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An overview of Worldwide Interoperability for Microwave Access

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Abstract

WiMAX signals the arrival of the next wave of wireless data technologies. Unhampered by the short range and data orientations of WLAN's these technologies will see users having high speed wireless on the road. WiMAX deployments are similar to that used in a WiFi network. ISPS use line of sight antennas which connect non line of sight antennas which beam the signal to residential and business clients WiMAX LOS(line of sight) antennas operate at frequency of 60mhz. The distribution antennas from the ISPS do not have to have to have LOS. The non line of sight towers operate in a range similar to that of WiFi. WiMAX does not suffer from interference such as mobile phone masts. Once in the residential building the WiMAX base station beams a signal to the WiMAX receiver in a desktop or notebook receiver. This is very similar to the process in a WiFi LAN. Third world countries will greatly benefit from deploying WiMAX networks. African countries are now going to start deploying WiMAX networks instead of cell phone networks and disaster zones could also utilize WiMAX giving them the ability to distribute crisis information quickly and cheaply. This paper provides an overview of WiMAX.

Keywords: Sociology, management, sociotechnical approaches, research, epistemology.

Introduction

Wireless communications can trace its history back to the start of the twentieth century and to the electrical engineer Nikola Telsa, who pioneered the early development on radio and wireless technologies. Perhaps the most well known of the early developers was Guglielmo Marconi, who developed early wireless communication through telegraphy and radio. During the nineteen sixties the space race between the USA and the USSR allowed for the development of communicating networks, the USA created a number of agencies that required to communicate and share information, the agencies setup a network between there facilities this network was to become more commonly known as Arpanet. In Hawaii, the Aloha net was born allowing for wireless networking (Wikipedia, 2006). The next major step in the evolution was mobile telecommunications. Wireless communication has developed rapidly in the last 10 years in the field of mobile telephone communications and more recently with the wireless network communications through the 802.11 groups of standards, more commonly known as Wi-Fi. The success of Wi-Fi has served only to encourage the development of WiMAX, which with the slow

rollout of mobile 3G technologies has only served to confirm the emergence of mobile WiMAX has a viable technology and alternative.

WiMAX development has been driven by the WiMAX Forum, this is an industry-based consortium that was set-up to promote and certify the compatibility and interoperability of broadband wireless access equipment with conformance to the IEEE802.16 set of standards. In particular the technology more commonly known as mobile WiMAX or IEEE 802.16e will be studied, this in some quarters is seen as possibly the most important member of the IEE 802.16 group of standards with the greatest potential. WiMAX transmits data from a single location point within a city to multiple locations throughout that city or cities. WiMAX is a high speed internet wireless technology planned purposely for outsized IP networks providing superior coverage than its rival competitor Wi-Fi. WiMAX will make sure that it will be more cost-effective than other wireless technologies by ensuring compatibility between high speed internet wireless access equipment. WiMAX is available in two different standards. 802.16-2004 is for fixed networks and 802.16e is for mobile. The 802.16-2004 is rigid, moveable and nomadic; the 802.16-2004 can be accessed in two different approaches, Line of Sight and Non Line of Sight. It can reach frequency bands of 5.8GHz.The 802.16e standard supports mobile access in frequency bands of up to 3.5GHz. This paper provides an overview of WiMAX, the history and evolution of wireless networking and current developments relating to WiMAX.

WiMAX

The Worldwide Interoperability for Microwave Access (WiMAX) is based on the IEEE 802.16 set of standards that have been developed from a need to have a standardized platform on which broadband wireless access could be introduced. The initial scope was that the technology would allow a standardization of technology that was already in use by communications companies who were using the technology to connect between the communication end users and the telecommunications backbone, but these various vendors each had there own proprietary solutions which were not inter-operability, as a local in-house solution this was acceptable but inhibited acceptance and growth in the wider market. Areas of opportunity and growth out with the original remit were then realized and seen as markets to which the technology could be aimed. The market that took a major lead was fixed wireless access, this was seen as an opportunity to allow broadband access to areas that lacked DSL or cable services, and in the past a major obstacle to this was the cost of the “final mile” (Marks, 2005), which is the connection between the infrastructure backbone and the customer’s home or place of work.

