Usage

ZigBee's advantages are low cost, very long battery life, reliable, supporting large number of nodes, and sure. So, this makes it become the widely used technology in the world. Nowadays, many devices rely on ZigBee technology, e.g.wireless keypads, smoke detectors, remote control, HID device, and etc.

ZigBee operates on the 2.4 GHz frequency band which is unrestricted for most of the countries worldwide. So, people in most of world can use this technology freely.

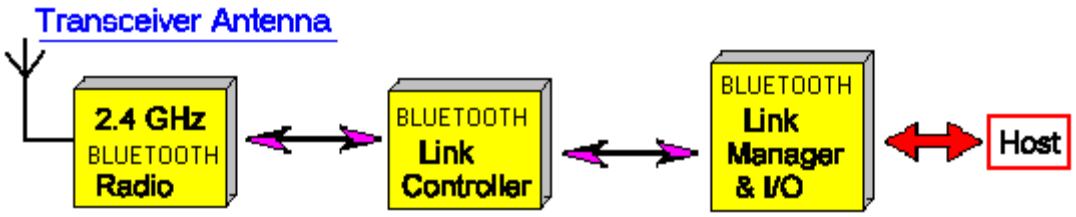
Cost

Comparing with other wireless technology, ZigBee is very cheap. It costs only half of the price of Bluetooth. Apart from this, as it consumes very low power consumption, its battery life is very long. So, the users don't have to worry about the batteries' costs.

Based on the information from 2003, ZigBee's module cost is only $1.5-$2.5.

Bluetooth is the way of using short range radio link to send and receives digital data between two devices. This way of communicate uses to replace short range communication that range and throughput are not so necessary. Ericsson Mobile Communication was the one that started this project and they named it “Bluetooth”

How it function?



Bluetooth uses the ad-hoc mode which means neither access point nor server but all units have fair access to the wireless media and the media provide that throughput is maximized for all the users in the service.

Three core protocols

1) The logical link control and adaptation protocol (L2CAP)
2) The service discovery protocol (SDP)
3) The RFCOMM protocol

L2CAP, which adapts upper layer protocols over the Baseband, provides data services to the high layer protocols with protocol multiplexing capability, segmentation and reassembly operations, and group abstractions. Device information, services and the characteristics of the services can be queried using the SDP.
Like SDP, RFCOMM is layered on top of the L2CAP. As a ‘cable replacement’ protocol, RFCOMM provides transport capabilities for high-level services (e.g. OBEX protocol) that use serial line as the transport mechanism.

Bluetooth antenna power of 0 dBm, spectrum spreading will be work at the power level up to 100 mW by a method called frequency hopping. 79 hops will displace into 1 MHz, starting at 2.402 GHz and stopping at 2.480 GHz. The maximum frequency hopping rate is 1600 hops/s.The nominal link range is 10 centimeters to 10 meters, but it can be extended to more than 100 meters by increasing the transmit power.

Bluetooth uses frequency hopping in timeslots because when it operate in noisy radio frequency environments and uses a fast acknowledgement and a frequency-hopping scheme to make the link between two device more accurate, it avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet. Bluetooth radio hop faster than other when compare in the same frequency.Use of Forward Error Correction (FEC) limits the impact of random noise on long-distance links.

Bluetooth have 2 level of transmit power

- a lower power level that covers the shorter personal area within a room, and
- a higher power level that can cover a medium range, such as within a home.

Bluetooth is specifically designed to provide low-cost, robust, efficient, high capacity, ad hoc voice and data networking with the following characteristics:

1. 1 Mb/sec. transmission/reception rate exploits maximum available channel bandwidth.
2. Fast frequency hopping avoids interference.
3. Adaptive output power minimizes interference.
4. Short data packets maximize capacity during interference.
5. Fast acknowledge allows low coding overhead for links.
6. CVSD (Continuous Variable Slope Delta Modulation) voice coding enables operation at high bit-error rates.
7. Flexible packet types supports a wide application range.
8. Relaxed link budget supports low-cost single chip integration.
9. Transmission/reception interface tailored to minimize electric current consumption.
10. One-to-one connections allow maximum data transfer rate of 721 kbits/s (corresponding to 3 voice channels).
11. It has low power consumption, drawing only 0.3 mA in standby mode. This enables maximum performance longevity for battery powered devices. During data transfer the maximum current drain is 30 mA. However, during pauses or at lower data rates the drain would be lower.

