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Final Report  
WiMAX

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Abstract:

The newest generation of internet connectivity is Worldwide Interoperability for Microwave Access, or more commonly know as “WiMAX,” now in a pre-launch and marketing stage. WiMAX is a certification mark for products that conform to the Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard.

WiMAX is similar to WiFi but it operates at greater speeds, over a greater distance and for a greater number of users. WiMAX has the potential to bring internet connectivity to rural areas that as of yet do not have internet connectivity.

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## Introduction

Since the emergence of the internet in the early 1990s, ways to connect have greatly varied. Within recent years wired connections are becoming obsolete and the demand for alternative “last mile” technologies is getting higher and higher.

The newest generation of internet connectivity is Worldwide Interoperability for Microwave Access, or more commonly know as “WiMAX,” now in a pre-launch and marketing stage. WiMAX is a certification mark for products that conform to the Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard.

WiMAX is similar to WiFi but it operates at greater speeds, over a greater distance and for a greater number of users. WiMAX has the potential to bring internet connectivity to rural areas that as of yet do not have internet connectivity.

The Purpose of this report is to provided an in depth look at the WiMAX technology, its strengths and weaknesses and compare it to other current technologies.

## What is WiMAX?

Simply put WiMAX is a wireless broadband technology that takes internet connectivity that is limited to the home or office and makes it available anywhere and anytime on laptops and mobile phones. Strictly speaking WiMAX is not a specific product but rather a certification mark for products that conform to the IEEE (Institute of Electrical and Electronics Engineers) 802.16 standard. So what exactly is the 802.16 standard?

Since the first 802.16 standard was approved in 2001 numerous amendments have been made. Figure 1 shows a brief timeline of these amendments.

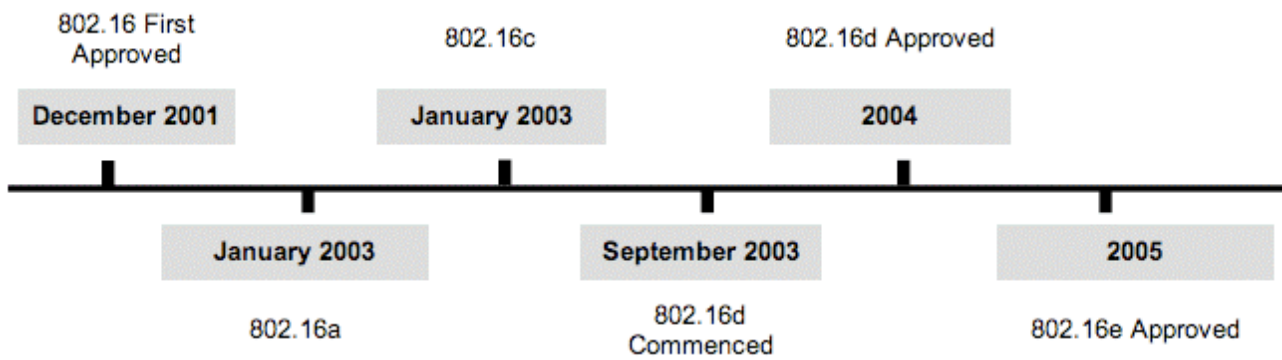


Figure 1: Timeline of WiMAX standards

As figure 1 shows the latest standard is 802.16e-2005, often referred to as 802.16e or “Mobile WiMAX”. This standard incorporates two parts of the air interface; the physical layer (PHY) and the media access control layer (MAC). So what are PHY and MAC?

The physical layer in the 802.16e standard uses scalable OFDMA to transmit data. OFDMA (Orthogonal Frequency Division Multiple Access) divides a signal into sub-channels, each user is allocated a different sub-channel. Therefore each user’s sub-channel is independent of any other sub-channel regardless of location, interference or power requirements; giving users simultaneous low data rate transmission. OFDMA is a registered trademark of Runcom Technologies Ltd. who has said:

*“OFDMA enables carriers to traverse the last-mile bottleneck and provide subscribers with enhanced broadband services. The optimized use of bandwidth for the simultaneous, bi-directional and high-speed flow of data for multiple subscribers is allocated according to customer requirements.”*  
(Runcom Technologies Ltd., 2007)

The 802.16e standard’s physical layer supports adaptive modulation and coding. This is when signal and protocol parameters, such as modulation and coding, are matched to the conditions on the radio link. These conditions include things like interference coming from other transmitters, receiver sensitivity or the available transmitter power margin. This means that coding schemes ranging from BPSK (Binary Phase-Shift Keying) right up to the very efficient 64 QAM can be used.

