Comparative and Technical Analysis of Broadband Access Technologies (WiMAX and WiBro).

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ABSTRACT

Wireless access networks, especially broadband wireless networks, are providing more capacity and coverage. Wireless networks have offered an alternative solution to the problems of information access and in-accessible areas where wired networks are not cost-effective. They have changed the way people communicate and share information by eliminating some worries of distance and location. This paper provides a technical analysis of alternatives for implementing wireless broadband services and it provides detailed technical differences between WiMAX (IEEE 802.16d) and WiBro (Mobile WiMAX IEEE 802.16e) networks.

(Keywords: WiMax, WiBro, WiFi, wireless broadband, mobile WiMAX)

INTRODUCTION

Wireless technology has greatly evolved to meet the exponential growth of mobile devices in the last four years. Although access to wireless technology has grown, there are significant limitations that make it difficult for some to exploit its proven and potential benefits. The main difficulty regarding expanded coverage is that WiMAX (Worldwide Interoperability for Microwave Access) broadband wireless technology is not available in all regions.

The growth of the internet over the last decade has lead to an increasing demand for high-speed internet access. Broadband Wireless Access (BWA) is increasingly gaining in popularity as an alternative technology to DSL lines and cable modems. As the following of the 802.11x wireless local area network standard, deployment of the IEEE 802.16d and IEEE 802.16e wireless network standards are currently in progress. This technology aims to provide broadband wireless access to residential and small business applications, as well as enable to internet access in countries without any existing wired infrastructure in place [1].

The IEEE has finalized the 802.16d standard, which specifies a set of different physical (PHY) and Medium Access Control (MAC) layers of BWA systems, which are Base Station (BS) and Subscriber Station (SS). This technology enables physically distant users to have access to the high-speed broadband wireless service with a relatively inexpensive cost compared to existing cable solutions. In addition, the wireless coverage of 802.16 is much wider than that of 802.11 WLAN technologies while providing more bandwidth to users.

Attracted by the above benefits, the industry has already been developing and selling commercial 802.16d systems and the market has started to grow. Moreover, in order to promote the interoperability and compatibility of 802.16 products, a number of companies have organized the WiMax Forum that offers the interoperability tests among various products and fosters the development and commercialization of the products [2].

The 802.16 standard is not only for fixed BWA systems, but also for the mobile BWA systems. In 2005, the federal government of the Republic of Korea and members of industry worked together to enable the wireless broadband service with mobility support, named WiBro (i.e., IEEE 802.16e Wireless Broadband). We have our own standard to describe a subset of 802.16d/e can working together and accelerate the world-wide broadband wireless service. In the standard of

802.16e fully mobility is supported by public service providers.

This paper is organized to describe the standards and technology associated with various wireless technologies usage models. The paper then gives a technical overview of the popular broadband wireless technologies (802.11x, 802.16d, and 802.16e). The next section provides a comparative analysis of the recent (802.16d and 802.16e) wireless technologies. This paper also shows how the two technologies can be combined to provide broadband access to remote areas and then ends with conclusions.

BEFORE OF WIMAX

IEEE 802.11 (Wi-Fi)

The IEEE 802.11 specification is an international standard describing the characteristics of a Wireless Local Area Network (WLAN). The name is Wi-Fi (Wireless Fidelity). Over the last several years, the explosion of Wi-Fi devices made possible the discovery of the wireless network world. These standards are sometimes associated with directional antennas to establish point-to-point connections.

The first 802.11 wireless network standards were developed in 1997 as an extension to the Local Area Network. It was known as wireless up to 2 Mbps. The IEEE 802.11 standard can comprised of more than 20 different standards, each of which is denoted by a letter appended to the end of the name. The most familiar standards are 802.11b and 802.11g which are used in the commercial Wi-Fi devices [3, 4]. Both of these standards can operate 2.4 GHz band, and that only major difference between two in the transfer rate, as seen in Table 1.

The IEEE 802.11b was a refined standard for the ordinal 802.11 and was successful due to its high data rates of 11 Mbps- range of 100m to a maximum of a few hundred meters, operates on 2.4GHz unlicensed band. 802.11b is most widely deployed wireless network within the 802.11 wireless families [3, 4].

The IEEE 802.11a is a standard 5 GHz band with maximum data rate of 54Mbps. The major disadvantage in deploying 802.11a with the other 80211 standards (b and g) is that, they cannot co-exist, as they operate on different frequency bands. 802.11b/g operates on the 2.4GHz spectrum. There are some wireless cards and access points which are compatible to all the three standards thereby supporting the 2.4GHz and 5GHz frequencies [3, 4].

