Portable and Mobile Communications over WiMAX

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IEEE 802.16 known as WiMAX has been around since 2001, first initially developed for a fixed point-to-point broadband, has evolved to a full mobility, non line-of-sight wireless technology capable of reaching up to 75 Mbps over distances of 30 miles, with exceptional QoS capabilities and low latency packets, allowing VoIP services to run smoothly with full roaming over WiMAX Access Points. This threat to current wireless technologies is expected to be on the market by the end of 2005, early 2006.

1. Introduction

Portable communications have become increasingly a very important issue over recent years, not only because the Internet nowadays plays a crucial– if not vital - role on everyday life but because communications itself has been a primary objective for our entire society since man started evolving.

It is not new that wireless telecommunications have had a rapid growth: developing new standards such as IEEE Std 802.11g and IEEE Std 802.15[1] also known as Bluetooth which have been serving an increasingly growing wireless user community of laptops, personal digital assistants and connection between these devices; but the lack of bandwidth has prevented any widespread deployment [1].

Since 2001, Intel along with Alvarion, AT&T, Samsung, British Telecom and hundreds of other IT worldwide companies have been working on a new wireless network standard the IEEE Std 802.16 most commonly known as WiMAX which promises it will bring non line-of-sight broadband up to 75Mb/s access points with a cell radius up to a maximum range of 30 miles based on tower height, antenna gain and transmit power (among other parameters) [2].

This technology is estimated be available on end-users during the next few years and it may be the key to finally integrate portable communications over a digital network, allowing to have high speed broadband access with mobility and regional roaming to devices such as laptops and PDAs.

This article will discuss the IEEE 802.16 standard, its viability to operate as an effective last mile access network and the proposal for a new mobile VoIP over WiMAX networks.

2. What is WiMAX

According to the IEEE the original 802.16 standard or WiMax, specified fixed point-to-point broadband wireless systems operating in the 10-66 GHz licensed spectrum [3]. Its

[1] IEEE Std 802.11, IEEE Std 802.15 and IEEE Std 802.16 are trademarks of the IEEE

evolution since its inception in 2001 has included non-line-of-sight extensions in the 2-11 GHz spectrum as lower-wavelength transmissions are not as easily disrupted by physical obstructions -- they are better able to diffract, or bend, around obstacles [4], delivering up to 70Mbps up to distances of 31 miles.

Because of this, 802.16 was initially conceived as a back end technology however its amendments up to 802.16e has been oriented for mobile and regional roaming and has the capacity to be adapted for individual computers or devices such as PDAs (as Shown in Table 1)

Table 1
IEEE 802.16 Standard
[2]

	802.16	802.16a/REVd	802.16e
Completed	Dec. 2001	802.16a: Jan 2003802.16 REVd: Q3 2004	Estimate: End of 2005
Channel Conditions	Line-of-sight only	Non line-of-sight	Non line-of-sight
Bit Rate	32 to 134 Mb/s at 28 MHz channelization	Up to 75 Mb/s at 20 MHz channelization	Up to 15 Mb/s at 5 MHz channelization
Modulation	QPSK, 16 QAM and 64 QAM	QFDM 256, QFDMA 64 QAM, 16 QAM, QPSK, BPSK	Same as REVd
Mobility	Fixed	Fixed and Portable	Mobility, Regional Roaming
Channel Bandwidths	20, 25 and 28 MHz	Selectable channel bandwidths between 1.25 and 20 MHz with up to 16 logical sub-channels	Same as REVd
Typical Cell Radius	1 to 3 miles	3 to 5 miles; Maximum range 30 miles based on tower height, antenna gain and transmit power.	1 to 3 miles

As in 802.11a/b/g, WiMAX operates similarly but at higher speeds which can increase the number of concurrent users and over greater distances. A basic WiMAX configuration requires a WiMAX tower or Access Point (AP) which provides can potential cover up to a 30 miles radius and a WiMAX receiver such as a wireless broadband modem for fixed mobility or a NIC Card for portable communications.