The technology when used in these circumstances has a typical deployment area of between three to ten kilometres without direct line of sight to a base station, which if used in major towns and cities would allow full coverage from a small number of base station, with this the need for expensive and high maintenance fixed wire solutions would be negligible. This is seen as a large growth market in developing and third world countries where current infrastructure is limited and the installation of new systems is prohibitive due to the costs. In remote areas or where the terrain makes fixed solutions difficult to deploy the advantages of the technology can also be utilized, with a range of up to fifty kilometres from emitter to receiver the cost difference between wired and wireless solutions are significant (see Figure 1).

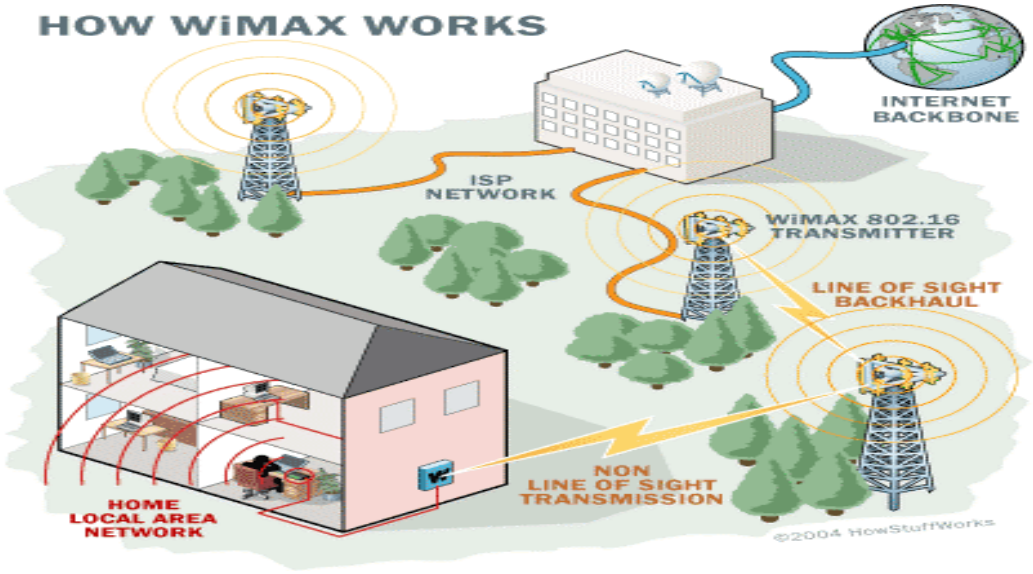

Figure 1. How WiMAX works (Grabianowski and Brain, 2006)

The natural progression of the technology was then to investigate how it would be implemented in a truly wireless situation rather than a fixed wireless scenario, for this a different set of objectives were realized and from this the IEE 802.16e standards were published in December of 2005, these standards would allow for the technology to be developed to allow high speed data access to be available to the mobile market. The mobile WiMAX market is seen as the most lucrative with possible earnings of up to US$45 billion per year from networking equipment only, compared to the fixed market with projected earnings of US$500 million per year (CISCO, 2006). The scope of uses for mobile WiMAX encompasses different technologies from mobile telephones to laptops to PDA's, in the telecommunication market mobile WiMAX is seen as a viable competitor to 3G technologies, currently the rollout and take-up of 3G services has been slower than expected due to high costs.

