E1-E2 UPGRADATION COURSE –CONSUMER MOBILITY

Overview of Wi-Fi and WiMAX

CHAPTER-TWELVE

An Introduction to Wireless-Fidelity (WI-FI)

Scope:

Wi-Fi is a registered trademark by the Wi-Fi Alliance. The products tested and approved as "Wi-Fi Certified" are interoperable with each other, even if they are from different manufacturer. It is Short form for **"Wireless-Fidelity"** and is meant to generically refer to any type of '802.11' network, whether '802.11'b, '802.11'a, dual-band, etc. Initially the term "Wi-Fi" was used in place of the 2.4GHz '802.11'b standard, in the same way that "Ethernet" is used in place of IEEE 802.3 but Alliance has expanded the generic use of the term to cover '802.11'a, dual-band etc.

General description of Wi-Fi Network:

A Wi-Fi network provides the features and benefits of traditional LAN technologies such as Ethernet and Token Ring without the limitations of wires or cables. It provides the final few metres of connectivity between a wired network and the mobile user thereby providing mobility, scalability of networks and the speed of installation. WIFI is a wireless LAN Technology to deliver wireless broad band speeds up to 54 Mbps to Laptops, PCs, PDAs , dual mode WiFi enabled phones etc. Apart from Data delivery Voice over WIFI is also in pipeline. The backhaul bandwidth from wired network i.e. ADSL modem, leased line etc. is shared among the users.

In a typical Wi-Fi configuration, a transmitter/receiver (transceiver) device, called the **Access Point (AP)**, connects to the wired network from a fixed location using standard cabling. A wireless Access Point combines router and bridging functions, it bridges network traffic, usually from Ethernet to the airwaves, where it routes to computers with wireless adapters. The AP can reside at any node of the wired network and acts as a gateway for wireless data to be routed onto the wired network as shown in **Figure-1**. It supports only 10 to 30 mobile devices per Access Point (AP) depending on the network traffic. Like a cellular system, the Wi-Fi is capable of roaming from the AP and re-connecting to the network through another AP. The Access Point (or the antenna attached to the Access Point) is usually mounted high but may be mounted essentially anywhere that is practical as long as the desired radio coverage is obtained.

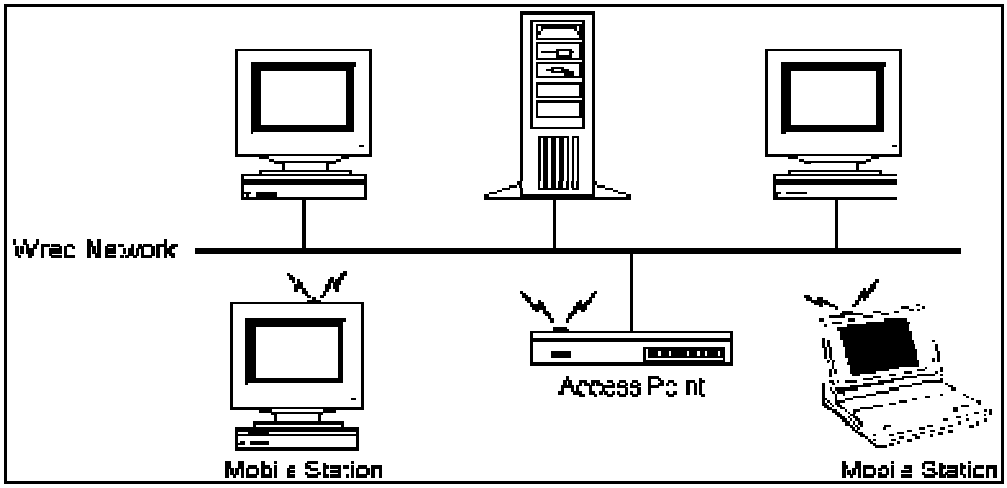


Figure -1: A typical Wi-Fi Network.

