Broadband Wireless Access based on WiMAX Technology
With business analysis

A Thesis

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by

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DECLARATION

We hereby declare that this thesis is based on the surveys found by ourselves. Materials of work found by other researcher are mentioned by reference. This thesis, neither in whole nor in part, has been previously submitted for any degree.

Signature of	Signature of
Supervisor	Author

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Abstract

WiMAX which represents World Interoperability for Microwave Access is a major part of broadband wireless network having IEEE 802.16 standard provides innovative fixed as well as mobile platform for broadband internet access anywhere in anytime. In its original release the 802.16 standard addressed applications in licensed bands in the 10 to 66 GHz frequency range. WiMAX, which is an IP-based wireless broadband technology, can be integrated into both wide-area third-generation (3G) mobile and wireless and wire line networks, allowing it to become part of a seamless anytime, anywhere broadband access solution. Ultimately, WiMAX is intended to serve as the next step in the evolution of 3G mobile phones, via a potential combination of WiMAX and CDMA standards called 4G. Bangladesh is also an emerging market for WiMAX technology. WiMAX is a dynamic solution to establishing long-haul data communication link to distant areas. Bangladesh Telecommunication Regulatory Commission (BTRC) had already gives WiMAX license at year 2008. The introduction of WiMAX can have a synergetic effect on rural areas. The government and private stakeholders could come forward and utilize this technology to build knowledge centers across the country where people can get e-heath, e-education and e-business related services which will effectively improve their livelihood. This thesis provides the detail about the applications and analysis of WiMAX system. Where WiMAX are designed in a proper network planning which is helpful to offer better throughput broadband wireless connectivity at a much lower cost with the help of existing architecture and available resources. Another objective is to provide better broadband connectivity business model with Technological and country perspective.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Chapter 1

1.1 Background:

Today's life is being changed step by step very thanks to the evolution of telecommunication industry. Internet, broadband and mobile technology has become the part of daily life that people can not live without. The requirements of portable, mobile and high speed connectivity are increasing rapidly. Services such as wireless VOIP, IPTV, streaming media and interactive gaming need to be supported with broadband access. 3G has been serving mobile market for some years, and it is still an expensive voice service and lacks the strong capacity to support data service. At present, significant mobile operators, service providers and other actors in telecom industry are looking for the way to build up high speed but cost-effective broadband wireless access (BWA).

WiMAX will play an important role in the Broadband Wireless Technology (BWT) sector, since it is more cost-effective and faster to set up [1] [2]. WiMAX is a fixed Broadband Wireless Access (BWA) system based on the IEEE 802.16 standard [3]. WiMAX will be used to provide "last mile" access to these broadband and Internet access services [4]. Although IEEE 802.16 Medium Access Control (MAC) protocols have been proposed to provide the QoS guarantees for different kinds of applications, they exclude a method to allocate system bandwidth to achieve the main QoS requirements for various applications while maintaining high system bandwidth utilization [3]. The QoS of Voice over IP (VoIP) becomes a crucial consideration. One of the challenges to achieve QoS 2 requirements is to determine how to dynamically allocate the system bandwidth to various applications [5].

1.2 Basic concept of WiMAX

WiMAX, the **W**orldwide **I**nteroperability for **M**icrowave **A**ccess, is a telecommunications technology aimed at providing wireless data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access. It is a wireless digital communications system that is intended for wireless "metropolitan area networks". This technology can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations.

WiMAX is a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to wired broadband like cable and DSL. WiMAX provides fixed, nomadic, and portable. Soon, mobile wireless broadband connectivity without the need for directs line-of-sight with a base station. In a typical cell radius deployment of three to ten kilometers, WiMAX Forum Certified systems can be expected to deliver capacity of up to 40 Mbps per channel, for fixed and portable access applications.

