Wi-MAX
(Worldwide Interoperability for Microwave Access)

Abstract:

The two driving forces of modern Internet are broadband, and wireless. The WiMax standard combines the two, delivering high-speed broadband Internet access over a wireless connection. The main problems with broadband access are that it is pretty expensive and it doesn't reach all areas. The main problem with WiFi access is that hot spots are very small, so coverage is sparse.

Here comes the technology of Wi-MAX, acronym for *Worldwide Interoperability for Microwave Access* and goes by and it also goes by the IEEE name 802.16. This technology would provide high speed of Broadband service, wireless access, and most importantly wide coverage area unlike the Wi-Fi. Because it can be used over relatively long distances, it is an effective "last mile" solution for delivering broadband to the home, and for creating wireless "hot spots" in places like airports, college campuses, and small communities.

The so-called "last mile" of broadband is the most expensive and most difficult for broadband providers
and Wi-MAX provides an easy solution. Although it is a wireless technology
unlike some other wireless technologies, it doesn't require a direct line of sight between the source and endpoint, and it has a service range of 50 kilometers. It provides a shared data rate of up to 70Mbps, which is enough to service up to a thousand homes with high-speed access. Ultimately, Wi-MAX may be used to provide connectivity to entire cities, and may be incorporated into laptops to give users an added measure of mobility.

This paper discusses about this revolutionary wireless technology that is challenging the present Broadband and wireless technologies. This paper deals with the working, different standards and comparison with other technologies like Wi-Fi.

1. Introduction:

Wi-MAX is short for Worldwide Interoperability for Microwave Access, and it also goes by the IEEE name 802.16. WiMAX has the potential to do to broadband Internet access what cell phones have done to phone access. In the same way that many people have given up their "land lines" in favor of cell phones, WiMAX could replace cable and DSL services, providing universal Internet access just about anywhere you go. Wi-MAX delivers a point-to-multipoint architecture, making it an ideal method for carriers to deliver broadband to locations where wired connections would be difficult or costly. It may also provide a useful solution for

delivering broadband to rural areas where high-speed lines have not yet become available. A WiMax connection can also be bridged or routed to a standard wired or wireless Local Area Network (LAN).

2. PARTS OF A WiMAX SYSTEM:

A WiMAX system has mainly two parts:
WiMAX Tower and
WiMAX Receiver.

2.1 WiMAX Tower:

It is similar in concept to cell-phone tower. It can provide coverage to a very large area -- as big as 3,000 square miles (~8,000 square km).

2.2 WiMAX Receiver:

The receiver and antenna could be a small box or they could be built into a laptop the way WiFi access is today.

Photo courtesy Intel
WiMAX transmitting tower

3. WORKING:

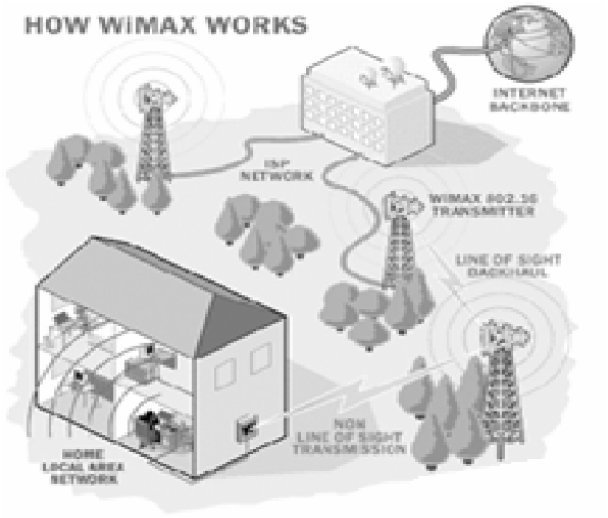
In practical terms, WiMAX would operate similar to WiFi. A WiMAX tower station can connect directly to the Internet using a high-bandwidth, wired connection (for example, a T3 line). It can also connect to another WiMAX tower using a line-of-sight, microwave link. This connection to a second tower (often referred to as a **backhaul**), along with the ability of a single tower to cover up to 3,000 square miles, is what allows WiMAX to provide coverage to remote rural areas. As opposed to a traditional Internet Service Provider (ISP), which divides that bandwidth among customers via wire, it uses a microwave link to establish a connection.