Wi-Fi Network Configuration:

A Wireless Peer-To-Peer Network: This mode is also known as ADHOC mode. Wi-Fi networks can be simple or complex. At its most basic, two PCs equipped with wireless adapter cards can set up an **independent network** whenever they are within range of one another. This is called a peer-to-peer network. It requires no administration or pre-configuration. In this case, each client would only have access to the resources of the other client and not to a central server as shown in **Figure-4**.

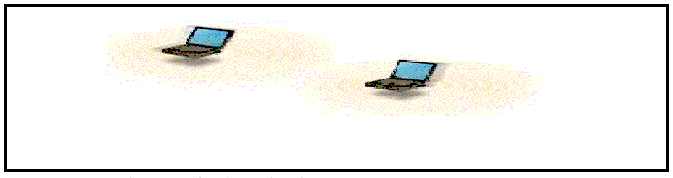


Figure-4: A Wi-Fi Peer-To-Peer Network.

Client and Access Point:

This is known as INFRASTUCTURE mode and is normally employed. However, wireless gateway can be configured to enable peer to peer communication in this mode as well.

In this mode, one Access Point is connected to the wired network and each client would have access to server resources as well as to other clients. The specific number client depends on the number and nature of the transmissions involved. Many real-world applications exist where a single Access Point services from 15 to 50 client devices as shown in **Figure-5.**

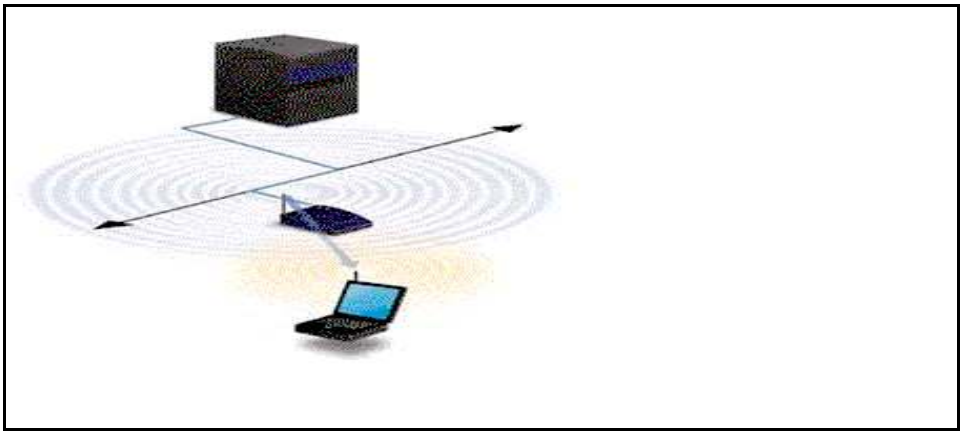


Figure-5: A Server and Clint Wi-Fi Network.

Multiple Access Points and Roaming:

Access points can be connected to each other through UTP cable or they can be connected to each other over radio through wireless bridging. There is an option to connect access points in a mesh architecture where in event of a fault in an access point the network heals itself and connectivity is ensured through other access point. This changeover takes place dynamically.

Access Points have a finite range, of the order of 500 feet indoor and 1000 feet outdoors. In a very large facility such as a warehouse, or on a college campus, it will probably be necessary to install more than one Access Point. Access Point positioning is done by a site survey. The goal is to blanket the coverage area with overlapping coverage cells so that clients might range throughout the area without ever losing network contact. The ability of clients to move seamlessly among a cluster of Access Points is called roaming. Access Points hand the client off from one to another in a way that is invisible to the client, ensuring unbroken connectivity as shown in **Fig-6**.

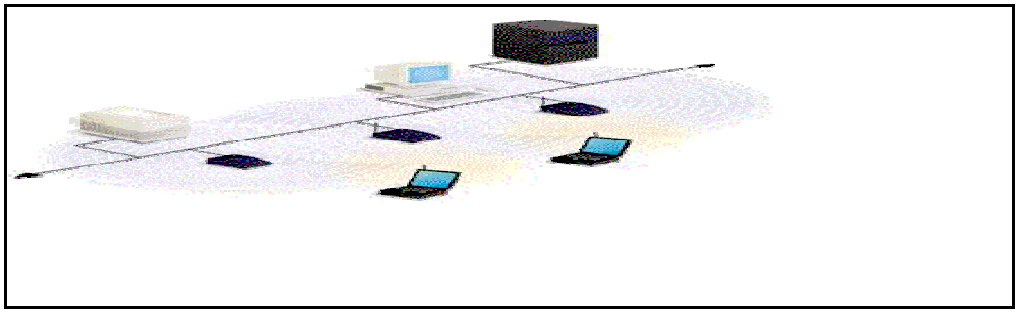


Figure-6: Multiple Access Points and Roaming.