Many companies are closely examining WiMAX for the "last mile" connectivity at high data rates. The resulting competition may bring lower pricing for both home and business customers or bring broadband access to places where it has been economically unavailable. Prior to WiMAX, many operators have been using proprietary fixed wireless technologies for broadband services. [2] [9][10]

Potential applications which are capable through the bandwidth and the requirement of WiMAX:
Connecting Wi-Fi hotspots with each other and to other parts of the Internet.
Providing a wireless alternative to cable and DSL for last mile broadband access.
Providing high-speed data and telecommunications services.

Providing a diverse source of Internet connectivity as part of a business continuity plan. That is, if a business has a fixed and a wireless Internet connection, especially from unrelated providers, they are unlikely to be affected by the same service outage.

Providing nomadic connectivity.

High speed data and nomadic connectivity of the WiMAX technology enables the freedom and convenience that comes from having your Internet standing by where and when we need it—staying connected on the go to the people, communities, and resources that make up our lives. Broadband on the go is your front row seat to all the rich multimedia Internet applications you already use, and exciting future possibilities enabled by Mobile WiMAX.

Playing in Real-Time: Play multiplayer 3-D games, view You Tube videos, and listen to radio broadcasts— it's all there waiting to entertain us on the go.

Working Smarter: WiMAX pulls productivity out of thin air. Capture lost time by doing things in areas previously unavailable. Working on the go changes the rules of competition by allowing us to be more productive.

Staying in Touch: Broadband on the go is about keeping in touch with family, friends, and our communities using all the typical tools like e-mail and IM, but WiMAX adds face-to-face video conferencing and voice to our connections.

Locating People and Places: WiMAX enables a spontaneous lifestyle. Location-based services creates a new paradigm in accessing real-time information where and when we need it.

Receiving TV and Radio on the Go: There are just more streams of data available with WiMAX, so why not pipe broadcast television and radio into a Mobile WiMAX device? Radio stations already co-broadcast over the Internet.

Mobile Internet-based TV Transmissions also set the stage for content-on-demand services like movies and sporting events.

1.3 WiMAX/IEEE 802.16 Standard Family

The IEEE 802.16 standard was originally approved for frequencies between 10 and 66 GHz. In order to overcome the disadvantage of the Line-of-Sight (LoS) requirement between transmitters and receivers, the IEEE 802.16a was approved in 2003 to cover frequencies between 2-11 GHz to support Non-Line-of-Sight (NLoS) links [12]. The 802.16-2004 (802.16d) standard was subsequently released primarily for fixed broadband wireless access. The release of the IEEE 802.16e amendment is expected during the later half of 2006 with the objective of extending the 802.16-2004 standards to support mobile terminals [13]. Only the 802.16-2004 standards are discussed in this report. WiMAX and IEEE 802.16 both refer to the 802.16-2004 standards in this report, while WiMAX and IEEE 802.16 are used interchangeably. **Table 1.1** presents the key attributes of the WiMAX standard.

Table 1.1: Key attributes of WiMAX air interface standard

	WiMAX Air Interface Standard		
	IEEE 802.16	**IEEE 802.16-2004**	**IEEE 802.16e**
Estimation Date	2003	Certification in 2005	2006
Service	Fixed	Fixed/No madic	Fixed, Mobile
Primary Market Segment	Urban: high density multi-tenant buildings	Urban, suburban, rural residential: SME, Wi-Fi backbaul	Broadband access to laptop, PDA or smart phone
Air Interface	SCA OFDM/OFDMA	OFDM/OFDMA	SOFDMA
Range	Los up to 5 Km	Los&near-Los up to 30 Km, non-Los up to 5 Km	Non-Los up to 10 Km
Channel BW	20, 25, 28 MHz	Various from 1.75 to 20 MHz (depending on frequency)	Various from 1.25 to 20 MHz (depending on frequency)
Channel Capacity	Up to 130 Mbps	Up to 70 Mbps	Up to 35 Mbps
Duplexing	TDD or FDD	TDD or FDD	TDD or FDD
QoS	Voice/data/video, Differentiated services	Voice/data/video, Differentiated services	Voice/data/video, Differentiated services
Frequency Band	Licensed 10-66 GHz	Licensed and unlicensed sub-11 GHz	Sub-6 Hz