Table 1: The IEEE 802.11 Family Standards.

Standards	802.11b	802.11a	802.11g
Year of standardized	1999	1999	2003
Frequency	2.4 GHz	5 GHz	24 GHz
Speeds	11 Mbps	54 Mbps	54 Mbps
Indoor Range	30-50 Meters	30-50 Meters	30-50 Meters
Advantages	Interoperable with 802.11g inexpensive	Reduced Wi-Fi interference more Non-Overlapping Channels	Interoperable with 802.11b High Speed Wireless Data Communication
Data Transfer Range Typical(MAX)	6.5(11)Mbps	25(54)Mbps	25(54)Mbps
Solution	Home users can connect to the internet in wireless network	Home/office users experiencing interference with existing 802.11g Wireless networks	Home/office Users Needed Faster Local Network Access for Multimedia Application

The IEEE 802.11g wireless standard also operates on the 2.4 GHz band and has similar range and characteristics as the 802.11b. it has a data rate of 54 Mbps. The 802.11g has backward compatibility with 802.11b and differs only on the modulation technique.

Wi-Fi Advantages:

- It allows Local Area Networks (LAN) to be setup with cabling. The can reduced associated cost of network connection and expansive.
- Wi-Fi products are extensively available in the market. There are different bands of access points and user's network interface is available to inter-operate at a very basic service level.
- Prices are considerably lower as competition amongst vendor's increases.

- Wi-Fi networks can support roaming. This allows mobile users with laptop computer to be able to move from one access point to another.

OVERVIEW OF WIMAX AND WIBRO

IEEE 802.16d (Fixed WiMAX)

WiMAX (Worldwide Interoperability for Microwave Access) standards define formal specification for deployment of broadband wireless metropolitan area networks (wireless MANs). Wireless MAN as defined in WiMAX standards provides wireless broadband access anywhere, anytime, and on virtually any devices. It is an access technology that promises high data rates and wide coverage at low cost. It allows accessing broadband internet even while moving at vehicular speeds up to 125kmph. WiMAX provides an impressive set of features like coverage radius of up to 50km, data rates of up to 70Mbps, ability to work in both licensed and license-exempt spectra and high spectral efficiency.

To achieve high throughput, high reliability, and very good efficiency, several mechanisms are built into the physical and MAC layers of WiMAX. Also, quality of service (QoS) concepts and security mechanisms were built into WiMAX standards from the very beginning. All these ensure that WiMAX is technically geared for an impressive performance.

In its simplest form of WiMAX network can consist of ISP network and WiMAX transmitter it is also like Base Stations (BS) and Sub Stations (SS). In this Figure 1, we see how WiMAX works using one fixed subscriber. WiMAX base station is mounted on a tower and its subscriber station is a WiMAX customer that is located inside the house. WiMAX base station on the tower can communicate wirelessly with the WiMAX subscriber stations inside the home.

The WiMAX base station on the tower is physically wired to the ISP (Internet Service Provider) network through fiber optic cables. At the ISP network terminus, data aggregated from all base stations are sent to the internet backbone through high-speed and high-capacity of “thick” fiber-optic cables [5].

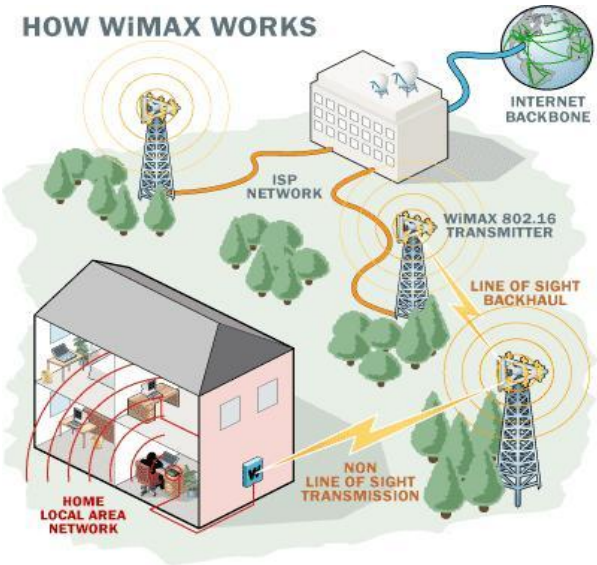

Figure 1: Illustration of How WiMAX Works.