Bluetooth's Error Correction Schemes

Bluetooth units often have to contend with electro-magnetically noisy environments. For error-detection, Bluetooth uses various checksum-calculations. When errors are detected, there are 3 error-correction schemes defined for Bluetooth:

1. 1/3 rate FEC (Forward Error Correction)
2. 2/3 rate FEC
3. ARQ unnumbered scheme (Automatic Repeat Request).

FEC is for reduce the number of re-transmissions, gives unnecessary overhead that reduces the throughput so it can keep flexible to use FEC in payload or not. These make

- The DM and DH packets for the ACL link
- The HV packets for the SCO link.

The packet header is always protected by a 1/3 rate FEC; it contains valuable link information and should be able to sustain more bit errors.

Signal Encoding Technique

Bluetooth will received analog data and encoded them in to digital. There are 2 ways to encode the data.

- Pulse Code Modulation (PCM) will redraw the input data in graph and compare them to find error.
- Continuous Variable Slope Modulation (CVSD) will compare the data to the average, if higher it will return 1 to the air interface. If it lower it will return 0 or -1.

Application

For example, headset, Bluetooth car kit mounts to steering wheel, phone data transmit, print a digital photo

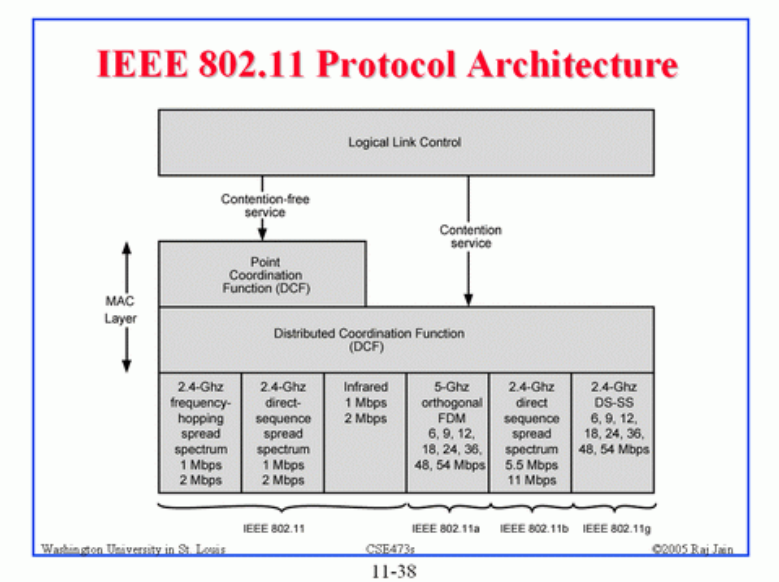
Usage

Famously use in phone to sent digital data and phone headset (in Thailand)
In office pager, modems, desktop and handheld computer, printer, Fax machines, keyboards and joysticks (that not famously in Thailand)

Wireless LAN

A **Wireless Local Area Network** (**WLAN**) links two or more devices using some wireless distribution method (typically spread-spectrum or OFDM radio), and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network.

Protocol Architecture



The 802.11 architecture is comprised of several components and services that interact to provide station mobility transparent to the higher layers of the network stack.

Wireless LAN Station

The *station* (STA) is the most basic component of the wireless network. A station is any device that contains the functionality of the 802.11 protocol, that being MAC, PHY, and a connection to the wireless media. Typically the 802.11 functions are implemented in the hardware and software of a network interface card (NIC).

A station could be a laptop PC, handheld device, or an Access Point. Stations may be mobile, portable, or stationary and all stations support the 802.11 station services of authentication, de-authentication, privacy, and data delivery.

Basic Service Set (BSS)

802.11 defines the *Basic Service Set* (BSS) as the basic building block of an 802.11 wireless LAN. The BSS consists of a group of any number of stations. The BSS is not a very interesting topic until we take the topology of the WLAN into consideration.

