WIMAX IN TELECOM: AN APPROACH

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ABSTRACT

WiMAX, a new wireless technology is poised to revolutionize broadband, is known as worldwide Interoperability for Microwave Access. WiMAX could be the key to breaking through the last-mile barriers that have slowed broadband adoption, in rural areas where the cost of deploying broadband connections has not been economical. WiMAX is a serious threat to third generation (3G) because of its broadband capabilities, distance capabilities and ability to support voice effectively with full QOS. WiMAX can slash the single biggest cost of deployment access charges for linking a hotspot to a local phone or cable network. WiMAX integrates perfectly into existing fixed and mobile networks. A high frequency version of 802.16 would allow entrepreneurs to blast a narrow, data-rich beam between antennas miles apart.

KEYWORD: Asynchronous Transfer Mode (ATM), Broadband Wireless Access (BWA), Quality of Service (Qos), Wireless ATM (WATM), Worldwide Interoperability for Microwave Access (WIMAX)

I. INTRODUCTION

WiMAX (world wide interoperability for Microwave Access), is a standard based wireless technology that provides high throughput broadband connections over long distances. WiMAX is a new wireless technology that is poised to revolutionize broadband wireless access(BWA). WiMAX is designed for Metropolitan Area Networks (MAN) whereas Wi-Fi is designed for local Area Networks (LAN). WiMAX can be used for a number of applications, including "last mile" broadband connections, hotspot and cellular backhaul and high speed enterprise connectivity or business.

1.1 How Does Wimax Differ From Wi-Fi

WiMAX provides metropolitan area network connectivity at speeds of upto 75Mb/sec .WiMAX can be used to transmit signal as far as 30miles. Wi-Fi is primarily suited for coverage over small areas. A single base station can service around a thousand users effectively over relatively small areas such as in offices or hotspots. The most commonly used standards of Wi-Fi 802.11b can transfer data at speeds upto 11Mbps over ranges upto 1,000 feet (300 meters) in open areas from a single base station.

1.2 Expectations

WiMAX is referred to as "Wi-Fi on steroids". It has the potential to enable even more millions to access the internet wirelessly, cheaply and easily. The WiMAX wireless coverage is measured in square kilometers (miles) while that of Wi-Fi is measured in square meters (yards). A WiMAX base station would beam high-speed internet connections to homes and business in a radius of upto 50kms which would cover an entire metropolitan area, making that area into a WMAN and allowing true wireless mobility within it as opposed to hot-spot hopping required by Wi-Fi.

1.3 Initial Version:

The initial version of the WiMAX standard operates in the 10-66GHz frequency band and requires line-of-sight towers, but the 802.16a extension, ratified in January 2003, uses the lower frequency of 2-11GHz enabling nonline-of-sight connections making it an appropriate technology for last-mile applications. Hence, this constitutes a major breakthrough in wireless broadband access as line-of-sight between your transmission point and the receiving antenna is not necessary.

The principal advantages of the systems based on 802.16 are as follows.

- The ability to provision service quickly, even in areas that are inaccessible for wired infrastructure.
- The avoidance of steep installation costs.
- The ability to overcome the physical limitations of traditional wired infrastructure.
- Wireless redundancy and quick redeployment.

II. WiMAX TECHNICAL INFORMATION

2.1 Overview of IEEE 802.16

IEEE802.16, the first standard in 802.16x family, supports point-to-multipoint architecture, operates at upto 124Mbps in the 28MHz channel (in 10-66GHz) and is primarily intended for line-of sight applications. The 802.16a standard operates at 70Mbps in lower frequency of 2-11GHz spectrum, in the 20MHz channel and enables nonline-of-sight (NLOS) implementations. WiMAX operates in a mixture of licensed and unlicensed radio spectrum and the initial products will be focused on 2.5GHz and 3.5GHz licensed and 5.8GHz unlicensed bands. The 802.16a spectrum uses various physical layer (PHY) variants but the dominant one is a 256-point orthogonal frequency division multiplexed (OFDM) carrier technology. The PHY layer modulation is based on OFDM, in combination with a centralized medium access control (MAC) layer for optimized resource allocation and support of QOS for different types of services (Voice Over Internet Protocol (VOIP), real time, and nonreal-time services. The OFDM PHY layer is well adapted to the NLOS propagation environment in the 2-11GHz frequency range. OFDM can provide a high spectral efficiency of about 3-4 bits/HZ. WiMAX is designed to accommodate either frequency division duplexing (FDD) which is more suited to enterprise traffic or time division duplexing (TDD), which is more adapted to asymmetrical traffic.