This points out that WiMAX actually can provide two forms of wireless service:
1. There is the non-line-of-sight, WiFi sort of service, where a small antenna on your computer connects to the tower. In this mode, WiMAX uses a lower frequency range -- 2 GHz to 11 GHz (similar to WiFi). Lower-wavelength

transmissions are not as easily disrupted by physical obstructions -- they are better able to diffract, or bend, around obstacles.

2. There is line-of-sight service, where a fixed dish antenna points straight at the WiMAX tower from a rooftop or pole. The line-of-sight connection is stronger and more stable, so it's able to send a lot of data with fewer errors. Line-of-sight transmissions use higher frequencies, with ranges reaching a possible 66 GHz. At higher frequencies, there is less interference and lots more bandwidth.

WiFi-style access will be limited to a 4-to-6 mile radius (perhaps 25 square miles or 65 square km of coverage, which is similar in range to a cell-phone zone). Through the stronger line-of-sight antennas, the WiMAX transmitting station would send data to WiMAX-enabled computers or routers set up within the transmitter's 30-mile radius (2,800 square miles or 9,300 square km of coverage). This is what allows WiMAX to achieve its maximum range.



4. STANDARDS OF WiMAX:

The different standards of WiMAX as given by the IEEE are:

4.1. *802.16-2001:*

This is first version of this technology approved in 2001.

4.2. *802.16a, 802.16c:*

These are the later versions of the 802.16-2001 technology. These are just the amendments of the above.

4.3. *802.16-2004:*

The current 802.16 standard is IEEE Std 802.16-2004, approved in June 2004. It renders the previous versions 802.16-2001 along with its amendments 802.16a and 802.16c as obsolete.

4.4. *802.16-2005(802.16e):*

IEEE Std 802.16-2004 addresses only fixed systems. An amendment is in the works which adds mobility components to the standard. This amendment comes in this new standard.
IEEE 802.16-2005, approved December, 2005, (formerly named 802.16e), the WiMAX mobility standard, is an improvement on the modulation schemes stipulated in the original WiMAX standard. It allows for fixed wireless and mobile Non Line of Sight (NLOS) applications primarily by enhancing the OFDMA (Orthogonal Frequency Division Multiplexing Access).

5. TECHNICAL ADVANTAGES OVER WiFi:

Because IEEE 802.16 networks use the same LLC layer (standardized by IEEE 802.2) as other LANs and WANs, it can be both bridged and routed to them.

An important aspect of the IEEE 802.16 is that it defines a MAC layer that supports multiple physical layer specifications. This is crucial to allow equipment makers to differentiate their offerings. This is also an important aspect of why WiMAX can be described as a "framework for the evolution of wireless broadband" rather than a static implementation of wireless technologies. Enhancements to current and new technologies and potentially new basic technologies incorporated into the PHY (physical layer) can be used. A converging trend is the use of multi-mode and multi-radio SoCs and system designs that are harmonized through the use of common MAC, system management, roaming, IMS and other levels of the system. WiMAX may be described as a bold attempt at forging many technologies to serve many needs across many spectrums.

The MAC is significantly different from that of Wi-Fi (and ethernet from which Wi-Fi is derived). In Wi-Fi, the MAC uses contention access-all subscriber stations wishing to pass data through an access point are competing for the AP's attention on a random basis. This can cause distant nodes from the AP to be repeatedly interrupted by less sensitive, closer nodes, greatly reducing their throughput. By contrast, the 802.16 MAC is a scheduling MAC where the subscriber station only has to compete once (for initial entry into the network). After that it is allocated a time slot by the base station. The time slot can enlarge and constrict, but it remains assigned to the subscriber station meaning that other subscribers are not supposed to use it but take their turn. This scheduling algorithm is stable under overload and oversubscription (unlike 802.11). It is also much more bandwidth efficient. The scheduling algorithm also allows the base station to control Quality of Service by balancing the assignments among the needs of the subscriber stations.