The standard is similar in most respects to the IEEE 802.3 Ethernet standard. Specifically, the 802.11 standard addresses

Wireless LAN Data Transmission

A WLAN data transmission occurs over radio signals that are sent out from a wireless router and received by network adapters within individual workstations. It specified three alternative physical layer technologies:diffuse infrared operating at 1 Mbit/s; frequency-hopping spread spectrum operating at 1 Mbit/s or 2 Mbit/s; and direct-sequence spread spectrum.

802.11 Protocol	Freq.(GHz)	Bandwdith(MHz)	Data rate per stream	Indoor range(m)	Outdoor range(m)
-	2.4	20	1,2	20	100
a	5	20	6,9,12,18,24,36,48,54	35	120
	3.7			-	5,000
b	2.4	20	1,2,5.5,11	38	140
g	2.4	20	1,2,6,9,12,18,24,36,48,54	38	140
n	2.4/5	20	7.2,14.4,21.7,28.9,43.3,57.8,65,72.2	70	250
		40		70	250

Encoding of transmission signals

In order for data to be exchanged, an encoding must be chosen for the transmission signals. This depends basically on the physical medium used to transfer the data, the guaranteed data integrity and transmission speed.

Wireless LANs Application

- LAN extension - extension of an existing wired LAN
  - for large open areas; historical buildings; small offices, etc.
- Cross-Building Interconnect
  - Connect two buildings without wires
- Nomadic access
- Ad hoc networking

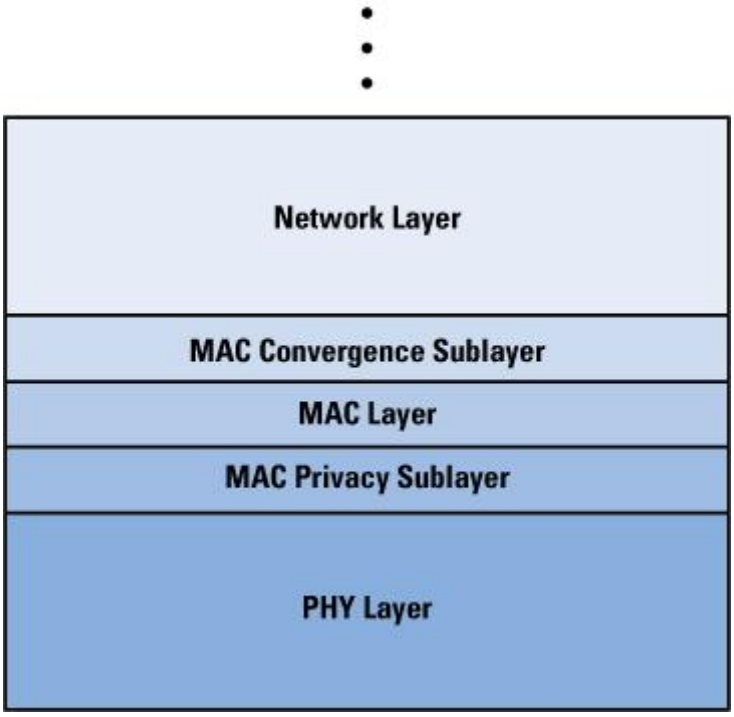
Error

A method in a wireless communications network is disclosed whereby errors due to incorrect transmission.This is achieved by using a known pseudo-random seed generating algorithm at both at least one transmitting device
1.That has an associated transmitting address and at least one receiving device.
2. That has at least one associated receiving address, it is possible to reduce errors due to incorrectly transmitted scrambler seed values. Error in transmission in frequenzy signal ,the signal will be re-broadcast on a different frequency in the next hop.

Usage

Wireless Local Area Network is becoming increasingly important as organizations rely more and more on wireless communication for mission-critical and real-time applications. They are used very widely in Thailand, you can use wireless LAN almost everywhere but you may cause to pay somewhere for using wireless LAN or not you can use it free. In SIIT there are wireless LANs for students to use without fee. In many delevoped countries, there are free wireless LAN for everyone to use.