1.4 WiMAX Architecture:

A wireless MAN based on the WiMAX air interface standard is configured in much the same way as a traditional cellular network with strategically located base stations using a point-to-multi-point architecture to deliver services over a radius of up to several miles, depending on frequency, transmit power, and receiver sensitivity. In areas with high population densities, the range will generally be capacity limited rather than range limited, owing to limited bandwidth. The base stations are typically backhauled to the core network by means of fiber or point-to-point microwave links to available fiber nodes or via leased lines from an existing wireline operator. The range and NLOS

capability make the technology equally attractive and cost effective in a wide variety of environments. The technology was envisioned from the beginning as a means of providing wireless last mile broadband access in the MAN with performance and services comparable to or better than traditional DSL, cable, or T1/E1 leased line services.

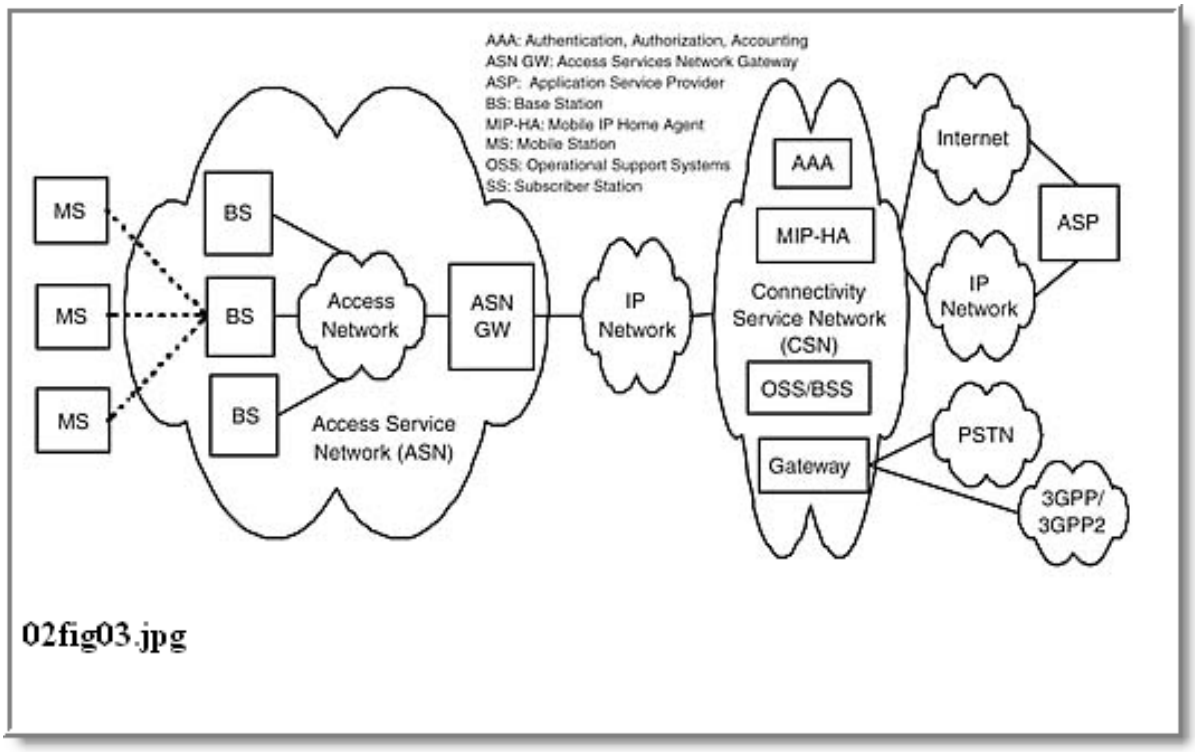

Figure1.1: WiMAX Architecture (IP based)

The technology is expected to be adopted by different incumbent operator types, for example, wireless internet service providers (WISPs), cellular operators (CDMA and WCDMA), and wireline broadband providers. Each of these operators will approach the market with different business models based on their current markets and perceived opportunities for broadband wireless as well as different requirements for integration with existing (legacy) networks. As a result, 802.16 network deployments face the challenging task of needing to adapt to different network architectures while supporting standardized components and interfaces for multi-vendor interoperability.

