

Wi-Fi and Wimax Networks: A Comparative Study

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Abstract:

A need for the benefits of high-speed internet access in the mobile environment has been increasing, with growing expectations for the implementation of Broadband Wireless Access (BWA) to exceed the transmission speeds of third generation mobile phone communications (3G). WiMAX extends the benefits of WiFi networks to deliver the next-generation mobile Internet. Integrating WiMAX and WiFi, it promises convenient and affordable broadband connectivity that brings new deployment models for service providers, as well as new usage models for subscribers.

Introduction:

Wireless technologies are used for tasks as simple as switching off the television or as complex as supplying the sales force with information from an automated enterprise application while in the field. Wireless means transmitting signals using radio waves as the medium instead of wires. A wireless communications system, allows user to access information beyond their desk and conduct business from anywhere without having wire connectivity. Wireless communication systems are easy and fast to deploy in comparisons of cabled network. Initial setup cost could be a bit high but other advantages overcome that high cost. There are basically three ways to setup a wireless network. They are point-to-point, point-to-multipoint and mesh or ad hoc network.[2]

Wireless technologies can be classified in different ways depending on their range. Each wireless technology is designed to serve a specific usage segment. The requirements for each usage segment are based on a variety of variables, including Bandwidth needs, Distance needs and Power. Wireless Wide Area Network (WWAN) enables to access the Internet via a WWAN access card and a PDA or laptop. These networks provide a very fast data speed and their range is also extensive.[2]

Wireless Local Area Network (WLAN) enables to access the Internet in localized hotspots via a WLAN access card and a PDA or laptop. Their range is very limited. Wi-Fi is the most widespread and popular example of WLAN technology.

Wireless Metropolitan Area Network (WMAN) enables to access the Internet and multimedia streaming services via a WMAN. These networks provide a very fast data speed compared with the data rates of mobile telecommunication technology as well as other wireless network, and their range is also extensive.[2]

Broadband Wireless Access (BWA) is a technology that promises high-speed connection over the air. The issues related To Wireless Networks are Quality of Service (QoS), security risk and reachable range.[2]

Looking past, wireless access technologies have followed different evolutionary paths. The first generation (1G) has fulfilled the basic mobile voice, while the second generation (2G) has introduced capacity and coverage. This is followed by the third generation (3G), which has quest for data at higher speeds to open the gates for truly mobile broadband experience, which will be further realized by the fourth generation (4G). The Fourth generation (4G) will provide access to wide range of telecommunication services [3]. 5G (5th generation mobile networks or 5th generation wireless systems) is a name used in some research papers and projects to denote the next major phase of mobile telecommunications standards. At present, 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardization bodies, but are considered as generations under the 4G umbrella.[7]

System overview:

Generally, broadband wireless networks can be categorized into two types: fixed and mobile wireless as shown in Figure 1. The broadband fixed wireless network technologies of interest here are Wireless Fidelity (Wi-Fi), which is an IEEE 802.11 standard and Worldwide Interoperability for Microwave Access (WiMax), which is also an IEEE 802.16 standard. [4]

The two broadband mobile wireless network technologies are the third Generation (3G) and Fourth Generation (4G) networks. The 3G standards are defined by ITU-T, IMT2000 and the standards for the 4G are currently being defined.[4]

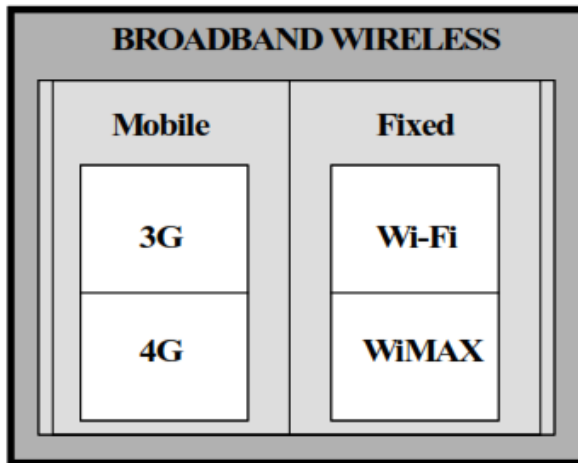


Figure 1: The broadband wireless at a glance.