2.2 Licensed Spectrum for Wireless MAN'S

3.5GHz Band: The 3.5GHz band is available as a licensed band in many countries outside the US for fixed broadband wireless access. This band is the most used spectrum for wireless MAN's.The characteristics for the 3.5GHz are

- Total available spectrum – about 200MHz between 3.4GHz and 3.8GHz
- Services allowed – fixed access

- FDD or TDD - this is mixed
- Spectrum per license - varies from 2x5MHz to 2x56MHz

2.5GHz Band: This band is allocated for fixed microwave services in many countries including US. The characteristics for the 2.5GHz band makes up for the fact that the 3.5GHz band is not available for wireless access in United States.

- Total available spectrum --- 195MHz, including guard-bands and MDS Channels, between 2.495GHz and 2.690GHz.
- Services allowed --- Fixed two-way or broadcast.
- FDD or TDD --- Both FDD and TDD are allowed
- Spectrum per license --- 22.5MHz per license, a 16.5MHz block paired with a 6MHz block, a Total of 8 licenses.

III. RADIO CHARACTERISTICS

In the 2.5GHz band, a TDD solution with a 5MHz channel bandwidth will be used and in the 3.5GHZ band a FDD solution with dual 3.5GHz bandwidth channels will be used. The propagation model used to predict the range is based on the contribution to the IEEE802.16 broadband wireless access working group. The propagation model covers three terrain categories ”A”, “B”, and “C”. Category “A” being the highest path loss. Category is used to predict propagation characteristics in urban environments. Category “B” is assumed for suburban environment range predictions and category “C”, the lowest path loss terrain is used in rural environments.The use of adaptive modulation and adaptive coding enables each end-user link to dynamically adapt to the propagation path conditions for that particular link. Since each modulation scheme has a different modulation efficiency the effective channel capacity can only be determined by knowing what modulation and coding scheme is being used for each end-user link sharing that particular channel.Deployments can be range-limited or capacity-limited. In a range-limited case, if a uniform distribution of active subscribers with outdoor CPE's is assumed, more than 60% of active users will be operating at either QPSK or BPSK with only 15% operating at 64QAM. The range estimates shown in figure (1) apply to a 3.5GHz deployment in a rural environment with all outdoor, non-LOS CPEs . With the distribution of users as shown, the effective downlink channel capacity for a range-limited deployment is 3.8Mbps as compared to 9.7Mbps for a capacity-limited case with all end-users operating at 64QAM. For fixed services, due to license assignments with limited spectrum, most deployments will be capacity-limited rather than range-limited.

3.1 Matching Data Density Requirement to Base Station Capacity

For capacity-limited deployments scenarios it is necessary to deploy base stations with a base station to base station spacing sufficient to match the expected density of end-customers. Data density is an excellent metric for matching base station capacity to market requirements. Demographics information, including population, households and business per square-mile, is readily available from a variety of sources for most metropolitan areas. With this information and the expected services to be offered along]ith the expected market penetration, data density requirements are easily calculated. This 6-step process is summarized in figure (2), With a fixed wireless network it is also important to project market requirements several years into the future and deploy base stations in accordance to what those projections dictate. Unlike mobile networks in which end users are equipped with handsets having omni-directional antennas, fixed networks are deployed with a combination of indoor, self-installable CPEs and professionally mounted outdoor units with fixed narrow beam antennas at the subscriber sites carefully aligned for maximum signal strength.