Wireless LAN Standards:

Wi-Fi and IEEE '802.11' are often used interchangeably. Wi-Fi is an interoperability certification program promoted by the Wi-Fi alliance, the idea is that a consumer should look for the Wi-Fi logo and feel free that this '802.11' product will work with other Wi-Fi certified products. The '802.11' specifications are wireless standards that

define as “over-the–air” interface between wireless client and a base station or Access Point. It includes task groups called ‘802.11’b, a, e, g working on amendments.

- **‘802.11’b** was the first version to reach the marketplace. It is the slowest and least expensive of the three. As mentioned above, ‘802.11’b transmits at 2.4 GHz ISM band and can handle up to 11 megabits per second. Wi-Fi reaches only about 7Mbps of throughput due to synchronization issues, ACK overhead etc.
- **‘802.11’g**: The -g group is a natural speed extension for the ‘802.11’b standard. It will extend the highly successful family of IEEE ‘802.11’ standards, with data rates up to 54 Mbps in the 2.4 GHz band.
- **‘802.11’a**: Task Group (TG a) operates in the 5GHz band. Because its operating frequency is higher than that of ‘802.11’b, ‘802.11’a has a smaller range. It tries to solve this distance problem by using more power and more efficient data encoding schemes. The higher frequency band gives the advantage of not residing in the crowded 2.4GHz region where we see cordless phones, Bluetooth and even microwave ovens operating.

  The major advantage is it's speed: the spectrum of ‘802.11’a is divided into 8 sub-network segments or channels of about 20 MHz each. These channels are responsible for a number of network nodes. The channels are made up of 52 carriers of 300 KHz each, and can present a maximum of 54 Mbps. This speed takes WLAN from the first generation Ethernet (10 Mbps) to the second (Fast Ethernet, 100Mbps). The new specification is based on a OFDM modulation scheme. The RF system operates at 5.15 to 5.25, 5.25 to 5.35 and 5.725 to 5.825 GHz U-NII bands. The OFDM system provides 8 different data rates between 6 to 54 Mbps. It uses BPSK, QPSK, 16-QAM and 64-QAM modulation schemes coupled with forward error correcting coding. Important to remember: ‘802.11’b is completely incompatible with ‘802.11’a
- **‘802.11’e** Task Group (TG e) is proceeding to build improved support for Quality of Service. The aim is to enhance the current ‘802.11’ MAC to expand support for LAN applications with Quality of Service requirements, to provide improvements in security and in the capabilities & efficiency of the protocol. Its applications include transport of voice, audio and video over ‘802.11’ wireless networks, video conferencing, media stream distribution, enhanced security applications and mobile & nomadic access applications.
- **‘802.11’d** Task Group (TG d) describes a protocol that will allow an ‘802.11’ device to receive the regulatory information required to configure itself properly to operate anywhere on earth. The current ‘802.11’ standard defines operation in only a few regulatory domains (countries). This supplement will add the requirements and definitions necessary to allow ‘802.11’ WLAN equipment to operate in markets not served by the current standard.

Configuring Wi-Fi:

Configuring a New Hotspot: Most wireless Access Points come with default values built-in. Once you plug them in, they start working with these default values in 90 percent of the cases. However, you may want to change things. You normally get to set three things on your Access Point:

The SSID: It will normally default to the manufacturer's name (e.g. "Linksys" or "Netgear"). You can set it to any word or phrase you like.
Same SSID eg. BSNL should be configured in all access points to allow seamless roaming between access points.