WiMAX Advantages:

- WiMAX provides broadband speeds for voice, data, and video applications.
- WiMAX, reaching a coverage area of up to 10 miles.
- WiMAX provides wide coverage, high capacity at low cost.
- WiMAX is standards-based. WiMAX products cost less due to economy of scale and interoperable equipments made possible by standards.
- WiMAX can be used for backhaul connectivity, fixed and mobile broadband Internet access for data and voice using VoIP (Voice-over-IP) technology.
- WiMAX can support for TDD (Time Division Duplex) and FDD (Frequency Division Duplex).
- Because WiMAX is based on wireless technology, and because it is cost-effective, it is easier to extend broadband internet access to suburban and rural areas. This helps in bringing wireless broadband to the masses and to bridge the digital divide that exists especially in developing and underdeveloped countries [5].

The evolution of IEEE 802.16 was expanding standard of mobile application and thus enabling broadband access directly to WiMAX. And this enabled portable devices increasing the range from Smartphone and PDAs to notebook and laptop computers. Table 2 adapted from the WiMAX Forum summarizes the 802.16 standards.

Table 2: IEEE 802.16 Family Standards.

Completion Date	802.16 Dec 2001	802.16a/d 802.16a-jan 2003 802.16e-2004	802.16e 2005
Spectrum	10 to 66 GHz	< 11 GHz	< 6 GHz
Channel Condition	Line-of-Sight only	Non-Line-of-Sight	Non-Line-of-Sight
Bit Rate	32-134 Mbps	75 Mbps, Max-20 MHz	15 Mbps, Max-5 MHz
Mobility	Fixed	Fixed	Mobility Regional Roaming
Channel Bandwidth	20,25 and 28 MHz	Selectable between 1.25 and 20 MHz.	Selectable between 1.25 and 20 MHz
Typical Cell Radius	1 to 3 miles	3 to 5 miles (30 miles max based on tower height, antenna gain, and power transmit)	1 to 3 miles

WiMAX PHY and MAC Layers

The WiMAX physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM). OFDM is the transmission scheme of choice of enable high-speed data, video, and multimedia communications and is used by a variety of commercial broadband systems, including DSL, Wi-Fi, and Digital Video Broadcast (DVB), besides WiMAX. OFDM is an elegant and efficient scheme for high data rate transmission in a non-line-of-sight or multipath radio environment.

The WiMAX MAC was designed point-to-multipoint broadband wireless access applications. The primary task of the WiMAX MAC layer is to provide an interface between the higher transport layers and physical layer. The MAC layer takes packets from the upper layer. These packets are called MAC Service Data Units (MSDUs), and organized them into MAC Protocol Data Units (MPDUs). For received transmission, MAC layer does the reverse [6].

IEEE 802.16e WiBRO (Mobile WiMAX)

WiBro, which stands for Wireless Broadband, has data transmission by radio waves developed by Korean telecom industry and the Korean government in year of 2002. WiBro offers a high data rate wireless internet access with PSS (Personal subscriber Station) under the stationary or mobile environment, anytime and anywhere. This communication technique uses radio waves (frequency of 2.3GHz) and allows a maximum theatrical speed of 30 megabits per second over a range of 1-5 km. The WiBro network can provide eventually flow down between 1 and 3 Mbps and between 128 and 512 Kbps for upstream. The response time is around 150 millisecond, and it's over then WiMAX [7]. The network architecture of WiBro is show in Figure 2.

Figure 2: Network Architecture of WiBro.

WiBro PHY and MAC Layers

The IEEE 802.16 standard essentially two aspects physical layer (PHY) and Medium Access Control layer (MAC). This section provides an overview of the technology in these two layers.

The IEEE 802.16e suite of standards defines PHY layers and MAC layers to develop a broadband wireless system. Among the PHY layers can having based on Orthogonal Frequency Division Multiple Access (OFDMA) and FFT (Fast Fourier Transform) based for point-to-multipoint operations at frequencies between 2 GHz and 11 GHz. In the IEEE 802.16e specification the PHY layer has modified in to

Scalable OFDMA (SOFDMA). The FFT size allows for optimum operation and implementation of the system over a wide range of channel bandwidths and radio condition. This both layers (PHY and MAC) have been accepted by WiMAX for mobile and portable operations and that are also referred to Mobile WiMAX (WiBro) [8].