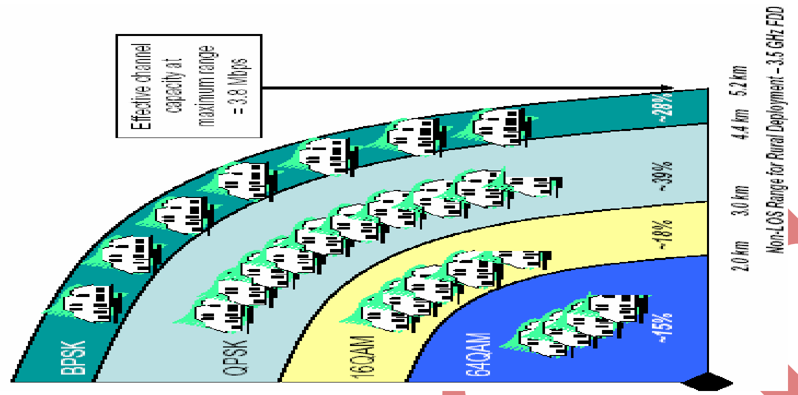

Figure (1): Nonlos Range for Rural Deployment-3.5GHZ

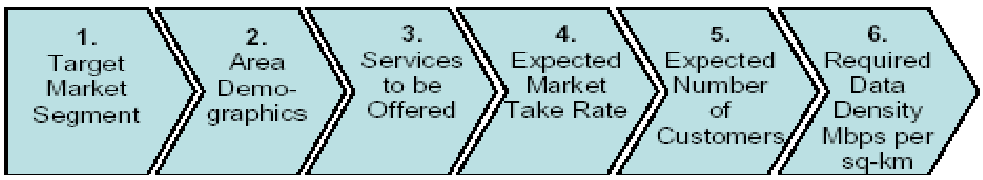

Figure 2: Determining Market Driven Capacity Requirements

3.2 Deployment with Outdoor CPEs

Here we shall look at some hypothetical WiMAX base station deployment examples in both bands assuming all outdoor CPEs in each of the three demographic areas; urban, suburban, and rural. The demographics and anticipated number of residential and SME customers for these examples are summarized in table (1) along with the data density that will be required to serve the anticipated number of end-customers or subscribers. A cell frequency re-use factor of 1 is assumed for all of the following examples to determine the amount of spectrum required.

	Urban	**Suburban**	**Rural**
Geographical Area to be Covered	60 sq-km	120sq-km	200 sq-km
Expected Number of Residential Customers	30,000	20,000	5,000
Expected Number of SME Customers	1,500	500	150
Required Data Density	29 Mbps/km^2	5.9 Mbps/km^2	1.0 Mbps/km^2

Table (1): Demographics for Deployment Examples

CAPEX for the operator but has a tendency to reduce them as well. To gain a more quantitative understanding of the benefits however, the capacity and range impact of indoor CPEs on the base station infrastructure cost must also be taken into account. In a 3.5GHz range-limited case approximately 7% of users can be supported with indoor CPEs in a rural environment as shown in Figure(1). This percentage is approximately 10% and 12% in suburban and urban propagation environments respectively. Since approximately 60% of the indoor CPEs will be operating at a lower modulation efficiency than 64QAM, the effective channel capacity at maximum range is reduced from 3.8Mbps to 3.4Mbps. These comparisons are summarized for all three propagation environments in table(2).

	Urban	**Suburban**	**Rural**
Frequency Band	3.5 GHz		
Maximum non-LOS Range	2.5 km	3.5 km	5.2 km
% Indoor Self-Installable CPEs	~12%	~10%	~7%
Channel Capacity at Maximum Range	3.6 Mbps	3.4 Mbps	3.4 Mbps
Channel Capacity at Maximum Range with 100% OutdoorCPEs	4.3 Mbps	4.0 Mbps	3.8 Mbps
Channel Capacity Reduction	16%	14%	11%

Table (2): Impact of Indoor CPEs on Channel Capacity

3.3 Deployment For Coverage

Deploying for coverage without regard for projected capacity requirements is a viable deployment strategy where the market requirements are uncertain and hence difficult to accurately quantify. For this deployment an urban environment of 60sq-km is assumed with the goal of providing a minimum of 128kbps to each nomadic customer that is connected to the network at any given time. It is also assumed that the connected customers are uniformly distributed over the coverage area. The 60sq-km urban area can be covered by three base stations in the 2.5 GHz band. When additional channels are deployed to increase base station capacity they do not have to be simultaneously added throughout the entire coverage area, but can be added over time to specific base stations as needed to cover high growth portions of the coverage area. This concept is depicted in figure (2) which shows a deployment migration from three 3-channel base stations (9 channels total) to three 6-channel base stations (18 Channels total) over N years with an interim deployment of 13 total channels.