WiMAX can be used for a number of applications, including "last mile" broadband connections, hotspot and cellular backhaul, and high-speed enterprise connectivity for businesses. Mobile WiMAX (802.16e) is part of a group of broadband wireless communications standards for Metropolitan Area Networks developed by IEEE. It complements the earlier standard of 802.11 for Wireless LANs. The earlier versions of 802.16 a b c and d are only for fixed Wireless connections 802.16e enables connections for mobile devices. WiMAX uses microwaves to transfer data through the air at high speed for a number of miles. The earlier standard 802.11 uses channels to transmit and receive data and voice from a fixed width of the bandwidth spectrum. WiMAX 'condenses' these channels narrowing the bandwidth allowing more users access and to be served. The same spread of the spectrum is used but more channels are available due to the 'narrowing' and more data is sent along the channels. The highway if you like is divided into more lanes and more traffic is packed into each lane. The same core technology underpins both

802.11 and 802.16e but WiMAX exceeds in distance by miles versus feet. This means that you can wander around buildings or areas there are hotspots and maintain your broadband connection. However, since the standard has only recently been ratified commercialization and true mobility will not be available for a couple of years. The 802.16e standard covers data rates from 1.5Mbps to 70Mbps over distances in excess 20 miles, although the farther away the lower the data rate. 802.16e is viewed as compatible with the 802.11 Wi-Fi LAN standards in that it can extend its range and support higher data rates.

WiMAX so far can be viewed as a complementary technology to 3G. However the WiMAX Forum and IEEE (both groups work to produce and test the standard) are keen to include greater interoperability in the standard. So when devices that are Mobile WiMAX enabled are actually produced commercially, different manufacturers' equipment and systems will be able to work together. Mobile WiMAX has clearly fixed its crosshairs on wireless data, which means it poses a potential threat to Wi-Fi but it also is aiming to include wireless voice which is perceived by the Telecom operators as a threat to their monopolies particularly with respect to what is know as the Last Mile. Last Mile refers to the last leg of getting broadband technology to the users house, which although is often a relatively short distance from the exchange becomes extremely expensive because of all the costs involved in getting the physical cable to the users house, such as labour, digging up the roads, the cost of the equipment etc, and the return on the investment shows little or no profit. With WiMAX the last mile does not present the same obstacles. Mobile WiMAX also alleviates the problems associated with 'backhaul' which means getting the network data on to the backbone so that it can be redistributed or routed to another location. The current explosion in Wi-Fi means that a lot of investment has been put into deploying and promoting the WLANs (Wireless Local Area Networks) but one of the problems users of Wi-Fi run into is what is referred to as 'no-connection space'. This is where the user basically is 'out of coverage' for about five minutes on average in a Metropolitan Area Network hotspot configuration. What WiMAX aims to achieve in the long-term is for the nomadic user to get a connection anytime anywhere and become a mobile user. The difference between the nomadic user and the mobile user is that the mobile user is connected all the time on the go, while the nomadic user finds a hotspot gets connected, disconnects, moves to another hotspot connects and so on. A similar explosion in Mobile WiMAX to that of Wi-Fi would see an estimated 2-4 million subscribers by 2008, with expected sales and revenue in excess of $1 billion. (Barry et al, 2005).

The type of connection being referred to in the WiMAX specification is high-speed broadband connectivity to the internet or Broadband Wireless Access (BWA). People who experience internet access using broadband tend to leave their connection open, remaining almost always connected to the internet. WiMAX recognizes this could be a major selling point for the new technology; that no matter where you are you will always be connected. Of course there are obstacles to this and the standard must address such things as interoperability, network security and roaming. The interoperability is dealt with in 802.16e and addresses the problem quickly discovered by Wi-Fi operators as they tried to extend their WLANs. They got equipment that was built to extend WLANs but it would not work with their particular brand of Wi-Fi equipment. The maximum transmission range for Wi-Fi is about 50 feet in an urban area so a large number of access points are needed to provide decent coverage for the area and to meet