WIMAX AND WIBRO COMPARISON

From the technical overview of the two wireless technologies, it can be seen that they are not addressed to the same market but are very complementary. WiMAX allows the implementation of metropolitan technology, whose objective is to interconnect houses, buildings, or even hotspots to allow communication between and with other networks like the internet, etc. WiBro is also the same concept as WiMAX, with additional technical aspects which can implement mobile applications and fast hand-overs, etc.

The recent technology of WiBro has several advantages compared to WiMAX, such as increasing the number of interconnections and including applications. WiBro has been in development for around the same time as WiMAX. This wireless technology was introduced as a mobile broadband access. The base station of WiBro provides data of 30 Mbits to 50 Mbits carrier and a 1 to 5 km radius permit for the use of moveable internet usage form moving devices in the range of 120 Km/h. While the coverage range of WiMAX 70 Km along a 4 Km radius.

The technology of WiBro also offers high quality services of video streaming compared with Fixed WiMAX technology. Table 3 shows the detailed comparative analysis of the two broadband wireless access networks (WiMAX and WiBro).

IMPLEMENTING WIRELESS BROADBAND SERVICES (WIMAX AND WIBRO)

The Fixed and Mobile WiMAX networks is a multi-sector base station. It enables product delivery of a number of significant cost benefit services and extensive coverage of inaccessible areas as shown in Figure 3. It can also provide free internet service to local residences, all sectors, and mobile users. This combination of WiMAX and WiBro networks can provide the best solution for this situation. WiBro can be used as an aggregation the functions of WiMAX and it can extend the reach of broadband in mobile client access through the community centers.

Table 3: WiMax and WiBro Comparison.

Parameter	WiMAX (802.16d)	WiBro (Mobile WiMAX) 802.16e
Standards	IEEE 802.16d Fixed WiMAX	IEEE 802.16e Mobile WiMAX
Application Type	Fixed	Fixed and Mobile
Bandwidth	3.5 MHz – 10 MHz	8.75 MHz – 10 MHz
Modulation	QPSK, 16 QAM, 64 QAM	QPSK, 16 QAM, 64 QAM
Down link data rate	9.4 Mbps in 3.5 MHz	32 Mbps in 8 MHz
Uplink data rate	3.3 Mbps in 3.5 MHz	7 Mbps in 10 MHz
Gross data rate	1 Mbps – 75 Mbps	1 Mbps – 75 Mbps
Multiplexing	TDM / OFDM	TDM / OFDMA
Duplexing	TDD, FDD	TDD Initially, FDD
Frequency	3.5 GHz and 5.8 GHz initially	2.3 GHz, 2.5 GHz and 3.5 GHz initially
Coverage	3 – 5 miles	< 2 miles
Mobility	Not applicable	Mid

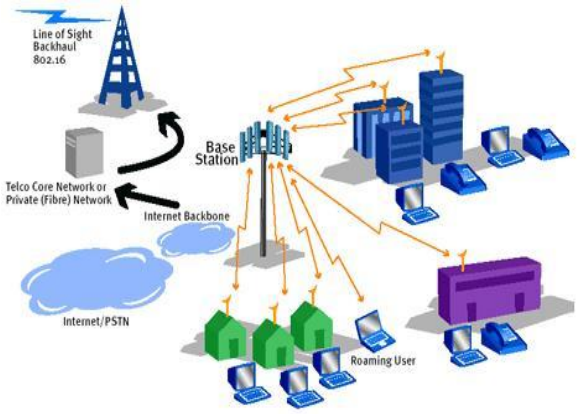

Figure 3: Implementing Wireless Broadband Network (WiMAX and WiBro).

New and existing operators may also attempt to use WiBro to offer differentiated personal broadband services, such as mobile environment. The flexible channel bandwidth and multiple level of Quality of Service (QoS) support may allow WiBro to be used by service providers for different type of mobile application.

Finally, a combined Fixed and Mobile WiMAX network may be defined to reach previously inaccessible areas and implement the broadband wireless network.

CONCLUSIONS

This paper has presented the development of different wireless access networks and a determination of how these technologies work together in wireless broadband approaches. We provided a technical analysis of alternatives for implementing wireless broadband services and detailed technical differences between WiMAX (IEEE 802.16d) and WiBro (Mobile WiMAX IEEE 802.16e) networks. This work has provided that the WiMAX standard is to replace WiBro, in its application to form an internet link for mobile networks.

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