Fixed Broadband Wireless Networks

Fixed broadband wireless technologies can be defined as high-speed wireless network that connect to stationary locations and are intended to serve nomadic users. Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMax) technologies are the fixed wireless technologies. These two technologies are respectively governed by IEEE 802.11 and 802.16 specifications.[4]

Wi-Fi is the first high-speed fixed wireless technology to penetrate the fixed wireless broadband market. The first WLAN (802.11) was capable of supporting 2 Mbps. There are currently many wireless products based on Wi-Fi technologies which include the approved IEEE 802.11a, b and g specifications, and a yet to be defined 802.11n specification. Wi-Fi coverage area is limited to a maximum of 300 feet radius and high speed connectivity is only possible as long as a user remains within the coverage range of the wireless access point. [4]

The main strength of Wi-Fi is its simplicity and ease of deployment. Furthermore, because it uses unlicensed radio spectrum, Wi-Fi allows users to be mobile for up to 300 feet from the base station and still have access to the network. Moreover, the cost for rolling out this wireless solution is low because no expensive wiring is required. [4]

As a fixed broadband access technology, Wi-Fi has its weaknesses. The user can only use the technology within the confines of a 300 feet radius thus limiting the level of mobility. Also, the fact that the technology operates in the 2.4GHz band which does not require any licensing, renders it susceptible to interference from other devices such as Bluetooth, cordless phones, etc. In terms of

security, the encryption standard used has been shown to be easily breakable [4].

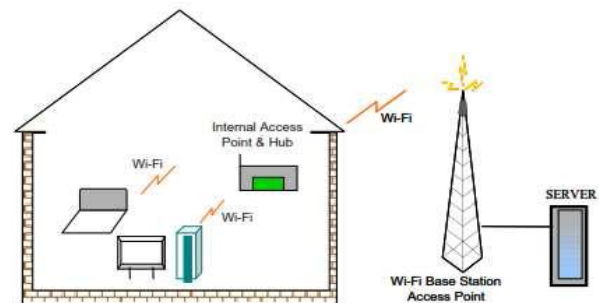


Figure 2: Wi-Fi architecture

Wimax:

Worldwide Interoperability for Microwave Access (WiMax) is an emerging fixed broadband wireless technology that will deliver last mile broadband connectivity in a larger geographic area than Wi-Fi. It is expected to provide coverage anywhere from one to six miles wide. Such WiMax coverage range is expected to provide fixed and nomadic wireless broadband connectivity without necessarily having a line-of-site (LOS) with a base station. WiMax will also enable greater mobility, higher speed data applications, range and throughput than its counterpart, Wi-Fi.[4]

WiMax uses the IEEE 802.16 standards specifications (802.16d and g). The IEEE 802.16d specification is primarily tailored to wireless wide area networks (WWANs). The recently approved IEEE 802.16e specification, the mobile version of WiMax, on the other hand is primarily used for mobile wireless metropolitan networks (WMANs). These two specifications render WiMax architecturally ideal for the last mile, the backhaul, Internet Service Providers, cellular base stations that bypass PSTNs, hotspots, and enterprise networks. [4]

Abilities such as high bandwidth frequencies between 2 GHz and 11GHz, makes WiMax ideal for data transport. WiMax has a total range of up to 30 miles. This ability is enhanced by WiMax's cell radius of 4-6 miles. More so, WiMax has the ability to support various data transmitting rates of up to 75Mbps as shown in Tables. WiMax is gaining tremendous popularity each day.[4]

There are several advantages that can be derived from the deployment of WiMax. Firstly, it supports higher throughput rates, higher data speed rates, and wider operating range. These make the technology very useful for deployment in bad terrain areas or in environments with limited wired

infrastructure. Moreover, WiMax supports and interfaces easily to other wired and wireless technologies such as Ethernet, ATM, VLANs, and Wi-Fi. Furthermore, WiMax provides network connectivity that explores multipath signals without the stringent requirement of a direct line of sight. Finally, WiMax provides a better Quality of Service (QoS) by taking advantage of smart antenna technology that utilizes the spectrum more efficiently. [4]

The main drawback to the deployment of WiMax is proprietary equipment. WiMax equipment must be able to utilize power efficiently in order to deliver optimum functionality. For WiMax, the output power usage is based on a ranging process that determines the correct timing offset and power settings. Therefore, the transmissions for each subscriber station are supposed to be such that they arrive at the base station at the proper time and at the same power level. When WiMax is deployed outdoors, in non-line of sight environments it may encounter delay, which can cause potential intersymbol interference. Though the use of scalable orthogonal frequency division multiplexing (SOFDMA) is meant to try and alleviate this problem, OFDM usage has the problem of generating phase noise, which increases the RF subsystem cost and complexity [4].