The channel: Normally it will default to channel 6. However, if a nearby neighbor is also using an Access Point and it is set to channel 6, there can be interference. Choose any other channel between 1 and 11. An easy way to see if your neighbors have Access Points and use the search feature that comes with your wireless card.
. Neighboring APs should have channels 1,6,11. However these can be repeated after some distance as is done in GSM cell planning

The WEP key: The default is to disable Wired Equipment Privacy (WEP). If you want to turn it on, you have to enter a WEP key and turn on 128-bit encryption
.It should be enabled to secure the network against eavesdropping and hacking. Though it is not full proof.

Access Points come with simple instructions for changing these three values. Normally you do it with a Web browser. Once it is configured properly, you can use your new hotspot to access the Internet from anywhere in your network.

Configuring Wi-Fi in client machine: On the newest machines, an '802.11' card will automatically connect with an '802.11' hotspot and a network connection will be established. As soon as you turn on your machine, it will connect and you will be able to browse the Web, send email, etc. using Wi-Fi. On older machines you often have to go through these simple 3-steps process to connect to a hotspot:

1. Access the software for the '802.11' card: Normally there is an icon for the card down in the system tray at the bottom right of the screen.
2. Click the "Search button" in the software. The card will search for all of the available hotspots in the area and show you a list.
3. Double-click on one of the hotspots to connect to it.

Old '802.11' equipment has no automatic search feature. You have to find what is known as the SSID of the hotspot (usually a short word of 10 characters or less) as

well as the channel number (an integer between 1 and 11) and type these two pieces of information in manually. All the search feature is doing is grabbing these two pieces of information from the radio signals generated by the hotspot and displaying them for you.

Benefits of Wi-Fi:

In a Wi-Fi users can access shared information without looking for a place to plug in, and network managers can set up or augment networks without installing or moving wires. Wi-Fi offers the following productivity, conveniences, and cost advantages over traditional wired networks:

- **Mobility:** Wi-Fi systems can provide LAN users with access to real-time information anywhere in their organization. This mobility supports productivity and service opportunities not possible with wired networks.
- **Installation Speed and Simplicity:** Installing a Wi-Fi system can be fast and easy and can eliminate the need to pull cable through walls and ceilings.
- **Installation Flexibility:** Wireless technology allows the network to go where wire cannot go.
- **Reduced Cost-of-Ownership:** While the initial investment required for Wi-Fi hardware can be higher than the cost of wired LAN hardware, overall installation expenses and life-cycle costs can be significantly lower. Long-term cost benefits are greatest in dynamic environments requiring frequent moves, adds, and changes.
- **Scalability:** Wi-Fi systems can be configured in a variety of topologies to meet the needs of specific applications and installations. Configurations are easily changed and range from peer-to-peer networks suitable for a small number of users to full infrastructure networks of thousands of users that allows roaming over a broad area.
- It offers much high speed upto 54 Mbps which is very much greater than other wireless access technologies like CORDECT, GSM and CDMA.

Limitation of Wi-Fi networks:

The key areas of limitation of Wi-Fi are:

- **Coverage**: A single Access Point can cover, at best, a radius of only about 60 metres. Hundreds of Access Points are necessary to provide seamless coverage in small area. For 10 square kms area roughly 650 Access Points are required, where as CDMA 2000 1xEV-DO requires just 09 sites.
- **Roaming**: It lacks roaming between different networks hence wide spread coverage by one service provider is not possible, which is the key to success of wireless technology.

- **Backhaul:** Backhaul directly affects data rate service provider used Cable or DSL for backhaul. Wi-Fi real world data rates are at least half of the their theoretical peak rates due to factors such as signal strength, interference and radio overhead .Backhaul reduces the remaining throughput further.
- **Interference:** Wi-Fi uses unlicensed spectrum, which mean no regulator recourse against interference. The most popular type of Wi-Fi, '802.11'b uses the crowded 2.4 GHz band which is already used in Bluetooth, cordless phones and microwave ovens.
- **Security:** Wi-Fi Access Points and modems use the Wired Equivalent Privacy (WEP) Standards, which is very susceptible to hacking and eavesdropping.
- **Security: WEP**(Wired Equivalent Privacy) is not very secure. WPA (WIFI Protected Access) offers much better security with the help of dynamic key encryption and mutual authentication.
- Authentication, Authorization and Accounting:
- In a server based configuration whenever a laptop enters into a wifi zone, a welcome page is sent to it. User enters username and password. It is connected through the wireless gateway(router) to AAA, LDAP servers. Once authenticated ,user can access sites of his choice. Prepaid and postpaid customers can be billed.