1.5 How WiMAX Works:

Basically, WiMAX system mainly consists of two parts - base station and WiMAX receiver. Base station is a tower which is similar to the concept of cell-phone tower that works together with a set of indoor electronics. A single WiMAX tower can provide widely coverage up to 30 miles radius at maximum, depending on the tower height, antenna gain and transmission power. Typically, the deployments will use cells of radius from 2 to 6 miles, so that the wireless node could get access within this range.

The center base station is connected with a number of subscriber's station, which is referred as customer premise equipment (CPE) receiver. The WiMAX communication network utilizing base station and CPE to build up wireless communication system are shown in figure. WiMAX receiver could be either installed as a small box out door of house and building, or integrated in the personal computer as memory card, or built into a laptop as the way Wi-Fi access does today.

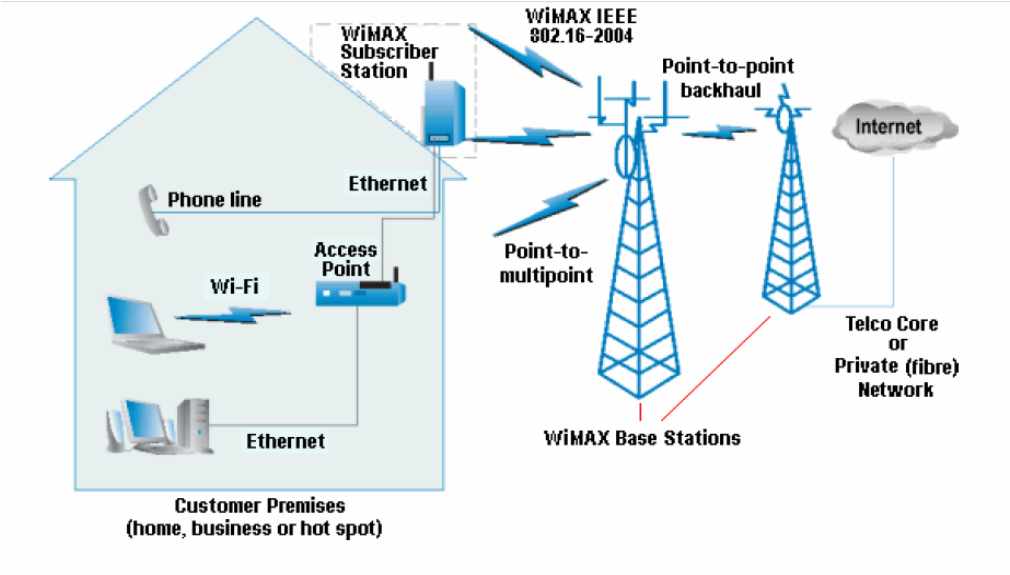

Figure 1.2: WiMAX 802.16 Network (Source Intel White Paper)

Figure shows the basic concept of fixed WiMAX. First, a subscriber sends a wireless access query from the fixed antenna on top of a building or using indoor CPE. The base station receives transmissions from multiple sites and sends the traffic over NLOS or LOS links to a switching centre by using 802.16d protocol. Then the switching centre sends traffic to the ISP or PSTN to access Internet. While in mobile WiMAX network, the terminal such as laptop, PDA and WiMAX phone that are embedded with WiMAX chips inside could directly receive the signal from nearest tower, and the user could be portable and move within a certain region up to 30 miles.