customer expectations. The deployment of Wi-Fi tends to take on a mesh-like topology largely because the Wi-Fi chipsets are very inexpensive and are being built into more and more devices. WLANs are then deployed in close proximity to each other, each Access Point connecting to each other Access Point. This poses a smaller obstacle to WiMAX. Mobile WiMAX has to convince manufacturers to install WiMAX components in their devices either alongside or in place of the Wi-Fi component. If WiMAX can achieve this then it is sure to accelerate the rapid adoption of WiMAX enabled products. This in turn will facilitate the spread of WiMAX. This ratification opens the door for the mass production of 802.16e compatible technology which will result in standard components that will enhance interoperability. WiMAX can deliver high speed broadband internet access over a wireless connection. It does not require Line of Sight between the source and the endpoint and this distance can range up as far as 50 kilometers providing a shared data rate of up to 70 Mbps. This could provide high speed internet access of 2Mbps for hundreds of home on last mile networks. Of course the service suffers degradation the further away the endpoint is from the source. The source, a Base Station, which would probably be on a tower or some high location, connects the users' devices, or Subscriber Stations, through their antenna, which may or may not be part of their device. This then is connected using a high speed wired connection or microwave point-to-point link in to the backbone, which is the main pipe of the internet. The WiMAX connection can also be routed or bridged into a standard LAN. Due to the absence of wires and cables, deployment of a WiMAX solution can be very fast.

In South Korea there has recently been a recent announcement to allow a WiMAX compatible standard called WiBro to be made available for use in the mobile market. WiBro is not exactly the same as WiMAX but it is based on similar technologies and the success of WiBro is seen as critical to the future of WiMAX (Clendenin, 2005). Within the mobile pc market either by use of laptop or PDA's it is seen that one of the opportunities will be for mobile WiMAX to be utilized in a similar but much larger scale to WiFi networking, it is envisaged that there will be the possibility to allow secure roaming. The success of WiFi can also be used as encouragement to the developers of WiMAX, in recent years the growth of WiFi hotspots where users can connect to the internet using their wireless 802.11 device has grown with many businesses such as restaurants, airports and shopping centres installing them to attract customers, small countries and cities have also taken up the mantle setting up regional wide WiFi zones for general use (Marks, 2005). With limited area coverage at approx 100 meters indoor and 150 meters outside the scope for WiFi is limited unless a mesh network connecting users and transmitters to the network can be utilized.

Each node acts as a repeater, allowing a large network to be constructed at a very low cost, this system can be quite robust with the network being set-up with more than one connection between nodes allowing nodes to leave and join the network without the integrity of the network being affected. This type of network setup and hotspots can be seen as another opportunity for WiMAX, existing networks could be supplied by a WiMAX signal to allow a central transmitter which could then transmit the Wi-Fi signal to create a Wi-Fi hotspot in area's of limited access or not being supplied by a fixed communications infrastructure. The range of potential uses for WiMAX is constantly growing and Figure 2 shows the breath of potential WiMAX applications for service providers. WiMAX can be used in the enterprise environment and the transportation and security industries (Kajian, 2004).

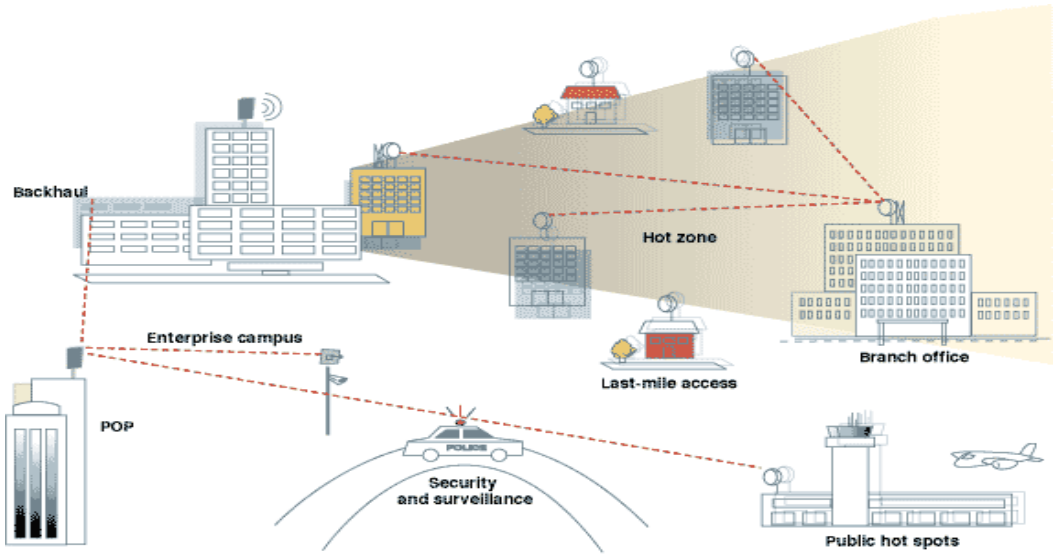

Figure 2. Potential WiMAX application for Service Providers (Kajian, 2004)

