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A Comprehensive Comparison between WiMAX and Wi-Fi

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Abstract: **WiMAX and Wi-Fi are rapidly progressing technologies and now days, it is common to find them not just in laptops and personal digital assistants, but in equipment as mobile phones, parking meters, security cameras and home entertainment equipment. A combination of Wi-Fi and WiMAX deployment, will offer more cost-effective Solution than a sole WiMAX or Wi-Fi implementation and a new technology that solves many of the difficulties in last-mile implementations. WiMAX extends the benefits of Wi-Fi networks to deliver the next-generation mobile Internet. This paper describes two technologies Wi-Fi (Wireless Fidelity) & WiMAX (Worldwide Interoperability for Microwave Access) used in wireless communication along with their comparison.**

Keywords: Wi-Fi (wireless fidelity), WiMAX**,** IEEE 802.11/802.16 Standards.

1. Introduction

WiMAX or Worldwide Interoperability for Microwave Access is a trade name for IEEE 802.16 International standard. It is a developed standard for Broadband Wireless Access (BWA) in fixed and mobile network. The aim of WiMAX to provide last-miles broadband to a metropolitan access network which will provide higher bandwidth and larger coverage than the currently available wireless technology like 3G. In terms of coverage, WiMAX can provide services up to 20 or 30 miles away from the based station. In WiMAX, Base Station (BS) has the responsibility to centrally control the subscriber Station (SSs). It means, the SSs have to communicate with each other through BS. As in WiMAX is not design to clash with Wi-Fi, but it is designed to coexist with Wi-Fi. WiMAX service is measured in square kilometers while Wi-Fi is measure in square meters. There are two variants of the WiMAX standard, which are fixed and mobile WiMAX.

Wi-Fi (stands for "wireless fidelity") is the popular term for a high-frequency wireless local area network (WLAN). The Wi-Fi technology is rapidly gaining acceptance in many companies as an alternative to a wired LAN. It can also be installed for a home network. Wi-Fi is specified in the 802.11b specification from the Institute of Electrical and Electronics Engineers (IEEE) and is part of a series of wireless specifications together with 802.11, 802.11a, and802.11g. All four standards use the Ethernet protocol and CSMA/CA (carrier sense multiple access with collision avoidance) for path sharing.

The 802.11b (Wi-Fi) technology operates in the 2.4 GHz range offering data speeds up to 11 megabits per second. The modulation used in 802.11 has historically been phase-shift keying (PSK). The modulation method selected for 802.11b is known as complementary code keying (CCK), which allows higher data speeds and is less susceptible to multipath-propagation interference. This paper aimed to analyses based on fixed, portable and mobile WiMAX and Wi-Fi networks.

2. Overview of Wi-Fi and WiMAX

2.1.1 IEEE 802.11 (Wi-Fi)

IEEE 802.11 WLAN or Wi-Fi is probably the most widely accepted broadband wireless networking technology, providing the highest transmission rate. Today's Wi-Fi devices can provide transmission rates up to 54 Mbps. The transmission range of a typical Wi-Fi device is up to 100 m, where its exact range can vary depending on the transmission power, the surrounding environments, and others. The 802.11 devices operate in unlicensed bands at 2.4 and 5 GHz, where the exact available bands depend on each country.

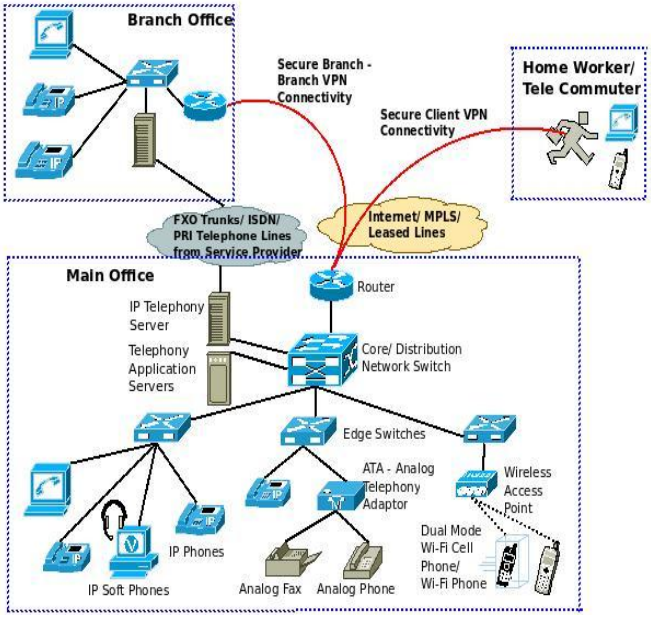

Figure 1: Wi-Fi Architecture

2.1.2 The IEEE 802.11b

The IEEE 802.11 is the original Wi-Fi standard and it was successful due to its high data rates of 11 Mb/s .The range of IEEE 802.11 is 100 m to a maximum of a few hundred meters, and operates on 2.4 GHz unlicensed band. 802.11b is the most widely deployed wireless network within the 802.11 wireless families. It uses the DSSS modulation technique that is more reliable than the FHSS.