Comparison Of Mobile And Fixed Wireless Broadband

In Table 1 the various wireless broadband technologies discussed in this paper are compared. The Table shows, that the throughput for 4G and the WiMax could be up to 200Mbps and 75Mbps respectively. Thus, they are suitable for backhauling and backbone configurations. [4]

Technology	Wi-Fi	WiMax	3G/3.xG	4G
Designed	1997	2002	1990/2001	2000
Implemented	2002	2006	2002/2005	2010
Standard	802.11 (a,b,g)	802.16 (a,d)	WCDMA, CDMA2000 / EVDO, etc.	One Standard Expected
Throughput	<= 54Mbps	<= 75Mbps	>= 2Mbps	<= 200 Mbps
Multiplexing	DSSS/ OFDM	OFDM/ SOFDM	WCDMA, CDMA2000	OFDM & OFCDM
Frequency	2.4 & 5 GHz	2 & 11 GHz	900,1800,1900, and 2100MHz	2 – 8 GHz
Usage	WLAN	WMAN	WWAN	WWAN
Coverage	<= 300ft	<= 30miles	Up to 6miles	>= 30miles
Services	Fixed wireless	Fixed wireless	Mobile wireless	Mobile wireless
	broadband	multimedia	broadband	multimedia
Air Interface	OFDMA	OFDMA/ FDD	CDMA2000/EVDO, WCDMA	OFDMA/ OFCDMA

Table 1: Comparison of broadband wireless technologies

Each of the broadband wireless technologies has many standards, except for the 4G where one single standard is expected. In terms of multiplexing and access methods, scalable OFDM and OFDMA are the main technologies in use for 4G and WiMax, though the method for each of the other technologies varies in terms of design and implementation. The 3G and 4G are well suited for Wireless Wide Area Network; whereas, the WiMax is well suited for Wireless Metropolitan Area Network (WMAN). On the other hand, the Wi-Fi is best deployed for Wireless Local Area Network (WLAN) with limited coverage. [4]

The 4G Network is expected to have coverage of up to 30 miles and similarly, the WiMax is also expected to have a total coverage of up to 30 miles between point to point backhaul and much lower for other operating methods. Furthermore, the coverage a WiMax base station can achieve is substantially lower than 3.xG (3G enhancements) and hence 3.xG operators will be able to deploy a smaller number of base stations to cover the same geographic area. The 3G coverage is in range of up to 6 miles and the Wi-Fi has a coverage area of just 300 feet. [4]

The Air Interface of the various technologies differs from OFDMA for Wi-Fi to OFDMA/FDD for WiMax. Furthermore, the 3G uses CDMA2000 or W-CDMA and 4G uses the OFDMA/OFCDMA. In a recent report by Arthur D. Little, a management consultant firm, finds that the HSPA, the 3.5G would account for the majority of investment in global mobile broadband networks over the next five years, while WiMax will account for at most 15 percent [4].

Despite this observation, the tide seems to be turning in favour of WiMax because in the recent 3GSM World Congress, many executives of prominent telecom operators pushed for WiMax as the way-forward and Sprint, the number three ranked operator in the US has adopted WiMax for its 4G initiative. [4]

The mobile wireless network technologies cater for mobile users that need access to the network with a large geographical area while the fixed wireless network technologies will help to meet the need for broadband services at the last mile where traditional wired infrastructure does not exist due to the terrain, or is not cost effective. On the surface, the fixed wireless broadband technologies would appear to be competing within the broadband mobile technologies, but when 4G is fully defined, it would integrate other technologies. In other

words, the broadband fixed wireless would complement the broadband mobile technologies.[4]

System Analysis:

Wi-Fi:

Wireless Fidelity (Wi-Fi) is a name given to the IEEE 802.11 standard, which was developed to specify an air interface between a wireless client and a base station. Wi-Fi was developed by the IEEE 802.11 working group and was initially designed to be used indoors at close range but has recently ventured into mobility. It includes the approved 802.11a, b, g, n, and p specifications.

Wi-Fi is the first high-speed wireless technology deployed in areas such as hotspots, homes, offices, airports, etc. Wi-Fi hotspots have become quite popular and have allowed mobile users to remain productive while on the go. WiFi, however, is limited by its range; users must remain within 300 feet (for 802.11a) or 1000 feet (for 802.11p) of a base station. [8]

Wi-Fi Salient Features:

WiFi has brought a new aspect in the ground of networking. The broadcast of data is completed via radio waves and the cost of cables for network lying down. WiFi enable a user to get access to internet anywhere in the given location. WiFi makes waves for business with their highly effective cable less media. Its features have been listed below:

1. Unmatched mobility and elasticity:

WiFi is allowing new intensity of connectivity without giving up functions.