WiMAX Forum

The WiMAX Forum was formed in June of 2001 with a mandate to facilitate and assist with the deployment of broadband wireless networks using the IEEE 802.16 standards. The forum would ensure that the equipment being developed for the technology by all manufacturers that were part of the forum would be compatible and inter-operability. The forum from the outset was set-up as a non-profit making organisation that would act as an association for the equipment and component suppliers who were members and ensure adequate promotion for the adoption of the new standard. The forum laid out set principles to which the forum would work towards, they are:

- Support IEEE 802.16 standard
- Propose and promote access profiles for their IEEE 802.16 standard
- Certify inter-operability levels both in network and the cell
- Achieve global acceptance
- Promote use of broadband wireless access overall

With the forum any equipment or component supplier that is a member can ensure that their equipment will be compliant and have full inter-operability with fellow members of the forum's equipment. This certification will ensure that a service provider that is sourcing and or purchasing equipment will have the confidence to know that equipment purchased from different manufacturers who are members of the forum and have their equipment listed as WiMAX Forum Certified will have full inter-operability and will have no major problems inter-connecting the equipment as full testing will have been carried out. The importance of the forum can be seen by reading through the list of the board members, from this list we can see that there is representation from a number of the major manufacturers and service providers on a global scale,

this ensured that there would be global acceptance of the technologies and that the forums initiative would be taken serious and be fully implemented to the one standard worldwide.

The list of the board members above highlights the strength of the forum, this strength can be also be verified with the list of member companies who have joined the forum. The current total is 368, this list of members contains companies from all aspects of the communications industry Dell, Nokia, Motorola, Samsung, Nortel, Cisco and Netgear are all members and show the varied interest from the hardware manufacturing industry. Major communication and service providers on the members list include AOL, AT&T, BT, and Sprint- Nextel.

Technical Overview

IEEE 802.16 standard has been developed for point to multipoint broadband wireless, for use in the range of sub 11GHz and 10-66 GHz frequency and covers the physical and media access control layers of the ISO model. The first standard was approved in December 2001 and was known as 802.16a, this was primarily developed for fixed broadband access, further development was announced in June 2003 with the 802.16-2004 standard which gave more support for customer support equipment, from then there has been a continual development and in December 2005 the 802.16-2005 commonly known as 802.16e standard was finalized, this is better known as the Mobile WiMAX standard, this allowed the standard to be better utilized and to include mobility in the standard which had been primarily developed for fixed operation.

During the development of the standard a number of critical consideration were included in the requirements, the ability to use various physical types would allow for different operating environments to be utilized. Non-line of site conditions can be used in the sub 10GHz frequencies compared to the higher frequencies in the 10 to 66 GHz ranges, which require line of sight; with this wide channels with high capacity links can be setup. The WiMAX standard has been developed to use the same MAC (Machine Access Control) layer for varying PHY (physical layers), this allows for technology to have a high inter-operability with the hardware for different vendors being compatible. The standard uses 256-point orthogonal frequency division multiplexed carrier (OFDM) compared to a 64-point orthogonal frequency division multiplexed, which is used by the 802.11 technologies giving it a higher range. OFDM is a digital encoding and modulation technology that has been previously used in applications used to access applications in DLS and cable systems, within the WiMAX technologies it will allow for the use in non line of sight environments. These non line of sight environments have been addressed by use of the OFDM that allows the ability to deliver higher bandwidth and data rate by using multiple overlapping carrier signals instead of one as with existing networks.