As has already been stated the WiMAX 802.16e standard can transmit using the very efficient 64 QAM coding scheme, but what is 64 QAM? Quadrature Amplitude Modulation is when

modulating the amplitude of two carrier waves to represent the data signal changes the carrier signal. This is much more sensitive than BPSK but gives a much higher bandwidth.

Finally the 802.16e standard's physical layer supports Multiple-In Multiple-Out (MIMO) antennas and Hybrid Automatic Repeat Request (HARQ). MIMO is when there are multiple antennas on both the receiver and transmitter. This improves the reception, reach and rate of transmission. MIMO also increases the spectral efficiency in WiMAX, which is the amount of data that can be transmitted over a specified bandwidth over a period of time.

*“MIMO uses multiple transmitters and antennae to provide increased bandwidth and maximize spectral efficiency.” (David Meyer, 2006)*

HARQ is an error control method. It is a variation of the standard ARQ error control method, which uses acknowledgments and timeouts. A receiver sends out an acknowledgment to the transmitter to let it know that it has successfully received the data. A timeout is a period of time that the transmitter should receive the acknowledgment within, if it doesn't receive it within the timeout period then the transmitter re-sends the data. Hybrid ARQ uses forward error correction; the transmitter adds redundant data to the already existing data, which allows the receiver to detect and correct errors without the need for the transmission of additional data. HARQ performs better than standard ARQ in poor signal conditions.

The MAC layer in the 802.16e standard uses a scheduling algorithm. Users are allocated a slot on the channel, which other users cannot access. The scheduling algorithm allows control over Quality of Service (QoS). In addition the MAC layer includes handover and power saving mechanisms as well as describing any security required during transmissions.

How is the 802.16e standard transmitted? So far we have looked at what the 802.16e standard is but how does it get to a user's device and give them internet connectivity? A WiMAX network needs to consist of at least two parts:

- A WiMAX tower
- A WiMAX receiver

The WiMAX tower could be compared to a mobile phone mast and has the power to cover an area as large as 3,000 square miles (howstuffworks.com, 2007). The WiMAX receiver works in a way similar to how a WiFi signal is received. It could be in the form of a small box or built into product to automatically receive a WiMAX signal.

*“The technology behind WiMAX has been optimized to provide excellent non-line-of-sight (NLoS) coverage. NLoS advantages are coverage of wider areas, better predictability of coverage and lower cost as it means fewer base stations and backhaul, simple RF planning, shorter towers and faster CPE install times. Thanks to techniques for improving NLoS coverage, such as diversity, space-time coding, and Automatic Retransmission Request (ARQ), coverage are increased.” (WiMAX Forum, 2007)*

WiMAX can use either of two types of wireless networks:

- Line-of-Sight (LoS)
- Non-Line-of-Sight (NLoS)

LoS connections are normally between two fixed WiMAX towers. A LoS signal is strong and more stable and therefore able to send data quicker with fewer errors. Line-of-sight means exactly what it sounds like i.e. there are no physical obstructions in the way of the signal transmission. This type of connection between two WiMAX towers is often referred to as the backhaul.

NLoS connections are normally between a WiMAX tower and a piece of user equipment. As it is a NLoS connection it has to work on a lower frequency range. Therefore it is not easily disrupted by any physical obstructions but does not provide as much bandwidth as a LoS connection can. Figure 2 shows a simple diagram on how WiMAX works:

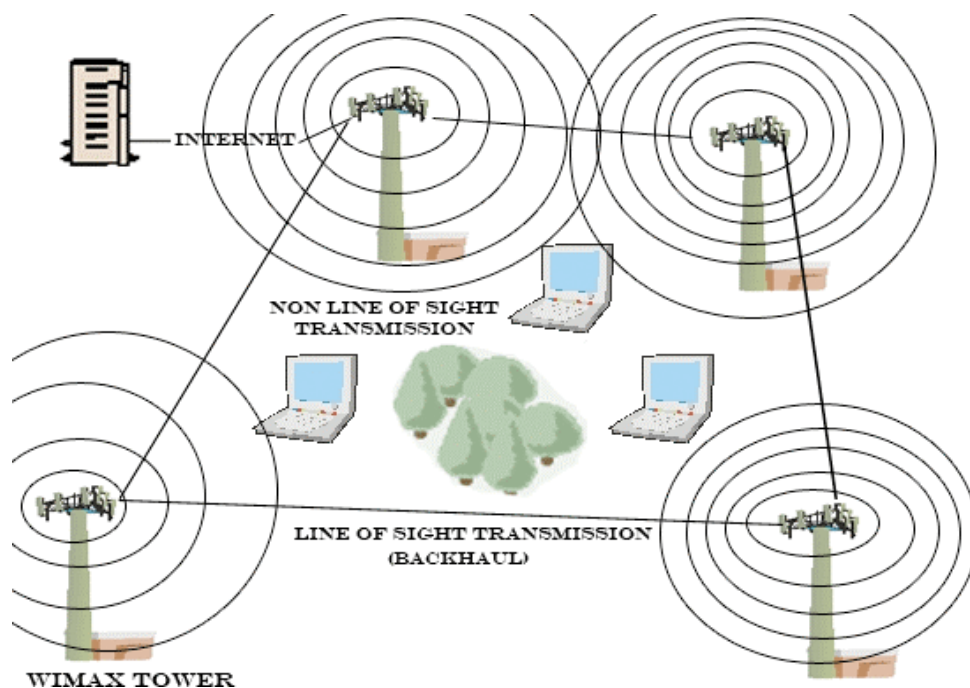


Figure 2: How WiMAX Works Diagram

WiMAX receivers come in either of two forms, an outdoor and an indoor version. For an indoor version to work well the user needs to be close to the WiMAX tower. If a user is not close to a WiMAX tower then a professionally installed outdoor unit would be a better option. Outdoor units are comparable to a home satellite dish whereas indoor units are more like a DSL modem / router.

## How Does WiMAX Move Things Forward?

The many advantages of WiMAX could be used in a wide range of applications quickly and effectively with lower costs than today's already established technologies. Some of these applications could include:

- **Mobile Phone Network Backhaul** – WiMAX can provide point-to-point links of up to 30 miles (WiMAXforum.org, 2005). Therefore mobile phone operators could use WiMAX as a backhaul instead of a wired alternative at a far greater expense.
- **Wireless Service Provider Backhaul** – Even if WiMAX is not used as a “last mile” solution, it could be used as a backhaul for wireless service providers. Again deployment of a wired solution would be far more costly and take more time to install.
- **Education Networks** – School boards could use WiMAX to connect schools within a district. Classroom instruction could be delivered in real time between two or more schools using video link via a private WiMAX network.
- **Public Safety** – WiMAX networks could be used to aid response in emergency situations. As well as two-way voice communication, video communication could also be relayed between the accident / disaster site to a dispatch centre allowing emergency teams to assess situations in real time. Also mobile WiMAX could allow emergency teams to access databases of information from moving vehicles.
- **Offshore Communications** – WiMAX could provide a communications link between land-based facilities and offshore sites to support remote operations. WiMAX networks are quickly and easily deployed, even when offshore sites are moved to a different location.
- **Campus Connectivity** – Multiple locations within campuses could be connected via WiMAX. Deployment times would be significantly lower than with wired solutions as minimal construction is required.
- **Temporary Construction Communications** – As construction sites are temporary wired solutions are impractical. WiMAX equipment is highly portable so therefore can be redeployed and reused at other construction sites.

- **Rural Connectivity** – WiMAX is a much more cost-effective solution for rural locations where little or no infrastructure is available.

(WiMAX Forum, 2005)

## What Does WiMAX Do For The Multimedia Industry?

WiMAX is a fast growing technology that could bring Internet connectivity to homes in rural or blackout areas that are not currently covered by broadband providers, thus bringing the internet to more people. WiMAX has a greater range than current WiFi setups. "WiFi hotspots" take a number of WiFi transmitters to work and even then the distance covered is significantly smaller than a single WiMAX tower could cover an entire city with a WiMAX internet connection giving many people internet on the move.