2.1.3 The IEEE 802.11g

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 54Mbps. The 802.11g has backward compatibility with 802.11b and differs only on the modulation technique; it uses Orthogonal Frequency Division Multiplexing (OFDM). This then makes the 802.11b devices not able to pick the signal from the 802.11g devices.

2.1.4 The IEEE 802.11a

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

S. No.	Standard	Frequencies (GHz)	Features
1.	802.11a	5	• The modulation technology is OFDM. • Supports speeds up to 54 Mbps.
2.	802.11b	2.4	• It uses direct sequence spread spectrum modulation technology. • Supports bandwidth speeds up to 11 Mbps.
3.	802.11g	2.4	• The modulation technology is OFDM. • Supports speeds up to 54 Mbps.

Table 1: The 802.11 Wi-Fi Standards

2.1.5 Benefits of using Wi-Fi

1. Wi-Fi is a cost-effective and convenient alternative to a wired network.

2. Wi-Fi provides increased mobility to their users.

3. Cost associated with wiring cables and connectors is eliminated.

4. Ability to access Internet information in meeting rooms and other locations in the office gives ready information to the employees and increases the productivity.

5. Wi-Fi helps in increasing revenues in Businesses like restaurants and other public places by creating hotspots to attract customers. This can be achieved at a low cost by a one-time investment in the Wi-Fi infrastructure.

6. Wi-Fi is useful in space exploration.

2.2 IEEE 802.16 (WiMAX)

WiMAX is the next generation evolution in wireless technology and enables high-speed connectivity to meet the increasing demand for broadband Internet at home, in the office, or while on the go. The IEEE 802.16e-2005 standard for portable devices enables a new era of high throughput and high delivered bandwidth together with exceptional spectral efficiency. WiMAX based on advanced technologies such as OFDMA and MIMO. WiMAX operates in between 10 and 66 GHz Line of Sight (LOS) at a range up to 50 km (30 miles) and 2 to 11GHz non Line-of-Sight (NLOS) typically up to 6 - 10 km (4 - 6 miles) for fixed customer premises equipment (CPE). Both the fixed and mobile standards include the licensed (2.5, 3.5, and 10.5 GHz) and unlicensed (2.4 and 5.8 GHz) frequency spectrum. However, the frequency range for the fixed standard covers 2 to 11 GHz while the mobile standard covers below 6 GHz. Depending on the frequency band, it can be Frequency Division Duplex (FDD) or Time Division Duplex (TDD) configuration. The data rates for the fixed standard will support up to 75 Mbps per subscriber in 20 MHz of spectrum, but typical data rates will be 20 to 30 Mbps. The

mobile applications will support 30 Mbps per subscriber, in 10 MHz of spectrum, but typical data rates will be 3 - 5 Mbps.

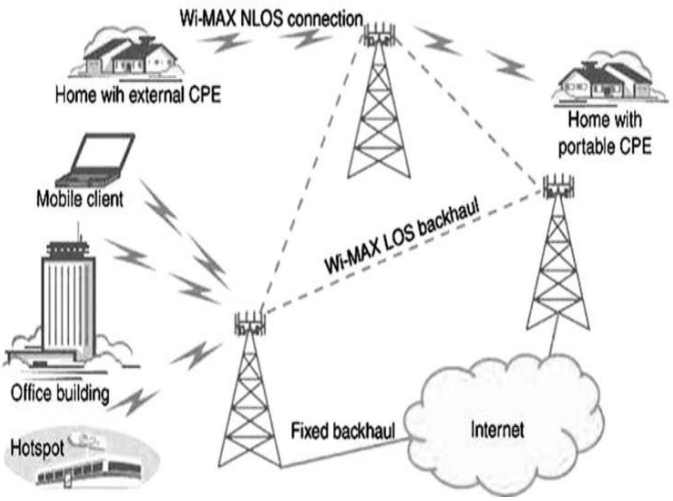

Figure 2: WiMAX Architecture

2.2.1 Standards Associated With WiMAX

IEEE 802 refers to a family of IEEE standards dealing with local area networks and metropolitan area networks. More specifically, the IEEE 802 standards are restricted to networks carrying variable-size packets. (By contrast, in cell-based networks data is transmitted in short, uniformly sized units called cells. Isochronous networks, where data is transmitted as a steady stream of octets, or groups of octets, at regular time intervals, are also out of the scope of this standard.) The number 802 was simply the next free number IEEE could assign, though "802" is sometimes associated with the date the first meeting was held February 1980.