2. Fortress Technology:

WiFi providing secure wireless solutions support the growth and release of a prototype mobile ad hoc wireless network for use in the wireless strategy.

3. Support an entire age bracket:

WiFi technology has several advantages it support an entire age bracket and create a connection between components on the same network and have ability to transfer data between the devices and enable different kind of devices such as game, MP3 player, PDA's and much more.

4. Ease of Use:

WiFi is a convenient technology and where the range station exists we are online during travel and can equip with a WiFi network and set up shop any place. We can automatically connect with internet if we are near hotspot. These days WiFi exist everywhere with all its wonders.

5. More faster and secure:

With WiFi we can get high speed of internet because it is very fast than DSL and Cable connection we can establish a WiFi network in

small space now we don't need any professional installation just connect to a power outlet with an Ethernet cord, and start browsing. WiFi security system for Threats makes it more renewable and its tool protects our Virtual Private Network and secure web page. We can easily configure the device to take better performance. The standard devices, embedded systems and network security make it more powerful[2].

Wimax

Worldwide interoperability of microwave access (WiMAX) is a name given to the IEEE 802.16 standard, which was developed to standardize the last mile wireless distribution technology. WiMAX is one approach for the metropolitan area to address the last mile problem of providing connections to individual homes and offices. Like the IEEE 802.11 standard, the IEEE 802.16 has several working groups. One of the working groups is developing the IEEE 802.16e standard. The IEEE 802.16e standard is attempting to standardize the technology used to provide wireless network access service for mobile users while maintaining a connection at speeds up to 93 miles per hour.[8]

WiMAX is the latest wireless technology to be approved by the IEEE 802.16 working group. It is a standard for point-to-multipoint wireless networking. Its intended to deliver last mile broadband connectivity to individual home or business locations and its data rates are comparable with cable and Digital Subscriber Line (DSL) rates. Phone companies are hoping it will be a replacement for their aging legacy wired networks. In fact, it is seen as the wireless replacement for a wired broadband connection. It has the ability to allow users to connect to a wireless Internet service provider even when they roam outside their home or business office.[8]

WiMAX is a point-to-multipoint (PMP) technology that operates in the 10 to 66GHz and sub11GHz wavelengths. At higher frequencies, line of sight is a requirement and it is compatible with technologies such as asynchronous transfer mode (ATM) and internet protocol (IP). It can provide service over distances up to 30 miles. The standard covers both media access control (MAC) and physical (PHY) layers for combined fixed and mobile operation in licensed frequency bands. The MAC layer is optimized for longer distances because it was designed specifically to tolerate longer delays and delay variations. WiMAX-based voice service can work on either traditional Time Division Multiplexed (TDM) voice or IP-based voice, also known as Voice over IP (VoIP). [8]

The IEEE 802.16e version is an extension of the IEEE 802.16 standard that was drafted specifically

to deal with mobility. It is backward compatible with all IEEE 802.16 standards. And while IEEE 802.16 was conceived as a back-end technology, IEEE 802.16e has the capacity to be adapted for individual computers, and has the quality of service features to support voice. It provides connectivity for high-speed data in both stationary and mobile situations. It will enable mobile users to maintain their network connection while moving at speeds up to between 75-93 miles per hour. The upper speed limit depends on the distance of the access point from the base station as well as other transmission quality issues, i.e., air density, solar flares, electromagnetic radiation, etc. WiMAX-based solutions include many advantages, such as robust security features, good quality of service, and mesh and smart antenna technology that will allow better utilization of the spectrum resources.[8]

The WiMAX-based solutions are set up and deployed like cellular systems using base stations that service a radius of several miles/kilometers. The most typical WiMAX-based architecture includes a base station mounted on a building and shall be responsible for communicating on a point to multi-point basis with subscriber stations located in business offices, homes, and even automobiles.[8]

Wimax Salient Features

WiMAX is a wireless broadband solution [07 09] that offers a rich set of features with a lot of flexibility in terms of deployment options and potential service offerings. Its features have been listed below:

1. Types of Services:

WiMAX can provide two types of wireless service. They are Non-line-of-sight and Line-of-sight. In Non-line-of-sight service (WiFi Sort of service) a small antenna on computer connects to the WiMAX tower. In this mode, WiMAX uses a lower frequency range—2 GHz to 11 GHz. In Line-of-sight service, a fixed dish antenna points straight at the WiMAX tower from a rooftop. The line-of-sight connection is stronger and more stable, so it's able to send a lot of data with fewer errors. In this mode WiMAX uses higher frequencies, with ranges reaching a possible of 66 GHz.