*“WiMAX enjoys widespread support throughout the industry, as it allows highly innovative applications to emerge from anywhere in the world. Applications such as voice, video streaming and online gaming will work significantly better, and WiMAX provides an effective platform for broadcast, on-demand and interactive video applications. With WiMAX providing the connections, service providers can offer customers a host of rich applications: mobile TV, video telephony, real time trading, location-based services. The possibilities are tremendous and the opportunity is exceptional.” (Motorola, 2007)*

On the move internet connectivity is the main advantage that WiMAX will bring to the multimedia industry. It will mean easy access to a vast range of media content on the move. Current luxuries such as mobile TV and video telephony could become everyday practice with WiMAX.

## WiMAX – A Comparison With WiFi

*Besides the obvious difference transmission range, there are a number of improvements in the radio link technology that distinguish WiMAX from WiFi.” (Michael F. Finneran, 2004)*

There is no doubt that WiMAX and WiFi are similar and could be very easily confused (both standards begin with 802), it has been said by many people “WiMAX is WiFi on steroids”. However they are both aimed at different applications. Before the differences are looked at the similarities must first be addressed. First of all both WiMAX and WiFi are standards published by the IEEE. WiFi is commonly known as the 802.11 standard and, as already has been stated, WiMAX is the 802.16 standard. Both technologies are deployed in a similar way i.e. a transmitter beams a signal to a receiver. Many differences in the two technologies do exist. First of all there is the obvious difference, the transmission range of the two technologies. WiMAX is a long-range technology that can transmit over many miles (an entire city) but WiFi is a short-range technology that can only transmit over a few metres (one household). WiMAX is used as a point-to-point connection from the internet service provider (ISP) to an end user; WiFi is used only by an end user to connect to their own network, which may not even be connected to the internet.

*“WiFi implementations use unlicensed frequency bands, WiMAX can operate in either licensed or unlicensed spectrum” (Michael F. Finneran, 2004)*

WiMAX does not operate on a globally licensed spectrum, however the WiMAX Forum has stipulated three licensed spectrum profiles for WiMAX use: 2.3GHz, 2.5GHz and 3.5GHz. WiFi used the 5GHz and 2.4GHz public spectrum bands.

WiMAX and WiFi differentiate in their quality of service (QoS) mechanisms. WiFi uses a mechanism where data packets are prioritised based on their tags. Whereas WiMAX has a guaranteed QoS. Each WiMAX connection between a WiMAX tower and a user is based on a scheduling algorithm that guarantees QoS.

The final difference between WiMAX and WiFi is security. WiMAX support the Advanced Encryption Standard (AES) and the Triple Data Encryption Standard (3DES), this provides users with security across the broadband wireless interface. Encryption used in a WiFi network is weak at best and its biggest disadvantage is that it has to be set up by the user. Therefore less technically minded users will have little or no security on their wireless network, leaving them open to unauthorised users.

Conclusions to be drawn from this comparison point to the superiority of WiMAX; even though the two technologies are used for different applications, it is clear that if choice had to be made between the two WiMAX would come out on top.

## Strengths of WiMAX

The strengths of WiMAX are many in number. Some of them could include:

- **Cost Efficiency** – The very fact that WiMAX is a wireless technology means that the expensive procedure of laying cables can be avoided. This removes the cost of labour, materials, land, etc and can be replaced with the cost of only installing a WiMAX tower. This could help, bring internet connectivity to rural areas, without the cost of wires WiMAX could easily be deployed in less densely populated areas.
- **Mobility of Data** – WiMAX could bring data on the move to many users, anywhere a WiMAX connection is available and a user has appropriate WiMAX ready devices, internet connectivity will be available. Not only does this have to potential of real time media streaming, there is also the potential for VoIP on the move. Services such as Skype could be used in conjunction with a WiMAX enable mobile phone, bringing cheaper phone calls to many people.
- **Mobility of Equipment** – Not only is data mobile with WiMAX but the equipment is portable also. WiMAX towers can be quickly and easily redeployed and reused in a completely different location, enabling WiMAX networks to be setup in many different locations after it is no longer required in a previous location.
- **Wider Coverage** – WiMAX offers a much wider coverage than any current WiFi hotspot. One WiMAX tower could cover an entire city instead of many WiFi hotspots covering only a small area.