WiMAX

WiMAX is a single wireless technology that can:

- Bridge the digital divide by delivering broadband in low-density areas,
- Connect enterprises and residential users in urban and suburban environments where access to copper plant is difficult,
- Make portable Internet a reality by extending public WLAN hotspots to city hotzones,
- Further expand hotzones to metropolitan area coverage for mobile data-centric service delivery.

WiMAX is state-of-the-art radio technology, offers Broadband wireless access at data rates of several tens of Mbit/s (up to 75 Mbit/s per base station) and within a range of several tens of kilometers (up to 50 km). This same radio technology offers high-speed data services to all nomadic terminals (laptops, PDAs, etc.) at a better cost : performance ratio than 3G, given an optimized trade off between throughput and mobility. Finally, WiMAX incorporates Quality of Service elements to offer multimedia services, including voice. Given its huge benefits, WiMAX will develop as a self-standing radio access solution in the global network architecture. WiMAX will also enable end-users to benefit from an "Always Best Connected" experience when accessing their applications via the best available network, at home, on the pause, or on the move. A technology with such enormous potential is destined for a bright future.

Introduction

Broadband Wireless Access (BWA) has been serving enterprises and operators for years, to the great satisfaction of its users. However, the new IP-based standard developed by the IEEE 802.16 is likely to accelerate adoption of the technology. It will expand the scope of usage thanks to: the possibility of operating in unlicensed frequency bands, unique performance under Non-Line-of-Sight (NLOS) conditions, Quality of Service (QoS) awareness, extension to mobility, and more. In parallel, the WiMAX forum, backed by industry leaders, will encourage the widespread adoption of broadband wireless access by establishing a brand for the technology and pushing interoperability between products. The purpose of this White Paper is to highlight and assess the value of WiMAX as the right solution to:

- Bridge the digital divide in low-density areas where technical and economic factors make broadband deployment very challenging,
- Offer fixed broadband access in urban and suburban areas where copper quality is poor or unbundling difficult,
- Extend the currently limited coverage of public WLAN (hotspots) to citywide coverage (hotzones) – the same technology being usable at home and on the move,

- Blanket metropolitan areas for mobile data-centric service delivery.

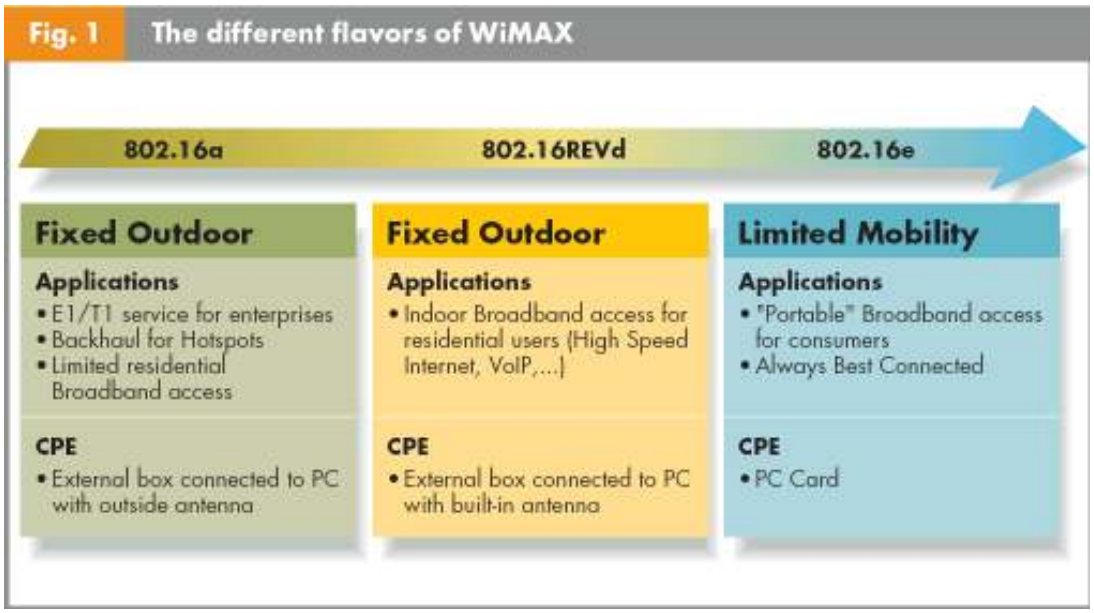
In addition to these uses, it has other potential applications, such as telephony or an effective point-to-multipoint backhauling solution for operators or enterprises.