Protocol Architectures



Physical and transmission layer functions:

- Encoding/decoding of signals
- Preamble generation/removal
- Bit transmission/reception

Medium access control layer functions:

- On transmission, assemble data into a frame with address and error detection fields.
- On reception, disassemble frame, and perform address recognition and error detection.
- Govern access to the wireless transmission medium.

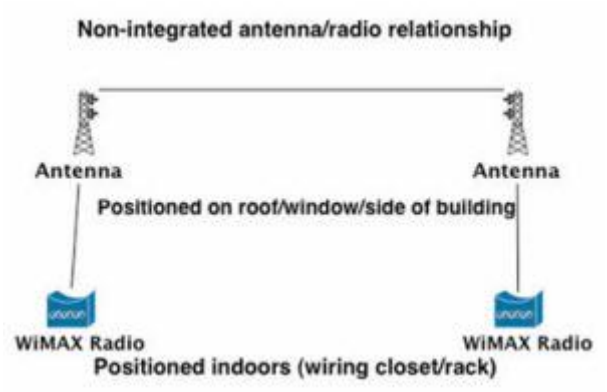
Convergence layer functions:

- Encapsulate PDU framing of upper layers into native 802.16 MAC/PHY frames
- Map upper layer's addresses into 802.16 addresses
- Translate upper layer QoS parameters into native 802.16 MAC format
- Adapt time dependencies of upper layer traffic into equivalent MAC service

Data Transmission

At the core of WiMAX is the WiMAX radio. A radio contains both a transmitter (sends) and a receiver (receives). It generates electrical oscillations at a frequency known as the carrier frequency (in WiMAX that is usually between 2 and 11 GHz). A radio might be thought of as a networking device similar to a router or a bridge in that it is managed by software and is composed of circuit boards containing very complex chip sets.

WiMAX architecture, very simply put, is built upon two components: radios and antennas. Most WiMAX products offer a base station radio separate from the antenna. Conversely, many CPE devices are also two piece solutions with an antenna on the outside of the building and subscriber station indoors as illustrated in the figure below.



Transmission Media

WiMax is cover 31 miles range. Transmit Power is +43 dBm for base station but for mobile station Transmit power is about +23 dBm. An antennas of WiMax is look like a Square dish for base station. For mobile station it up to your device, it may have a stick antennas or not have.

Signal Encoding Technique

The backhaul of the Wimax (802.16) is based on the typical connection to the public wireless networks by using optical fibre, microwave link, cable or any other high speed connectivity. In few cases such as mesh networks, Point-to-Multi-Point (PMP) connectivity is also used as a backhaul. Ideally, Wimax (802.16) should use Point-to-Point antennas as a backhaul to join subscriber sites to each other and to base stations across long distance.

A wimax base station serves subscriber stations using Non-Line-of-Sight (NLOS) or LOS Point-to-Multi-Point connectivity; and this connection is referred to as the last mile communication. Ideally, Wimax (802.16) should use NLOS Point-to-Multi-Point antennas to connect residential or business subscribers to the Wimax Base Station (BS). A Subscriber Station (Wimax CPE) typically serves a building using wired or wireless LAN.

Error

WiMAX technology have built-in **error detection techniques** to reduce the system Signal to Noise Ratio (SNR) obligations. Convolutional Encoding, Strong Reed Solomon FEC, and interleaving algorithms are used to identify and correct errors to enhance throughput. These strong error correction techniques assist to recover corrupted frames that may have been missing due to frequency selective fading or burst errors. To remove the errors, Automatic Repeat Request (ARQ) is used that cannot be corrected by the Forward **Error Detection** (FEC) by resending the error-ed information again. This notably improves the Bit Error Rate (BER) performance for a similar maximum level