## Weaknesses of WiMAX

Where there are strengths to any technology there are also weaknesses. Some weaknesses of WiMAX include:

- **Lower Data Rates at Greater Distances** – As a user gets further away from a WiMAX tower their data rate will drop. Data rates at theoretical maximums are approximately 75Mbps (wimax.com, 2007). In reality data rates are 1-5Mbps (WiMAXforum.org, 2007), which will only get lower as a user gets further away from the source.

- **WiMAX is Power Intensive** – Advances in battery technology are limited compared to advances in processor technology.

*“Power-efficient modulation and coding schemes tend to be less spectrally efficient. Since spectral efficiency is also a very important requirement for broadband wireless, it is a challenge to make the appropriate trade-off between them.” (WiMAX.com, 2007)*

As WiMAX is a power intensive technology, it will require strong electrical support. Is today's current battery technology able to handle this level of power intensity?

- **Multiple Users On One Channel** – As has already been stated each WiMAX signal is divided up into sub-channels and each user is allocated a different sub-channel, however this means that each signal is going to many different users

*“A single WiMAX base station or node should be able to serve thousands of subscribers.” (WiMAXform.org, 2007)*

The WiMAX signal being divided up between many different users means that the bandwidth will also be divided up, at peak times data rates could become very low.

## Evaluation

From this report many conclusions could be drawn, there is a real concern that WiMAX may be vapourware. As it has been in development for almost a decade this concern is growing. Although with an equally growing list of deployed networks it is yet to be seen weather or not WiMAX will make it worldwide. Based on this report it is clear that WiMAX is a real contender for wireless internet connectivity, not only as a last mile solution but also as a strong backhaul solution. With strengths such as cost effectiveness out weighing few weaknesses, it is hard to see why WiMAX would not be used.

What does the future hold for WiMAX? With the 802.16m amendment in progress, mobile data rates of up to 100 Mbit/s and fixed data rates of up to 1 Gbit/s are looking likely. WiMAX has the potential of the way we all connect.

## References

Brain, Marshall & Grabianowski, Ed. (2007). *How WiMAX Works*. Available: <http://computer.howstuffworks.com/wimax1.htm>. Last accessed 02 Dec 2007.

David Meyer. (2006). *Mobile WiMAX to hit UK mid-2007*. Available: <http://news.zdnet.co.uk/communications/0,1000000085,39284060,00.htm>. Last accessed 30 Nov 2007.

Michael F. Finneran. (2004). *WiMAX Verses WiFi - A Comparison of Technologies, Markets, and Business Plans*.

Motorola. (2007). *Motorola WiMAX Benefits and Applications*. Available: <http://www.motorola.com/content.jsp?globalObjectId=7903-11115>. Last accessed 10 Dec 2007.

Runcom Technologies Ltd. (2005). *OFDMA Overview*. Available: <http://www.runcom.com/SiteFiles/1/2/13.asp>. Last accessed 30 Nov 2007.

Westech Communications Inc. on behalf of the WiMAX Forum. (2005). *Can WiMAX Address Your Applications?* Available: [http://www.wimaxforum.org/technology/downloads/Can\\_WiMAX\\_Address\\_Your\\_Applications\\_final.pdf](http://www.wimaxforum.org/technology/downloads/Can_WiMAX_Address_Your_Applications_final.pdf). Last accessed 07 Dec 2007.

WiMAX.com. (2007). *1.7.5 Portability*. Available: [http://www.wimax.com/commentary/wimax\\_weekly/1-7-5-portability/?searchterm=power%20intensive](http://www.wimax.com/commentary/wimax_weekly/1-7-5-portability/?searchterm=power%20intensive). Last accessed 11 Dec 2007.

WiMAX.com. (2007). *What is the actual throughput (data transfer rate) of WiMAX Technology?* Available: <http://www.wimax.com/education/faq/faq38>. Last accessed 10 Dec 2007.

WiMAX Forum. (2007). *Frequently Asked Questions*. Available: <http://www.wimaxforum.org/technology/faq/>. Last accessed 01 Dec 2007.