Basically, as said before, higher frequencies (11 to 66 GHz) allows higher bandwidths and longer distances however easily disrupted by physical obstructions so requires a line-of-sight communications; on the other side, frequencies from 2 through 11 GHz will eventually allow “Full Mobility” [5] (as shown on Figure 1) and would provide incremental support for low latency, low packet loss real-time handovers between APs at speeds of 120 km/hr or higher both within a network and between networks with a non line-of-sight service.

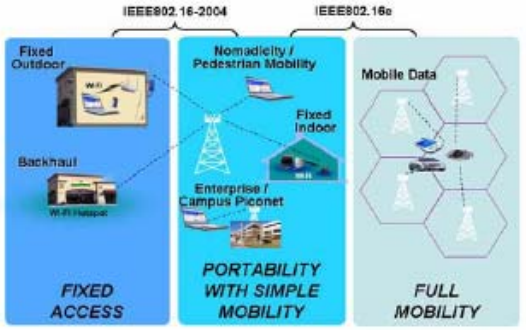

Figure 1: 802.16 standards and deployment evolution

3. Technical Specifications of 802.16a

802.16 operates at up to 124 Mbps in the 28 MHz channel using frequencies of 10-66 GHz, 802.16a at 70Mbps in lower frequencies (2-11 GHz, similar as 802.11)

It supports Orthogonal Frequency Division Multiplexing (OFDM) which allows transmitting huge quantity of digital data over a radio wave because it divides the radio signal in many sub-channels that are transmitted simultaneously to the receptor on different frequencies. 802.16a defines a Media Access Control or MAC layer that supports 3 physical layers (PHY) specifications: an OFDM with 256 sub-carriers, with 2048 sub-carriers and a single carrier option [5].

WiMAX can transport IPv4, IVv6, Ethernet or ATM, supporting multiple services simultaneously.

One of the most important specifications of the 802.16 Standard is the robust quality-of-service (QoS) protection for services such as streaming audio and video. This is because with any other type of network, users have to share the data capacity; however with WiMAX the service provider can actually manage the traffic for each individual subscriber on a link by link basis.

In 802.11 technology the CSMA/CD with less than 10 users per access point, the network experiences little contention for use of airtime and occasional packet collisions may occur, however if the number of users increases, the collisions increase as well and the network performance drastically decrease [6].

The 802.16 MAC is designed for Point-to-Multipoint (PMP) applications and is based on Collision Sense Multiple Access with Collision Avoidance (CSMA/CA). The 802.16 AP MAC manages UL and DL resource. WiMAX avoids collisions problem when many users are connected to a single AP by using a grant-request mechanism that allocates a small portion of each transmitted frame as a contention slot and each user can ask for a allocation an uplink slot. The AP evaluates and allocates the requested slot in which the subscriber station can transmit. This mechanism prevent a large number of users from interfering with one another.

4. Other wireless technologies

Several other wireless technologies are available and each has its pros and cons. Each one of them has different frequencies spectrums and many of the share frequencies. Table 2 shows its differences.

Most of wireless technologies that have high data rates such as 802.11 which can reach rates up to 54Mbps[2] have a limited coverage reaching at most 150Mts in perfect conditions and no obstacles. On the other side, DVB-T and DAB are mainly used to broadcast television signals and return channels can only reach up to 2 Mbps.

Table 2
Characteristics of heterogeneous wireless access systems [7]

Access network type	Frequency	Data rate	Coverage	Cost	Technology
Bluetooth	2.4 GHz ISM band	Max. 721 kbps	0.1-10m	Low	DSSS, FHSS
IEEE 802.11g	2.4 GHz	54 Mbps	30-150m	Low	OFDM
IEEE 802.11b	2.4 GHz	11 Mbps	Up to 100m	Low	DSSS
IEEE 802.11a	5 GHz	20 Mbps	50-300m	Low	OFDM, TDD
HiperLAN2	5 GHz	54 Mbps	150m max	Low	OFDM
IMT2000, UMTS	2 GHz	Max. 2 Mbps	30m-20Km	High	FDD, TDD
IEEE 802.20	Below 3.5 GHz	Up to 9 Mbps	20Km	High	OFDM
IEEE 802.16	2-66 GHz	Max. 70 Mbps	Over 50 Km	Low	OFDM
GSM, GPRS, EDGE	900-1900 Mhz	9.6-384 Kbps	Up to 35 Km	High	TDMA, FDD
Satellite	Up to 14 GHz	Max. 144 Kbps	Several Km	High	OFDM
DAB	176-230 MHz	1.5 Mbps	Up to 100 Km	Low	OFDM
DVB-T	<860MHz	5-31 Mbps	Up to 50 m	Low	OFDM
DECT/DECT Link	1880-1900MHz	Up to 2 Mbps	2-6 Km	Low	TDMA, FDD