1.6 Types of WiMAX:

The WiMAX family of standards addresses two types of usage models: a fixed-usage model (IEEE 802.16-2004) and a portable usage model (802.16 REV E, scheduled for ratification in current year). Before we discuss more about these distinct types of WiMAX, it is important to understand and appreciate key differences between the mobile, nomadic, and fixed wireless access systems. The basic feature that differentiates these systems is the ground speed at which the systems are designed to operate. Based on mobility, wireless access can be divided into four classes: stationary (0 km/hr), pedestrian (up to 10 km/hr), and vehicular (sub classified as “typical” up to 100 km/hr and “high speed” up to 500 km/hr).

A mobile wireless access system is one that can address the vehicular class, whereas the fixed serves the stationary and pedestrian classes. This raises a question about the nomadic wireless access system, which is referred to as a system that works as a fixed wireless access system but can change its location. An example is a WiMAX subscriber operating from one location, i.e., the office during daytime, and moving to another location, i.e., the residence

in the evening. If the wireless access system works at both the locations, it can be referred to as nomadic.

1.6.1 Fixed

Service and consumer usage of 802.16 for fixed access is expected to mirror that of fixed wire line service, with many of the standards-based requirements being confined to the air interface. Because communication takes place via wireless links from CPE to a remote NLOS base station, requirements for link security are greater than those needed for wire line service. The security mechanisms within the IEEE 802.16 standards are adequate for fixed access service. An additional challenge for the fixed-access air interface is the need to establish high-performance radio links capable of data rates comparable to wired broadband service, using equipment that can be self installed indoors by users, as is the case for DSL and cable modems. IEEE 802.16 standards provide advanced physical (PHY) layer techniques to achieve link margins capable of supporting high throughput in NLOS environments.