2. OFDM-based physical layer:

The WiMAX physical layer (PHY) is based on orthogonal frequency division multiplexing, a scheme that offers good resistance to multipath, and allows WiMAX to operate in NLOS conditions.

3. WiMAX uses OFDM:

Mobile WiMAX uses orthogonal frequency division multiple access (OFDM) as a multiple-access technique, whereby different users can be allocated different subsets of the OFDM tones.

4. Quality-of-service support:

The WiMAX MAC layer has a connection-oriented architecture that is designed to support a variety of applications, including voice and multimedia services. WiMAX system offers support for constant bit rate, variable bit rate, real-time, and non-real-time traffic flows, in addition to best-effort data traffic. WiMAX MAC is designed to support a large number of users, with multiple connections per terminal, each with its own QoS requirement.

5. Robust security:

WiMAX supports strong encryption, using Advanced Encryption Standard (AES), and has a robust privacy and key-management protocol. The system also offers a very flexible authentication architecture based on Extensible Authentication Protocol (EAP), which allows for a variety of user credentials, including username/password, digital certificates, and smart cards.

6. Support for mobility:

The mobile WiMAX variant of the system has mechanisms to support secure seamless handovers for delay-tolerant full-mobility applications, such as VoIP.

7. IP-based architecture:

The WiMAX Forum has defined a reference network architecture that is based on an IP platform. All end-to-end services are delivered over an IP architecture relying on IP-based protocols for end-to-end transport, QoS, session management, security, and mobility [2].

Comparison Of Wi-Fi And Wimax

We can compare it with WiFi based on the following factors.

1) IEEE Standards: The IEEE 802.11 and IEEE 802.16 standards are referred to as WiFi and WiMAX, respectively. However both are IEEE standards.[2]

2) Range: WiFi typically provides local network access for around a few hundred feet with speeds of up to 54 Mbps, a single WiMAX antenna is expected to have a range of up to 40 miles with speeds of 70 Mbps or more.

As such, WiMAX can bring the underlying Internet connection needed to service local WiFi networks.[2]

3) Scalability: WiFi is intended for LAN applications, users scale from one to tens with one subscriber for each Consumer premises equipments (CPE) device. Fixed channel sizes (20MHz). WiMAX is designed to efficiently support from one to hundreds of CPEs, with unlimited subscribers behind each CPE. Flexible channel sizes from 1.5MHz to 20MHz. [2]

4) Bit rate: WiFi works at 2.7 bps/Hz and can peak up to 54 Mbps in 20 MHz channel. WiMAX works

at 5 bps/Hz and can peak up to 100 Mbps in a 20 MHz channel.[2]

5) Quality of Service: WiFi does not guarantee any QoS but WiMAX will provide several level of QoS. [2]

Wi-Fi and Wimax Synergies

Although both WiMAX and WiFi provide wireless broadband connectivity, they have been optimized for different usage models: WiFi for very high-speed WLAN connectivity and WiMAX for high-speed WMAN connectivity. By combining WiMAX and WiFi technologies, service providers can offer their subscribers a more complete suite of broadband services in more places. Table 1 illustrates how WiMAX and WiFi complement each other from an implementation and deployment perspective. The draft IEEE 802.11n standard is a new high-throughput enhancement designed for digital home and office applications. IEEE 802.16e-2005 is the mobile enhancement to IEEE 802.16-2004 and is designed to support wide area mobility via scalable OFDMA technology. Both of these technologies leverage OFDM and advanced antenna innovations to attain high broadband Data rates and improved signal reception. WiMAX and WiFi networks use IP-based technologies to provide connection services to the Internet.[2]