The recent ratification where ‘e’ was appended to 802.16 means that mobility is included. The first 802.16 addressed spectrum ranges from 10 – 66 GHz, was focused on multipath Line of Sight issues which were combatted using orthogonal frequency division multiplexing (OFDM) techniques. It allowed for wide channels greater than 10 MHz in the licensed spectrum. Changes were made to the two layers the MAC layer and the Physical (PHY) layer. The MAC layer uses Point to MultiPoint as its foundation for the Downlink from the Base Station to the Subscriber Station. That means all Subscriber Stations with in a given frequency and antenna sector will receive the same transmissions. In other words the Downlink is broadcast to all unless modified

otherwise. The MAC connection is geared towards Quality of Service and meeting and managing the services being used. This means depending on the users application the transmission can be continual as is with Voice over IP traffic or in bursts such as MPEG transmissions. When the Subscriber Station connects after satisfying a number of criteria based on the DOCSIS standard (Data Over Cable Service Interface Specifications) such Downlink channel synchronisation, range and capability agreement, authentication, registration and IP connectivity, bandwidth is allocated based upon the type of service. The Base Station can manage the allocation by resizing the amount of bandwidth needed by the service being used. In the Mesh topology Subscriber Stations can communicate directly with each other with out having to go through the Base Station. ARQ processing maintains Quality of Service by retransmitting dropped or lost blocks. The scheduling service comprising of the Fast Data Scheduler, dynamic resource allocation and frequency selective scheduiling is designed to deliver the broadband services of data, video and voice efficiently and with in Quality of Service parameters. Three handoff methods are supported; Hard Handoff which is mandatory, Fast Base Station Switching and Macro Diversity Handover. The delay of handover is kept to less than 50 milliseconds.

The Physical layer (PHY) is defined for the 10 – 66 GHz licensed range of the spectrum and supports the 2 – GHz band of licensed and unlicensed spectrum bands. The most significant modification to this layer allows the Non Line of Sight environment to send a signal by different routes. This was enabled by adding the Othogonal Frequency Division Multiplexing (OFDM) modulation scheme. The data is transmitted in the signal with forward error correction in place then using an Inverse Discrete Fourier Transform applied to the data the frequency domain is converted, filtered and modulated up to the carrier frequency using Time Division Multiplexing on the Downlink and Time Division Multiple Access on the Uplink. The 802.16e is based on the OFDMA system. In this system the signal can be divided into many sub-channels that run at lower speeds. This increases the resistence to interference that would be experienced on the non line of sight multipath routes. As noted previously depending on the distance and services being accessed by the user the allocation of sub-channels is dynamically assigned. When the location is in close proximity to the Base Station, QAM, quadrature amplitude modulation can be used for higher bandwidth across several channels. When the distance from the Base Station is great the number of channels being used drops but the power per channel increases ensuring that even if the data rate goes down the user stays connected. OFDM technology uses Fast Fourier Transform (FFT) algorithms to get the frequencies perpendicular (orthogonal) to each other so that the sub-channels can overlap with out causing interference to one another. This method fully utilises the available spectrum. FFT is a formula that uses a variable N, where N can be 1K, 2K, 128, 256 etc. and The fast Fourier transform (FFT) is extremely useful in analyzing unsteady measurements, because the frequency spectrum from an FFT provides information about the frequency content of the signal. So by using this technique, OFDMA in the PHY layer dynamically corrects and stabilizes the multi path spectrum use by Mobile WiMAX. It is important to note that OFDMA and OFDM are two different modes that have very much in common. Both support high data rates, utilizing multipath methods to increase signal quality in non line of sight environments and the ability to split channels up into many sub channels. Both also support Time Division Duplex (TDD) and Frequency Division Duplex (FDD) in the modulation scheme to dynamically shift the allocation depending on capacity and proximity. OFDMA is also scalable which means it can adapt to the different channel frequencies in

different countries, and can use a variety of FFT versions. Deciding on the type of architecture to deploy is dependent on whether to use TDD or FDD. TDD will only transmit or receive at a specified time, reducing interference because the transmitter is off when the receiver is on, however this can create problems when switching modes and reduce throughput and curtailing the number of users supported. It is economical due to the reuse of the local oscillator to generate the frequency which saves in space and costs and components. FDD can be employed in both the Base Station and the Subscriber Stations; it uses two different frequencies to transmit and receive at the same time. This method uses up a considerable amount of the spectrum bandwidth but does give higher throughput and can support a lot more users. All these factors come into play when approving the standard. At least three manufacturers have to agree to provide a basis for interoperability. The choice will affect the mobility and speed of handoff (going from one cell to another), the spectrum range and size of channels available.