The original WiMAX standard, IEEE 802.16, specifies WiMAX in the 10 to 66 GHz range. 802.16a added support for the 2 to 11 GHz range, of which most parts are already unlicensed internationally and only very few still require domestic licenses. Most business interest will probably be in the 802.16a standard, as opposed to licensed frequencies. The WiMAX specification improves upon many of the limitations of the Wi-Fi standard by providing increased bandwidth and stronger encryption. It also aims to provide connectivity between network endpoints without direct line of sight in some circumstances. The details of performance under non-line of sight (NLOS) circumstances are unclear as they have yet to be demonstrated. It is commonly considered that spectrum under 5-6 GHz is needed to provide reasonable NLOS performance and cost effectiveness for PtM (point to multi-point) deployments. WiMAX makes clever use of multi-path signals but does not defy the laws of physics.

WiMAX operates on the same general principles as WiFi -- it sends data from one computer to another via radio signals. A computer (either a desktop or a laptop) equipped with

WiMAX would receive data from the WiMAX transmitting station, probably using encrypted data keys to prevent unauthorized users from stealing access.

The fastest WiFi connection can transmit up to 54 megabits per second under optimal conditions. WiMAX should be able to handle up to 70 megabits per second. Even once that 70 megabits is split up between several dozen businesses or a few hundred home users, it will provide at least the equivalent of cable-modem transfer rates to each user.

The biggest difference isn't speed; it's distance. WiMAX outdistances WiFi by miles. WiFi's range is about 100 feet (30 m). WiMAX will blanket a radius of 30 miles (50 km) with wireless access. The increased range is due to the frequencies used and the power of the transmitter. Of course, at that distance, terrain, weather and large buildings will act to reduce the maximum range in some circumstances, but the potential is there to cover huge tracts of land.

6. IEEE 802.16 SPECIFICATIONS:

The specifications for 802.16,i.e., WiMAX as given by the IEEE are:

6.1. Range - 30-mile (50-km) radius from base station
6.2. Speed - 70 megabits per second
6.3. Line-of-sight not needed between user and base station
6.4. Frequency bands - 2 to 11 GHz and 10 to 66 GHz
6.5. Layers - Defines both the MAC and PHY layers and allows multiple PHY-layer specifications.

7. POTENTIAL APPLICATIONS:

WiMAX is a wireless metropolitan area network (MAN) technology that can connect IEEE 802.11 (Wi-Fi) hotspots with each other and to other parts of the Internet and provide a wireless alternative to cable and DSL for last mile (last km) broadband access. IEEE 802.16 provides up to 50 km (31 miles) of linear service area range and allows connectivity between users without a direct line of sight. Note that this should not be taken to mean that users 50 km (31 miles) away without line of sight will have connectivity. Practical limits from real world tests seem to be around "3 to 5 miles" (5 to 8 kilometers). The technology has been claimed to provide shared data rates up to 70 Mbit/s, which, according to WiMAX proponents, is enough bandwidth to simultaneously support more than 60 businesses with T1-type connectivity and well over a thousand homes at 1Mbit/s DSL-level connectivity. Real world tests, however, show practical maximum data rates between 500kbit/s and 2 Mbit/s, depending on conditions at a given site.

It is also anticipated that WiMAX will allow interpenetration for broadband service provision of VoIP, video, and Internet access-simultaneously. Most cable and traditional telephone companies are closely examining or actively trial-testing the potential of WiMAX for "last mile" connectivity. This should result in better pricepoints for both home and business customers as competition results from the elimination of the "captive" customer bases both telephone and cable networks traditionally enjoyed. Even in areas without preexisting physical cable or telephone networks, WiMAX could allow access between anyone within range of each other. Home units the size of a paperback book that provide both phone and network connection points are already available and easy to install.

There is also interesting potential for interoperability of WiMAX with legacy cellular networks. WiMAX antennas can "share" a cell tower without compromising the function of cellular