The IEEE 802.16 Working Group on Broadband Wireless Access Standards, which was established by IEEE Standards Board in 1999 and aims to prepare formal specifications for the global deployment of broadband Wireless Metropolitan Area Networks. The Workgroup is a unit of the IEEE 802 LAN/MAN Standards Committee. Although the 802.16 family of standards is officially called Wireless MAN, it has been called "WiMAX" (from "Worldwide Interoperability for Microwave Access") by an industry group called the WiMAX Forum. The mission of the Forum is to promote and certify compatibility and interoperability of broadband wireless products.

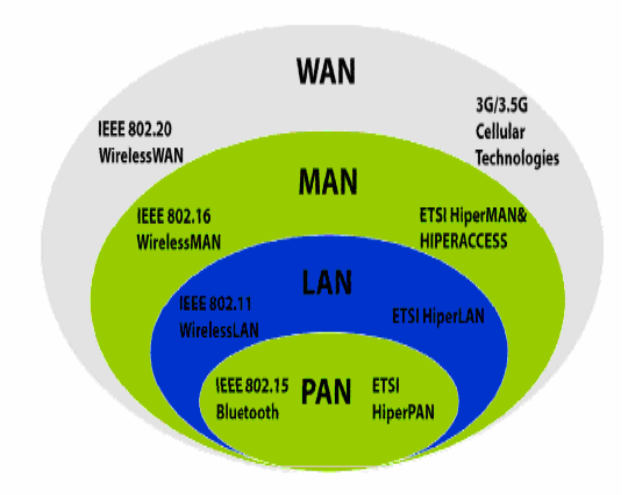

Figure 3: Standards Associated With WiMAX

2.2.2 IEEE 802.16 Specifications

	802.16-2004		802.16e
	802.16	802.16a	
Spectrum	10 – 66 GHz	2 – 11 GHz	< 6 GHz
Configuration	Line of Sight(LOS)	Non-Line of Sight(NLOS)	Non-Line of Sight(NLOS)
Bit Rate	32 to 134 Mbps (28 MHz Channel)	70 to 100 Mbps (20 MHz Channel)	15 Mbps
Modulation	QPSK, 16-QAM, 64-QAM	256 Sub-Carrier OFDM using QPSK, 16-QAM, 64-QAM, 256-QAM	2048 Sub-Carrier (S)OFDMA using QPSK, 16-QAM, 64-QAM, 256-QAM
Mobility	Fixed	Fixed	~130 km/h
Channel Bandwidth	20,25,28 MHz	selectable 1.25 to 20 MHz	5 MHz
Cell Radius	1 – 5 km	45 km(30miles)	1 – 5 km
Application	last-mile broadband access, SOHO, etc.	alternative to DSL, VoIP, etc.	Applications 802.16-2004 + QoS based applications etc.

Table 2: IEEE 802.16 Specifications

2.2.3 TYPES of WiMAX

The WiMAX family of standards concentrates on two types of usage models a fixed usage model and a mobile usage model. The basic element that differentiates these systems is the ground speed at which the systems are designed to manage. Based on mobility, wireless access systems are designed to operate on the move without any disruption of service; wireless access can be divided into three classes; stationary, pedestrian and vehicular**.**

(a) Fixed WiMAX

Service and consumer usage of WiMAX for fixed access is expected to reflect that of fixed wire-line service, with many of the standards-based requirements being confined to the air interface. Because communications takes place via wireless links from Customer Premise Equipment (CPE) to a remote Non Line-of-sight (NLOS) base station, requirements for link security are greater than those needed for a wireless service. The security mechanisms within the IEEE 802.16 standards are sufficient for fixed access service.

(b) Mobile WiMAX

The 802.16a extension, refined in January 2003, uses a lower frequency of 2 to 11 GHz, enabling NLOS connections. The latest 802.16e task group is capitalizing on the new capabilities this provides by working on developing a specification to enable mobile WiMAX clients. These clients will be able to hand off between WiMAX base stations, enabling users to roam between service areas.

2.2.4 Benefits of using WiMAX

1. WiMAX technology can be quickly deployed to remote locations where the reach of copper networks is limited. It is relatively cheaper also.