The Last Mile

A phrase that is commonly associated with WiMAX technologies but not necessarily mobile WiMAX is "The Last Mile", this is described as being the Holy Grail in communications infrastructures, and needs to be explained to understand the demand for this new technology. With the development and rollout of broadband services globally the bottleneck worldwide has been the connection between the infrastructure backbone and the end user customer either domestic or commercial. In the developed world the telecommunications network has been established and in place for a long period of time and totally unsuitable to use with the new technologies, the cost of replacing this has been high with a large financial outlay to the companies that have went ahead with the upgrade, in the developing world the cost of installing this technology is not possible due to financial constraints. It is also seen that major telecommunication companies own and manage the network infrastructure and are therefore in an advantageous position for implementing the broadband technologies, to allow for more competition by means of allowing more service providers to enter the market giving the customer more choice. The wireless networks supplied by WiMAX will allow for low cost installation and maintenance of the network, for both provider and customer.

WiMAX Versus 3G and Wi-Fi

WiMAX can and does give more significant advantages of wireless technology over WIFI. WiMAX presents a superior range and has more bandwidth on offer. WiMAX could eventually take out most of the cabled networks that connect to the internet as it can provide connectivity to whole towns and cities. WiMAX could even replace the WIFI receivers that are built into laptops as WiMAX was built for outdoor mobility. The main challenge now for WiMAX developers is to get more chips (WiMAX receivers) into laptops and PC's.

Currently Mobile WiMAX is the biggest threat to 3G and they compete as to who offers the better service of wireless connectivity. WiMAX are still trying to market this new technology and "experts" believe that the longer this product takes to get on the market the better chance that 3G has. Intel state that 3G is excellent for voice and WiMAX will take over the market for mobile data services. For providers to stay competitive they may have to start to offer WiMAX and 3G.

Figure 3 illustrates the distance range and data rate that each standardisation provides. WiMAX is superior to WIFI in terms of data transfer and the range that it provides.

Wireless Communication Standard	Max Data Rate	Distance Max Range
Wide Area Network		
802.16d Fixed WiMAX	75MBps	6 Miles
802.16e Mobile WiMAX	30MBps	3 Miles
Local Area Network		
802.11a/g WIFI	54MBps	300 Feet
802.11b WIFI	11MBps	300 Feet

Figure 3. WiMAX statistics

Security

Wireless had received some bad press in recent years because of a proliferation of security issues and while no system is completely secure Mobile WiMAX is supporting many of the best security technologies available today. Among these are Privacy and Key Management Protocol v2 which manages the EAP authentication, Traffic Encryption and Handover Key Exchange. Extensible Authentication Protocol (EAP) is the main protocol for device and user authentication from the Internet Engineering Task Force (IETF). Advanced Encryption Standard (AES) encrypts data when activated. These features builtin to the 802.16e standard provide the basis for secure networks. The weakest link is also the human factor so it becomes critical that users maintain high security practices when accessing networks. The keystone to the success of Mobile WiMAX will be the development and spread of Smart Antenna technologies. Fortunately OFDMA supports smart antenna technologies in particular Multiple Input Mulitple Output (MIMO) which behaves as if it is many antenna thereby giving large coverage while maximising use of the spectrum. It does this by using adaptive switching and providing coverage where conditions deteriorate. Support is also built into the Mobile WiMAX architecture for a packet-switched framework and IP as well as for a variety of topologies. The network architecture can support voice, data, multimedia and a host of other services. One other exciting development arising from Mobile WiMAX is Voice over IP on mobile phones which will benefit further from the adoption of .IPv6.