There is no single wireless network technology that can deliver low latency, high bandwidth and wide area data service to a large number of mobile users. Well, not until IEEE 802.16e is officially released by IEEE. Although it is envisioned that on future generations wireless clouds will be a combination of diverse but complementary access technologies [7], it seems clear that new standards such as IEEE 802.16e will not only cover rural and black spots of wireless access but will also access into cities for its low cost, high bandwidth and big coverage area.

5. VoIP over wireless

The Voice over Internet Protocol commonly known as VoIP is the technology used to transmit voice conversations over a data network using Internet Protocol. Since data is transmitted over a ‘public’ network, VoIP best characteristic is that the cost of a local call is almost the same as an international call, bypassing phone companies entirely

VoIP has been around for several years, and has reached certain level of popularity especially among small and medium sized companies that needs to reduce costs on communication using these types of alternative technologies.

[2] IEEE Std 802.11g

Wirelessly has not been a real success, since most of the current wireless networks available are based on the WiFi or 802.11 standard, which does not provide a good QoS, its coverage is limited only for a couple of hundred meters and there has not yet been a real integration between heterogeneous networks.

Now days, there are several type of both software and hardware that allow simple users to setup in less than 10 minutes a VoIP mobile phone. The experiment was made using a DELL Axim X50v PDA, with a 802.11g NIC card incorporated, Microsoft Windows ME operating system, and Skype Out VoIP service. The whole process took less than 5 minutes to install and configure the PDA and start talking. However, mobility still is problem for WiFi, there is no support for low latency and QoS, a factor that is of most importance when referring to VoIP.

802.16 is optimized to deliver high data rates to users and can simultaneously support real-time multimedia and VoIP applications as well. Because of the QoS discussed previously, high data rates and low latency.

With companies such as Nokia, involved on the deployment of mobile WiMAX compatible mobile phones, there is no doubt VoIP will be a real option for mobile communications over Internet.

6. Conclusion

WiMAX is a serious threat to most of the current wireless technologies because of its broadband capabilities, distance capabilities and ability to support voice effectively with full QoS. This makes it an alternative to cellular in a way that Wi-Fi could never be.

The upcoming IEEE 802.16e standard not only provides high distance and data rates but the ability to roam along many AP in order to provide full mobility to users.

Although it was designed initially as a last mile access, the companies supporting and developing this standard such as Intel and Nokia are targeting as a new technology for mobile communications at very reduced price, since VoIP communications relays on a public network such as Internet, bypassing expensive network leases among current telecommunications companies.

It seems analysts are still skeptical and first chipsets with WiMAX support should be shipping over the next few months. While WiFi wireless networks still dominates the commercial market, it seems IEEE 802.16 will be a complete success.

References

[1] C. Perkins, ‘Mobile networking in the internet’, Mobile Networks and Applications 3 (1998) 319-334
[2] ‘Telephony’s Complete Guide to WiMAX’, WIMAX © TELEPHONY 2004
[3] IEEE 802® General Information, IEEE 802.16, 2005, http://www.ieee.org
[4] Grabianowski E., Brain M., 'How WiMAX Works', http://computer.howstuffworks.com/wimax.htm

[5] Agis E., Mitchel H., Ovadia S., Aissi S., Bakshi S., Iyer P., Kibria M., Rogers C., Tsai J., 'Global Interoperable Broadband Wireless Networks: Extending WiMAX Technology to Mobility', Intel Technology Journal
[6] Whitepaper, 'WiMAX Technology and Deployment for Last-Mile Wireless Broadband and Backhaul Applications', 2004, Fujitsu Microelectronics America
[7] Siddiqui F., Zeadally S., 'Mobility management across hybrid wireless networks: Trends and challenges', Computer Communications (2005) 1-23