2. When compared to GSM and 3G, WiMAX produces DSL like speeds and operates at greater distances at lower cost.

3. WiMAX offers uploading of large files.

4. WiMAX enables operators to offer triple-play services such as voice, data and video.

5. WiMAX provides features that businesses need. These include –

- Quality of Service (QoS) which determines if a wireless technology can successfully deliver high value Services such as voice and video.

- Toll-quality which is a voice call having quality comparable to that of an ordinary long distance call, Originally placed over circuit-switched public telephone network.

- Bandwidth at a low cost – WiMAX provides fixed and mobile technology. WiMAX promises a low cost, high bandwidth 4G technology.

6. NASA would like to utilize WiMAX relay stations, based on the evolving WiMAX 802.16j standard, to extend coverage and increase data throughput and to determine the feasibility of using IEEE 802.16 (WiMAX) as the communication protocol.

3. Difference between WiMAX and Wi-Fi

PARAMETERS	WiMAX (802.16a)	Wi-Fi (802.11 b)	Wi-Fi (802.11a/g)
Primary Application	Broadband wireless access	Wireless LAN	Wireless LAN
Frequency Band	Licensed/unlicensed 2 to 11 GHz	2.4GHz ISM	2.4 GHz ISM(g) 5 GHz –U(a)
Channel Bandwidth	Adjustable 1.25MHz to 20 MHz	25MHz	20 MHz
Duplex	Full	Half	Half
Radio Technology	OFDM	DSSS	OFDM
Bandwidth Efficiency	5bps/Hz	0.44 bps/Hz	2.7 bps/Hz
Modulation	BPSK,QPSK,16.64,256QAM	QPSK	BPSK,QPSK,16,64 QAM
FEC	Convolutional, reed solemon	None	Convolutional codes
Mobility	Mobile WiMAX(802.16e)	In deployment	In deployment
Access Protocol	Grant Request	CSMA/CA	CSMA/CA

Table 3: Difference b/w WiMAX and Wi-Fi

4. Integrated WiMAX / Wi-Fi Network Architecture

When constructing integrated WiMAX/Wi-Fi networks, one of the most challenging issues facing network designers is that of designing efficient links and Medium Access Control (MAC) layer protocols to optimize the QoS between the WiMAX and the Wi-Fi components of the architecture.

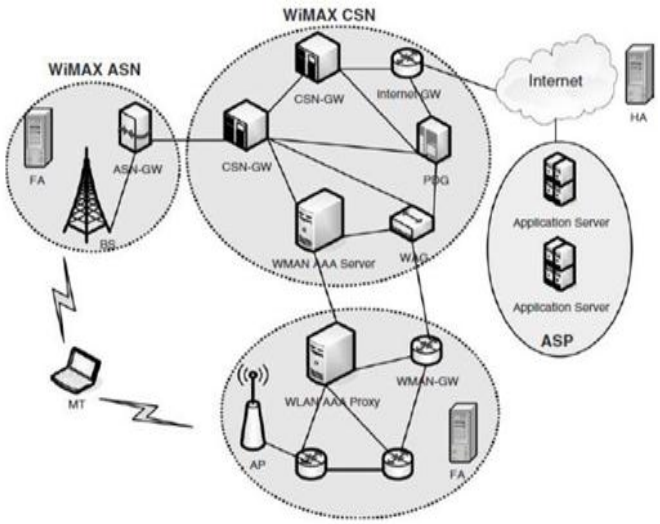

Figure 4: Integrated WiMAX / Wi-Fi Network Architecture

Figure 4. Shows combination between Wi-Fi and WiMAX. In this case, communication can be done up to client level. WiMAX coverage is overlapping with Wi-Fi coverage. It gives better service choices, more flexible to the changes of network and is more user friendly with connection ease compatible with terminal that has been owned. Moreover with dual AP radio implementation (Wi-Fi and WiMAX), integration will be easier and network development also can be faster.

5. Conclusion and Future Scope

WiMAX and Wi-Fi integration promises convenient and affordable broadband connectivity that brings new deployment models for service providers, as well as new usage models for subscribers. This study explored the performance details of WiMAX and Wi-Fi access technology. It aims was also to study whether WiMAX applications could provide better network performance compare to Wi-Fi. At the same time to explore the performance and QoS of both WiMAX and Wi-Fi wireless access. The ability to be connected to the Internet and to have access to real-time information in more places is of high value to both business professionals and consumers services.

This paper provides a comparison and technical analysis of alternatives for implementing last-mile wireless broadband services. It provides detailed technical differences between 802.11 (Wi-Fi) wireless networks with 802.16 (WiMAX), a new technology that solves many of the difficulties in last-mile implementations.

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