arrays already in place. Companies that already lease cell sites in widespread service areas have a unique opportunity to diversify, and often already have the necessary spectrum available to them (i.e. they own the licenses for radio frequencies important to increased speed and/or range of a WiMAX connection). WiMAX antennae may be even connected to an Internet backbone via either a light fiber optics cable or a directional microwave link. Some cellular companies are evaluating WiMAX as a means of increasing bandwidth for a variety of data-intensive applications. In line with these possible applications is the technology's ability to serve as a very high bandwidth "backhaul" for Internet or cellular phone traffic from remote areas back to a backbone. Although the cost-effectiveness of WiMAX in a remote application will be higher, it is definitely not limited to such applications, and may in fact be an answer to expensive urban deployments of T1 backhauls as well. Given developing countries' (such as in Africa) limited wired infrastructure, the costs to install a WiMAX station in conjunction with an existing cellular tower or even as a solitary hub will be diminutive in comparison to developing a wired solution. The wide, flat expanses and low population density of such an area lends itself well to WiMAX and its current diametrical range of 30 miles. For countries that have skipped wired infrastructure as a result of inhibitive costs and unsympathetic geography, WiMAX can enhance wireless infrastructure in an inexpensive, decentralized, deployment-friendly and effective manner.

Another application under consideration is gaming. Sony and Microsoft are closely considering the addition of WiMAX as a feature in their next generation game console. This will allow gamers to create ad hoc networks with other players. This may prove to be one of the "killer apps" driving WiMAX adoption: WiFi-like functionality with vastly improved range and greatly reduced network latency and the capability to create ad hoc mesh networks.

Another important application of the WiMAX technology is the Govt. security. Communication is crucial for government officials as they try to determine the cause of the problem, find out who may be injured and coordinate rescue efforts or cleanup operations. A gas-line explosion or terrorist attack could sever the cables that connect leaders and officials with their vital information networks. WiMAX could be used to set up a back-up (or even primary) communications system that would be difficult to destroy with a single, pinpoint attack. A cluster of WiMAX transmitters would be set up in range of a key command center but as far from each other as possible. Each transmitter would be in a bunker hardened against bombs and other attacks. No single attack could destroy all of the transmitters, so the officials in the command center would remain in communication at all times.

8. SCENARIO OF WiMAX:

An Internet service provider sets up a WiMAX base station 10 miles from your home. You would buy a WiMAX-enabled computer (some of them should be on store shelves in 2005) or upgrade your old computer to add WiMAX capability. You would receive a special encryption code that would give you access to the base station. The base station would beam data from the Internet to your computer (at speeds potentially higher than today's cable modems), for which you would pay the provider a monthly fee. The cost for this service could be much lower than current high-speed Internet-subscription fees because the provider never had to run cables.

If you have a home network, things wouldn't change much. The WiMAX base station would send data to a WiMAX-enabled router, which would then send the data to the different computers on your network. You could even combine WiFi with WiMAX by having the router send the data to the computers via WiFi.

The smallest-scale network is a personal area network (PAN). A PAN allows devices to communicate with each other over short distances. Bluetooth is the best example of a PAN.

The next step up is a local area network (LAN). A LAN allows devices to share information, but is limited to a fairly small central area, such as a company's headquarters, a coffee shop or your house. Many LANs use WiFi to connect the network wirelessly.

WiMAX is the wireless solution for the next step up in scale, the metropolitan area network (MAN). A MAN allows areas the size of cities to be connected.

9. NETWORK SCALE:

The wireless networking, in the broad sense may be classified into three major types. They, in the order of the area they span over, are given below:

9.1. PAN *(Personal Area Network):*

The standard used here is the IEEE 802.15 standard. The best example for this is Bluetooth.

9.2. LAN (*Local Area Network***):**

The standard used here is the IEEE 802.11 standard. The best example for this is WiFi.

9.3 MAN (*Metropolitan Area Network*):

The standard used here is the IEEE 802.16 standard. The best solution for this is WiMAX.

10. Conclusion:

The IEEE 802.16 family of standards and its associated industry consortium, WiMax, promise to deliver high data rates over large areas to a large number of users in the near future. This exciting addition to current broadband options such as DSL, cable, and WiFi promises to rapidly provide broadband access to locations in the world's rural and developing areas where broadband is currently unavailable, as well as competing for urban market share.

The WiMAX protocol is designed to accommodate several different methods of data transmission, one of which is Voice Over Internet Protocol (VoIP). VoIP allows people to make local, long-distance and even international calls through a broadband Internet connection, bypassing phone companies entirely. If WiMAX-compatible computers become very common, the use of VoIP could increase dramatically. Almost anyone with a laptop could make VoIP calls.

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