Application

Wimax network provides the ability for service provider to deploy new era broadband service**.** Wimax applications are most effective than today. It provides a broad customer base, while adding up a mobility feature to those services**.** Wimax technology applications are a mean of service providers to present data, video, voice, mobile and internet access. There are various benefits of Wimax technology such as it provides simple based prospective cost saving and service efficiency but to be capable to allow VoIP calling, mobile devices, video making and high speed data transfer. Wimax technology brings a new ingredient to today's mobile community. The most important application offered by Wimax Technology is business, consumer connectivity, and backhaul. Wimax Technology carry real augmentation to communications through which you can get benefit not only from voice but also video and data transmission to get quick response to situation. Through Wimax Technology a client can deploy a temporary communication services and speed up their network to support events and circumstances. Wimax technology applications enable you to get temporary access to media, visitors and employees. If you are exist in tower range then you can get easy access to premises equipment for such events. The basic strength behind the Wimax Technology applications are high bandwidth, high quality services, security, deployment, full duplex including DSL and versus cable, and its cost.

Usage

Thailand's telecoms regulator National Telecommunications Commission (NTC) plans to auction WiMAX, 3.9G (LTE) licences in September 2010. The NTC has agreed to use spectrum of 2.3 GHz and 2.5 GHz for the high-speed broadband service. Issuing WiMax licences should help expand coverage of broadband Internet services in Thailand.

Regulator plans to allocate a maximum of 30 MHz to each provider, and would announce details at a public hearing in July 2010. NTC published a draft for licences of the 3.9 (LTE) generation of mobile service and expected an auction to be held in September 2010.

The NTC had shown a progressive vision by proposing to move straight to 3.9G and bypass the stillborn 3G. However, limited bandwidth resources may make it difficult to adopt the new technology

Cost

This technology being still quite new, it's hard to estimate the real cost of non-existing components or prototypes. These costs are estimated assuming a successful trend of this technology deployment.

Base station

The cost of installation and equipment of a base station is reduced to the following items

Base station	1,582,800 Baht
Sector antenna	118,710 Baht
Total base station	1,701,510 Baht
Total bandwidth (Mb/s)	320

Comparison table

	Zigbee	Bluetooth	Wireless Lan	WiMax
frequency	868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4 GHz in most jurisdictions worldwide	between 2.402 GHz and 2.480 GHz	2.4 and 5 GHz	2 GHz to 11 GHz reaching a possible 66 GHz
bandwidth	5 MHz	low-bandwidth	54 Mbps	70 Mbps
data rates	250 kbps (@2.4 GHz), 40 kbps (@ 915 MHz), and 20 kbps (@868 MHz)	1 Mbit/s transfer speed up 24 Mbit/s	over 100 Mbps	120 MB/s
transmit power	0 dBm		about 100 mW	+43 dBm(for station) +23 dBm
antennas	Chip or stick	could be a small box or PCMCIA card	box that contain chip and system inside	look like a Square dish
distance	10-100 meters	10-100 meters	50-100 meters	3,000 square miles (~8,000 square km).
Encoding	IEEE802.15.4	PCM, CVSD		WiMax is transmitted from Base Station to other mobile station, from greater to lower form and from higher amount of coding to lower bit-rate
Errors	cannot detect the error, Because the algorithm of ACK frame is prove that there is no error	1/3 FEC, 2/3 FEC, ARQ	re-broadcast on a different frequency in the next hop	WiMax has an error correction feature that ensures a robust RF link while maximizing the number of bits/sesivecond for each subscriber unit

References

http://www.stg.com/wireless/ZigBee_comp.html
http://www.sena.com/blog/?p=359
http://en.wikipedia.org/wiki/Bluetooth
http://en.wikipedia.org/wiki/WiMAX
http://www.kmitl.ac.th/~ktnarin/wimax.pdf
http://www.freewimaxinfo.com/
http://www.hpl.hp.com/personal/Jean_Tourrilhes/Linux/Linux.Wireless.Overview.html
http://www.windowsnetworking.com/articles_tutorials/wlan.html
http://www.stg.com/wireless/index.html
http://focus.ti.com/analog/docs/gencontent.tsp?familyId=367&genContentId=24190&DCMP=hpa_rf_general&HQS=NotApplicable+OT+zigbee
http://en.wikipedia.org/wiki/ZigBee
http://en.wikipedia.org/wiki/Wireless_LAN