The Future

The future implementation of WiMAX technologies and in particular mobile WiMAX seems inevitable. The role of the WiMAX Forum has played a crucial role in positioning the technology in a powerful position. Once the forum was able to list such names like Intel, Nokia, Motorola, Cisco and AT&T amongst its members then acceptance to the wider technology market would be assured, with a large number of similar companies joining the forum. Announcements of testing and plans to rollout WiMAX networks, include the South Korean governments plans to develop a mobile WiMAX compatible telecommunication network (WiBro). In France Iliad have announced plans to offer WiMAX services to a base of 1.6 million users (Gabriel, 2006),

previously BT have announced membership of the forum and testing of WiMAX in a number of rural areas of the UK including Northern Ireland (Smith, 2004). Subsequent developments will likely see a new breed of PDA and multifunction mobile phones. With the variety of applications available over Mobile WiMAX the target audience will be as diverse as the Mobile WiMAX enabled products and it has been suggested that with the large scale adoption that has been predicted costs will be driven down with in two to three years. At this point Mobile Wimax products will not be commercially and generally available until about 2007. The main aspect under for consideration for worldwide adoption is to ensure that the same spread from the spectrum is being used and educating users about the benefits of mobile highspeed wireless broadband. With non line of sight high speed and long reach combined with flexible on demand delivery and connectivity Mobile WiMAX looks like having a good future.

These announcements tend to heighten expectation that can only help the acceptance of the technology along with similar type announcements from the WiMAX Forum on equipment being submitted for certification. Another gauge for the market is monitoring start-up companies that are managing to acquire significant amounts of capital from investors with the sales pitch of developing WiMAX networks, a good example is Clearwire a US based company who recently announced that they had raised US$1 billion to build a WiMAX network (Murphy, 2006). Announcements like what have been mentioned previously only serve to establish the technology. With these kinds of investments taking place then the rollout of mobile WiMAX can only benefit from the infrastructure being put together and benefit from the work of the forum guaranteeing inter-operability of the hardware. Intel have recently announced the release in the latter part of 2006 of laptops with integrated 802.16e technology onboard (Wimaxxed, 2006), Nokia have just announced successful testing using 802.16e technologies between two bases and Motorola, and Samsung have published plans for mobile telephones with the technology inbuilt either in 2007 or 2008 (Motorola, 2006), with announcements from companied of this stature the future looks positive and will be further enhanced if the trials in South Korea with WiBro are successful. Samsung have released their first mobile phone with WiMAX capabilities Nokia and Motorola have since broadcasted that they are employing WiMAX for use in these mobile phones[1]. Intel[2] have predicted that the first version of service 802.16d fixed WiMAX will be available to users by the second half of 2006 but this will only be accessible through an external box, possibly a USB interface. The possibility of incorporating WiMAX chips into laptops seems to lack clarification as WI-FI is occupying the PCI Slot of the laptop, this would mean that there would need to be some integration in the compatibility between the two chips.

Conclusion

WiMAX promises cost effective service for both consumer and manufactures as they have all the key components to supply a wider area with high speed internet access compared with wired broadband. WiMAX sends the wireless frequencies directly to the customer avoiding the need for unnecessary costs for underground cabling and physical labour. WiMAX is most certainly a “promising next generation wireless technology” with high data rate transfers (peak rates

[1] http://www.channelregister.co.uk/2005/06/10/intel_nokia_wimax/
[2] http://www.whatlaptop.co.uk/YdNQTkpom_3ZfA.html

20Mbps) over vast distances removing the necessity of having to find a Wi-Fi hot-spot. Telco's, have spent small fortunes upgrading their mobile network but are limited to transfer speeds of approximately 400kbps per second -700kbps per user. WiMAX can operate at environmentally friendly frequencies below 11GHz. Higher frequencies do require line of sight. There are some concerns however regarding the "battery life" for WiMAX and it seems that portable competition from 3G and 4G networks will be the main competitor against WiMAX.

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