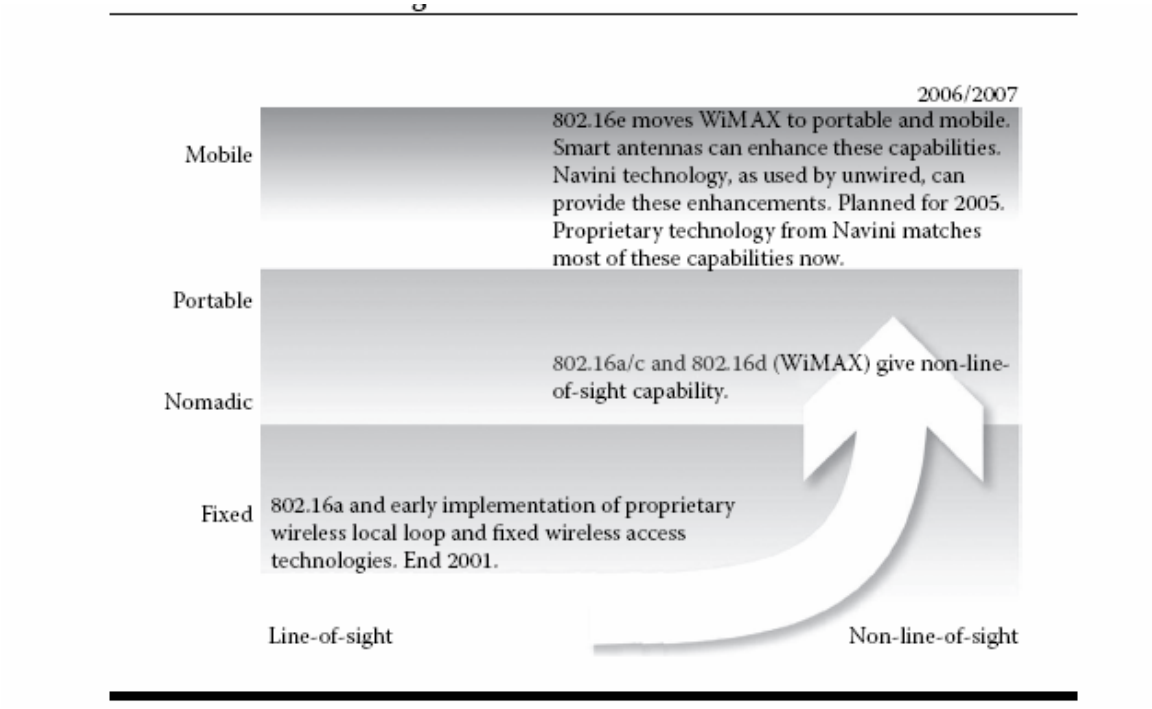

Figure 1.3: Types of WiMAX

1.6.2 Portable or Mobile

The 802.16a extension, ratified 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 802.16 clients. These clients will be able to hand off between 802.16 base stations, enabling users to roam between service areas. There can be two cases of portability: full mobility or limited mobility. The simplest case of portable service (referred to as
Nomad city) involves a user transporting an 802.16 modem to a different location. Provided this visited location is served by wireless broadband service, in this scenario the user reauthenticates and manually reestablishes new IP connections and is afforded broadband service at the visited location. In the fully mobile scenario, user expectations for connectivity are comparable to facilities available in third-generation (3G) voice/data systems. Users may move around while engaged in a broadband data access or multimedia streaming session. Mobile wireless access systems need to be robust against rapid channel variation to support vehicular speeds. There are significant implications of mobility on the IP layer owing to the need to maintain rout ability of the host IP address to preserve in-flight packets during IP handoff. This may require authentication and handoffs for uplink and downlink IP packets and MAC frames. The need to support low latency and low-packet-loss handovers of data streams as users' transition from one base station to another is clearly a challenging task. For mobile data services, users will not easily adapt their service expectations because of environmental limitations that are technically challenging but not directly relevant to the mode of user (such as being stationary or moving). For these reasons, the network and air

interface must be designed to anticipate these user expectations and deliver accordingly.

IEEE 802.16e will add mobility and portability to applications such as notebooks and PDAs. Both licensed and unlicensed spectrums will be utilized in these deployments. 802.16e is tentatively scheduled to be approved in the second half of this year.

1.7 WiMAX Advantages:

QoS: A Powerful WiMAX Advantage

Several features of the WiMAX protocol ensure robust quality-of-service (QoS) protection for services such as streaming audio and video. As with any other type of network, users have to share the data capacity of a WiMAX network, but WiMAX's QoS features allow service providers to manage the traffic based on each subscriber's service agreements on a link-by-link basis. Service providers can therefore charge a premium for guaranteed audio/video QoS, beyond the average data rate of a subscriber's link.

Improved User Connectivity

WiMAX keeps more users connected by virtue of its flexible channel widths and adaptive modulation. Because it uses channels narrower than the fixed 20 MHz channels used in 802.11, the 802.16-2004 standards can serve lower-data-rate subscribers without wasting bandwidth. When subscribers encounter noisy conditions or low signal strength, the adaptive modulation scheme keeps them connected when they might otherwise be dropped.

Link Adaptation: Provides High Reliability

WiMAX provides adaptive modulation and coding — subscriber by subscriber, burst by burst, and uplink and downlink. Transmission adaptation with the help of modulation depending on channel conditions provides high reliability to the system. Further, this feature imparts differential service provision, making the system economically more appealing to operators.

Intelligent Bandwidth Allocation: Provides Guaranteed

Service Levels: Terminals have a variety of options available to them for requesting bandwidth, depending on the QoS and traffic parameters of their services. The option of bandwidth on demand (frame by frame) by reallocation of frequency band makes WiMAX flexible as well as efficient.

NLOS Support: Provides Wider Market and Lower Costs WiMAX solves or mitigates the problems resulting from NLOS conditions by using multiple frequency allocation support from 2 to 11 GHz, orthogonal frequency division

multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) for NLOS applications (licensed and license-exempt spectrum), subchannelization, directional antennas, transmit and receive diversity, adaptive modulation, error correction techniques, and power control.