Standards associated to WiMAX

Worldwide Interoperability for Microwave Access (WiMAX) is the common name associated to the IEEE 802.16a/REVd/e standards. These standards are issued by the IEEE 802.16 subgroup that originally covered the Wireless Local Loop (WLL) technologies with radio spectrum from 10 to 66 GHz. Recently, these specifications were extended below 10 GHz:

- In January 2003, the IEEE approved 802.16a as an amendment to IEEE 802.16-2001, defining (Near) Line-Of- Sight capability,
- Mid-2004, IEEE 802.16REVd, which should be published under the name IEEE 802.16-2004, will introduce support for indoor CPE (NLOS) and nomadicity through additional radio capabilities such as antenna beam forming and OFDM sub-channeling,
- Early 2005, an IEEE 802.16e variant will introduce support for mobility.

See Figure 1 for the applications associated with each of these standards.



The WiMAX Forum intends to do for 802.16 what the Wi-Fi Alliance did for 802.11:

- Harmonize standards and certify interoperability between equipment from different vendors. Standardized interoperable solutions will result in mass volume and bring down costs,
- Promote and establish a brand for the technology.

WiMAX offers broadband wireless access at data rates of several tens of Mbit/s (up to 75 Mbit/s per base station) and within a range of several tens of kilometers (up to 50 km). However,

- 75 Mbit/s is achievable with a 20 MHz channel. Regulators will often allow only smaller channels (10 MHz or less) reducing the maximum bandwidth,
- 50 km is achievable only under optimal conditions and with a reduced data rate (a few Mbit/s). Typical coverage will be around 5 km with indoor CPE (NLOS) and around 15 km with a CPE connected to an external antenna (LOS),
- Mobility will target only urban usage, with up to 60 km/h vehicle speed to maintain optimum throughput performance.

Market for WiMAX

WiMAX will boost today's highly fragmented BWA market thanks to standardization and interoperability, state-of-the-art radio efficiency with NLOS capability, and strong support from the radio equipment manufacturers and chipset industries. WiMAX will also target the mobility market with the introduction of low power-consumption chipsets. The strong support from some of the most important chipsets manufacturers such as Intel or Fujitsu is a key enabler for the success of WiMAX, since it will lead to wide availability of affordable WiMAX-enabled terminals (e.g., laptops, PDAs, etc.).

WiMAX and its three main markets

WiMAX will open up three main markets – see Figure 2. This will happen in three waves:

- It will bridge the digital divide in low-density areas where technical and economic factors inhibit cost effective broadband deployments. The prime markets are in Western Europe, North America, and some Asia-Pacific countries. This will be the first market to take off - in 2005.
- It will offer high-speed Internet and voice access in urban and suburban areas where access to the copper plant is difficult. It will also support nomadic usage for operators wishing to stand out from competition (the same subscription could be used throughout a city). This market will also start in 2005, with WiMAX progressively replacing current proprietary products.
- It will then introduce the portable Internet application by providing broadband access on the move, extending the currently limited coverage of public WLANs to city-wide coverage (hotzones). Later expansion will be to Metropolitan areas, providing high-speed data services under mobility conditions. This market will first emerge in North America, followed by most of the developed and developing countries. It will take off with the availability of WiMAX-enabled laptops in 2006.