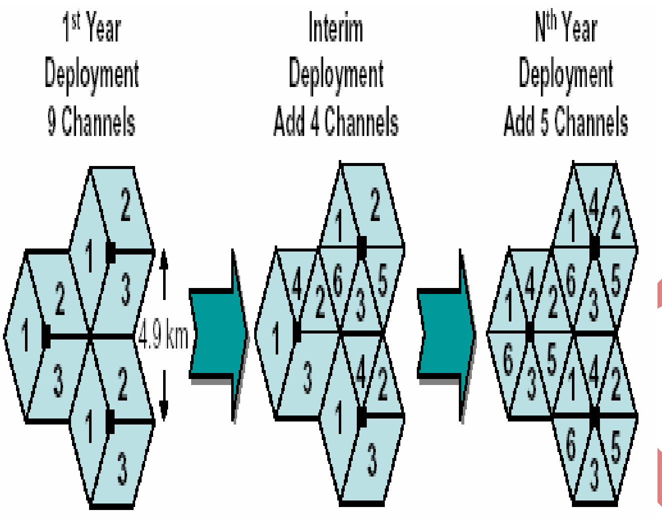

Figure (2): Growing Capacity by Adding Channels or Splitting Sectors

- 3 x 120◦ sectors with 15MHz of spectrum in 2.5GHz band
- 3 Base stations cover 60sq-km in range-limited urban deployment
- DL Data density 0.74 Mbps per sq-km
- Supports upto 360 simultaneous non-LOS nomadic customers over a 60sq-km coverage area.
- With 15MHz of additional spectrum a second channel can be added to each sector (total spectrum = 30 MHz)
- Increase data density to 1.5Mbps per sq-km
- Supports upto 720 simultaneous nomadic customers.

3.4 Market For Wimax

WiMAX is a very promising technology that meets the key requirements for BWA services, but its success in the market is far from certain. Some of the key elements that will determine the success of WiMAX • Performance: So far, the specifications for WiMAX are still on paper (source WiMAX Forum, March 22, 2004), as there is no commercial product certified by the Forum and the final version of 802.16a has not yet been approved. It is possible that the certification process will prove more arduous than expected. There is also a possibility that real-life performance does not meet the expectations, especially with regard to coverage range and CPE form factor, cost and ease of installation.

• Split of WiMAX into multiple semi proprietary solutions: 802.16a and the expected 802.16e standards could complement each other, providing subscribers with a mix of fixed and mobile access.

802.20 Mobile Broadband Wireless Access (MBWA) and 802.16e

The IEEE 802.20 Working Group is a new wireless networking standard for Mobile Broadband Wireless Access (MBWA). The 802.20 or Mobile-Fi standard defines the physical and MAC layers for a high bandwidth, IP–based, fully mobile wireless network. The group's intention is to fill the gap between existing 802 standards with high data rates and low mobility and existing cellular standards with low data rates and high mobility. The IEEE 802.16e standard is also addressing the need for high-bandwidth mobile wireless Internet Access within a metropolitan area. This will be similar in function to the general packet radio service (GPRS) and the radio transmission technology (1xRTT). The 802.16e standard combines fixed and Mobile operation in licensed bands (2–6 GHz), approved in December 2002. There are some technical differences between both the standards viz. 802.20 and 802.16e. For one, 802.16e will add mobility in the 2 to 6GHz licensed bands, while 802.20 aims for operation in licensed bands below 3.5GHz. More importantly, the 802.16e specification will be based on an existing standard (802.16a), while 802.20 is starting from scratch. The 802.20 interface seeks to boost real-time data transmission rates in wireless metropolitan area networks to speeds those on which rival DSL and cable connections (1Mbps or more) are based, cell ranges of up to 15kilometers or more, and it plans to deliver those rates to mobile users even when they are traveling at speeds up to 250 kilometers per hour (155 miles per hour). This would make 802.20 an option for deployment in high-speed trains. The 802.16e project authorization request specifies that it will only support subscriber stations moving at vehicular speeds of 120 to 150 kilometers per hour (75 to 93 miles per hour). Essentially, 802.16e is looking at the mobile user walking around with a PDA or laptop, while 802.20 will address high-speed mobility issues . This key difference will define the manner in which the two standards would be deployed.

IV. CONCLUSION

WiMAX - compliant equipment based on the IEEE802.16-2004 Air Interface Standard will provide operators the technology necessary to deploy cost–effective wireless metro area networks with ubiquitous coverage offering broadband services to multiple types of customers.
A projected path way will appear something like the following

- Adoption in these markets will be high because it will be the first viable option for high-speed data access for many customers in these markets.
- These deployments will generate capital to be reinvested for future deployments, which will create the initial scale of product demand. This will begin driving both the cost of carrier and customer equipment down.
- As the economy of scale makes deployment less expensive mobile platforms will begin to appear. This development will be spread between high population centers and the rural markets that already have fixed platforms deployed which will act as a springboard for mobile deployment.
- Interconnections will begin to form between rural markets and metropolitan markets as carriers form cooperative agreements to share network resources. The economy of scale will increase exponentially at this point and we will notice a marked negative impact on traditional cellular, Internet and voice services.
- Once the initial hot underserved rural markets and high-density metro areas are complete springboard deployments will quickly take WiMAX coverage to the level of coverage offered by traditional wireless today.

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