WiMAX is an acronym that stands for Worldwide Interoperability for Microwave Access. 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. It can provide a wireless alternative to cable and DSL for last mile (last km) broadband access. WiMAX is the wireless solution for the next step up in scale, the metropolitan area network (MAN). WiMax does not conflict with Wi-Fi but actually complements it. A WiMax system consists of two parts: A WiMax tower & A WiMax receiver. WiMAX has the potential to do to broadband Internet access what cell phones have done to phone access. Some cellular companies are also evaluating WiMAX as a means of increasing bandwidth for a variety of data-intensive applications. The purpose of this Paper is to highlight and assess the value of WiMAX as the right solution to:
• offers cheap voice calls and high speed internet
• ensures a boost for government security
• extend the currently limited coverage of public LAN (hotspots) to citywide coverage (hot zones) the same technology being usable at home and on the move,
• blanket metropolitan areas for mobile data-centric service delivery,
• offer fixed broadband access in urban and suburban areas where copper quality is poor or unbundling difficult,
• bridge the digital divide in low-density areas where technical and economic factors make broadband deployment very challenging.

In addition to these uses, this paper will highlight other potential applications, such as telephony or an effective point-to-multipoint backhauling solution for operators or enterprises

1. INTRODUCTION

WiMAX is an acronym that stands for Worldwide Interoperability for Microwave Access, a certification mark for products that pass conformity and interoperability tests for the IEEE 802.16 standards.

Products that pass the conformity tests for WiMAX are capable of forming wireless connections between them to permit the carrying of internet packet data. It is similar to Wi-Fi in concept, but has certain improvements that are aimed at improving performance and should permit usage over much greater distances. 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.

2. TECHNICAL ADVANTAGES OVER WIFI

Because IEEE 802.16 networks use the same Logical Link Controller (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 (PHY) 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 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. A recent addition to the WiMAX standard is underway which will add full capability by enabling WiMAX nodes to simultaneously operate in "subscriber station" and "base station" mode. This will blur that initial distinction and allow for widespread adoption of WiMAX based mesh networks and promises widespread WiMAX adoption. 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.

3. HOW WIMAX WORKS

A WiMAX system consists of two parts:

A WiMAX tower, similar in concept to a cell-phone tower - A single WiMAX tower can provide coverage to a very large area -- as big as 3,000 square miles (~8,000 square km). A WiMAX receiver - The receiver and antenna could be a small box or PCMCIA card, or they could be built into a laptop the way WiFi access is today.

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. What this points out is that WiMAX actually can provide two forms of wireless service:

- 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.

WIMAX TRANSMITTING TOWER

In practical terms, WiMAX would operate similar to WiFi but at higher speeds, over greater distances and for a greater number of users. WiMAX could potentially erase the suburban and rural blackout areas that currently have no broadband Internet access because phone and cable companies have not yet run the necessary wires to those remote locations.
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).

The final step in the area network scale is the global area network (GAN). The proposal for GAN is IEEE 802.20. A true GAN would work a lot like today's cell phone networks, with users able to travel across the country and still have access to the network the whole time. This network would have enough bandwidth to offer Internet access comparable to cable modem service, but it would be accessible to mobile, always-connected devices like laptops or next-generation cell phones). This is what allows WiMAX to achieve its maximum range.

5. USES FOR WIMAX

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 price points 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.

Think about how you access the Internet today. There are basically three different options:

- Broadband access - In your home, you have either a DSL or cable modem. At the office, your company may be using a T1 or a T3 line.
- WiFi access - In your home, you may have set up a WiFi router that lets you surf the Web while you lounge with your laptop. On the road, you can find WiFi hot spots in restaurants, hotels, coffee shops and libraries.
• Dial-up access - If you are still using dial-up, chances are that either broadband access is not available, or you think that broadband access is too expensive.

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. What if there were a new technology that solved all of these problems? This new technology would provide:

• The high speed of broadband service
• Wireless rather than wired access, so it would be a lot less expensive than cable or DSL and much easier to extend to suburban and rural areas
• Broad coverage like the cell phone network instead of small WiFi hotspots

This system is actually coming into being right now, and it is called WiMAX. WiMAX 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. WiMAX will also be as painless as WiFi -- turning your computer on will automatically connect you to the closest available WiMAX antenna.

6. WHAT CAN WIMAX DO?

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.

7. IEEE 802.16 SPECIFICATIONS

• Range - 30-mile (50-km) radius from base station
• Speed - 70 megabits per second
• Line-of-sight not needed between user and base station
• Frequency bands - 2 to 11 GHz and 10 to 66 GHz (licensed and unlicensed bands)

8. WIMAX COULD BOOST GOVERNMENT SECURITY

In an emergency, 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. Here's what would happen if you got 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.

Network scale: 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.

. 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.

WiMAX doesn't just pose a threat to providers of DSL and cable-modem service. 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.

9. TECHNICAL ADVANTAGES

WiMax does not conflict with WiFi but actually complements it.

WiMAX is a wireless metropolitan area network (MAN) technology that will connect 802.11(WiFi) hotspots to the Internet and provide a wireless extension to cable and DSL for last mile (last km) broadband access. 802.16 provides up to 50 km (31 miles) of linear service area range and allows users connectivity without a direct line of sight to a base station. The technology also provides 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 hundreds of homes at DSL-type connectivity.

An important aspect of the 802.16 is that it defines a MAC layer that supports multiple physical layer (PHY) specifications. This is crucial to allow equipment makers to differentiate their offerings.

10. CONCLUSION
The WiMAX forum, backed by industry leaders, helps the widespread adoption of broadband wireless access by establishing a brand for technology. Initially, WiMAX will bridge the digital divide, 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 endorsers 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.

11. GLOSSARY

CPE: Customer Premise Equipment
DSL: Digital Subscriber Line
FDD: Frequency Division Duplex
MAC: Media Access Control
MIMO: Multiple-Input-Multiple-Output
NLOS: Non-Line-Of-Sight
OFDMA: Orthogonal Frequency Division Multiplex Access
PLC: Power Line Communications
POTS: Plain Ordinary Telephone System
STC: Space Time Coding
TDD: Time Division Duplex
WLAN: Wireless Local Area Network
WLL: Wireless Local Loop

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