The WiMAX CPE

In most case, a simple plug and play terminal, similar to a DSL modem, provides connectivity. See Figure 3. For customers located several kilometers from the WiMAX base station, a self-install outdoor antenna may be required to improve transmission quality. To serve isolated customers, a directive antenna pointing to the WiMAX base station may be required. For customers requesting voice in addition to broadband services, specific CPE will allow the connection of standard or VoIP phones.

WiMAX Technology Challenge WiMAX, more flexibility and security

Unlike WLAN, WiMAX provides a media access control (MAC) layer that uses a grant-request mechanism to authorize the exchange of data. This feature allows better exploitation of the radio resources, in particular with smart antennas, and independent management of the traffic of every user. This simplifies the support of real-time and voice applications.

One of the inhibitors to widespread deployment of WLAN was the poor security feature of the first releases. WiMAX proposes the full range of security features to ensure secured data exchange:

- Terminal authentication by exchanging certificates to prevent rogue devices,
- User authentication using the Extensible Authentication Protocol (EAP),
- Data encryption using the Data Encryption Standard (DES) or Advanced Encryption Standard (AES), both much more robust than the Wireless Equivalent Privacy (WEP) initially used by WLAN. Furthermore, each service is encrypted with its own security association and private keys.

WiMAX Spectrum and Regulation Issues

WiMAX-compliant equipment will be allowed to operate in both licensed and unlicensed bands. The minimum channel bandwidth for WiMAX usage is 1.75 MHz per channel, while 10 MHz is considered as an optimum.

Although 2.4 GHz and 5 GHz non-licensed bands are largely available, their usage could be limited to trials because of the risks of interference preventing QoS commitments.

The 2.5 and 3.5 GHz licensed bands will be the most common bands for WiMAX applications. It should be noted that the 5 GHz band is also partially licensed in some countries.

Most countries have already allocated licensed spectrum, generally to alternate operators. Nevertheless large quantities of spectrum are still in process of allocation, and some countries have not even defined any WiMAX licensed bands yet.

WiMAX is designed to accommodate either Frequency Division Duplexing (FDD), which is more suited to enterprise traffic, or Time Division Duplexing (TDD), which is more adapted to asymmetrical traffic. Cohabitation of FDD and TDD techniques is possible within the same bands, provided guard bands are implemented.

Conclusion

The latest developments in the IEEE 802.16 group are driving a broadband wireless access (r)evolution thanks to a standard with unique technical characteristics. In parallel, the WiMAX forum, backed by industry leaders, helps the widespread adoption of broadband wireless access by establishing a brand for the technology. Initially, WiMAX will bridge the digital divide. Then, thanks to competitive equipment prices, the scope of WiMAX deployment will broaden to cover markets where the low POTS penetration, high DSL unbundling costs, or poor copper quality have acted as a brake on extensive high-speed Internet and voice over broadband. WiMAX will reach its peak by making portable Internet a reality. When WiMAX chipsets are integrated into laptops and other portable devices, it will provide high speed data services on the move, extending today's limited coverage of public WLAN to metropolitan areas. Integrated into new generation networks with seamless roaming between various accesses, it will enable end users to enjoy an "Always Best Connected" experience. The combination of these capabilities makes WiMAX attractive for a wide diversity of people: fixed operators, mobile operators, and wireless ISPs, but also for many vertical markets and local authorities. Alcatel, the worldwide broadband market leader with a market share in excess of 37%, is committed to offer complete support across the entire investment and operational cycle required for successful deployment of WiMAX services.

References:

1. Technical article at internet site: www.wirelesslan.com.

2. Technical article at internet site: www.proxim.com.

Questions

1) What are all the Wi-Fi Standards?
2) What are the speed achievable in different standards?
3) What are the types of network configuration?
4) What are the three important things while configuring a new HOTSPOT?
5) What are the standards, distance, speed on Wi-Max?