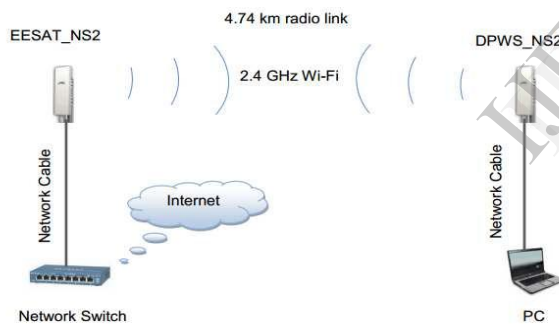


Figure 4.3: Wimax network

Conclusion

People love WiFi because a single base station – a box with a wired connection to the Internet, such as a DSL or cable – can broadcast to multiple users across distances as great as 100 meters indoors and 400 meters outdoors, but WiMAX provides wireless broadband Internet connections at speeds similar to WiFi's, but over distances of up to 50 kilometers from a central tower. The advantages of coupling WiMAX and WiFi together enable service providers to:

- Provide bundled fixed, portable, and mobile broadband Internet services based on WiMAX and WiFi.

- optimize the network by routing traffic based on the subscribers need for mobility, QoS, and bandwidth.

- offer appealing and compelling devices with both WiMAX and WiFi capabilities and take advantage of device cost savings enabled by the synergies between the two technologies. Motorola and Intel are delivering best in class WiMAX silicon, end user devices and network infrastructure equipment to drive the mobile broadband Internet revolution forward.[2]

WiMAX is based on a very flexible and robust air interface defined by the IEEE 802.16 group. WiMAX is similar to the wireless standard known as WiFi, but on a much larger scale and at faster speeds. The WiMAX physical layer is based on OFDM, which is an elegant and effective technique for overcoming multipath distortion. The physical layer supports several advanced techniques for increasing the reliability of the link layer. WiMAX supports a number of advanced signal-processing techniques to improve overall system capacity. It has a very flexible MAC layer that can accommodate a variety of traffic types, including voice, video, and multimedia, and provide strong QoS. Robust security functions, such as encryption and authentication, are built into the WiMAX standard. WiMAX defines a flexible IP-based network architecture that allows for the exploitation of all the benefits of IP. [2]

Applications

Applications of wifi:

1. Nanostation2:

It is a radio equipment built on Wi-Fi technology that works on 2.4 GHz frequency band. Using two Nanostations, a radio link of about 15 km (max.) can be established forming a point-to-point wireless link. [9]

2. Video Conference using Wi-Fi Technology

Wi-Fi technology could be utilized to chat, to do a voice call and even to do a video conference without the use of internet. [9]

3. Browsing Internet using Wi-Fi Technology

In this demonstration, we show them how Wi-Fi technology could be utilized to browse internet even in the place where we dont have internet connection. [9]

Applications of Wimax

The bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through a variety of devices.

- Providing a wireless alternative to cable and digital subscriber line (DSL) for "last mile" broadband access.

- Providing data, telecommunications (VoIP) and IPTV services (triple play).

- Providing a source of Internet connectivity as part of a business continuity plan.

Smart grids and metering Internet access

WiMAX can provide at-home or mobile Internet access across whole cities or countries. In many cases this has resulted in competition in markets which typically only had access through an existing incumbent DSL (or similar) operator. Additionally, given the relatively low costs associated with the deployment of a WiMAX network (in comparison with 3G, HSDPA, xDSL, HFC or FTTx), it is now economically viable to provide last-mile broadband Internet access in remote locations.[11]

Connectivity for SMBs

Most effective application by Wimax is SMBs which mean the small to medium-sized businesses. Due to Wimax technology the small or medium sized business progressing day by day because Wimax technology offer a connectivity which attract clients and facilitate them with various types of services like hotspot etc. Therefore a lot of regional applicant entered into the broadband internet access and spotlight on this application. [10]

Nomadic Broadband

Wimax Technology next application is Nomadic Broadband which is under the marvelous plan of WiFi. There are lots of medium or small business companies that might pay for the base station of wimax in key areas for the development of business and commerce. These business companies permit of facilitate their clients to use them for free. WiFi also rolled out for similar aims but WIMAX offer enhanced Quality of Service. Wimax Technology provide less access point but very high security. MAN (Metropolitan area network) a wireless access could supply a solid draw when business leaders attempt to catch the attention of businesses to their region.[10]

Broadband for Developing Countries

There are many countries such as Asia, Africa, and Eastern Europe are likely to achieve the most from the fixed wide area wireless networking technology. [10]

Private Networks

Mostly small and medium sized business man pay Wimax to get access but big companies having large campuses may finally deploy and control their own WIMAX networks. Such private networks are expected to be the very last WIMAX application. [10]

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