Highly Efficient Spectrum Utilization

In WiMAX, the MAC is designed for efficient use of spectrum and incorporates techniques for efficient frequency reuse, deriving a more efficient spectrum usage of the access system.

Secured Data Exchange

WiMAX proposes the full range of security features to ensure secured data exchange: terminal authentication by exchanging certificates to prevent rogue devices, user authentication using the Extensible Authentication Protocol (EAP), data encryption using the Data Encryption Standard (DES) or Advanced Encryption Standard (AES), both of which are much more robust than the Wireless Equivalent Privacy (WEP) standard initially used by WLAN. Furthermore, each service is encrypted with its own security association and private keys.

Chapter 2

2 WiMAX Services and Benefits

2.1 Services

In recent years many new services have been implemented on IP-based networks. As IP networks become faster (higher bandwidth) and more responsive (lower delay), the set of services has grown. This growth generates more revenue opportunities for service providers, and thus next-generation networks are all migrating toward IP technologies.

From an operator standpoint, services can be broken down into four billable classes:

Basic Internet services

Premium Internet services

VPN services

Operator premium services

2.1.1 Basic Internet Services

Basic Internet services are typically billed at a flat rate. They don't offer an operator the ability to increase average revenue per user (ARPU) for premium content or applications. Basic Internet service does not provide end-to-end QoS and therefore cannot guarantee good service for demanding QoS applications.

2.1.2 Premium Internet Services

Premium services are important not only to improve ARPU, but to add new services. Premium Internet services allow operators to have a business

relationship with an application service provider (ASP) that feeds their QoS offerings. This is accomplished when both the operator and ASP use compatible QoS technologies. Examples of billable premium content are TV stations, movies, on-demand content, and radio.

2.1.3 VPN Services

VPN is in its own class because the operator's network has no visibility into the application data. To meet the security needs of an enterprise the implementation of a VPN typically creates a tunnel between the user device and a VPN concentrator within the enterprise network. Because a VPN tunnel is encrypted, there is no mechanism for billing by application. However, an enterprise's VPN service can be billed by QoS level. Enterprises that outsource their data service might use a managed VPN which is slightly different because the operator owns at least one end of the tunnel.

2.1.4 Operator Premium Services

Operator premium services are applications provided on the operator's network. These services have the advantage of a controlled environment where QoS can be strictly enforced. For example, a voice-over-IP (VoIP) service on a QoS-enabled network can guarantee more consistent quality than a VoIP call over the best-effort Internet. In addition, broadcast services, based on IP multicast technologies can be accommodated efficiently on an end-to-end IP based transport network.

2.2 Benefits

2.2.1 Value to Government and Society

Today, political leaders at all levels of government are working to strengthen economic development, bridge the digital divide, streamline the delivery of government services, and improve the quality of citizens' lives within their communities. To accomplish these goals, local officials are embracing a vision for digital cities, a term used to describe communities in which access technology such as WiMAX will be applied to make universal broadband access a reality and hence promote economic development and community enhancement. Specifically, this will benefit society as follows:

Broadband telecommunication for businesses, residents, and government agencies will be universally available and affordably priced; hence, its positive impact on economic development and community enhancement.

Solutions will be deployed to create a more efficient and responsive government while easing citizen-to-government interaction in areas such as public safety, transportation, education, e-government, healthcare, and public works.

A formal process for cooperation between local governments and private technology and telecommunications companies means more effective technologies will emerge with these segments as a target.

More technology investment and programs will bring technology products, services, and training to lower-income or disadvantaged areas of the community, helping bridge the digital divide.

2.2.2 Value to Consumers

Although market demand is not clear, technology development is driving the value for customers currently getting DSL as well as for those who do not. Existing DSL customers get far more features, including new applications and flexibility, whereas prospective customers not having DSL access can hope to get connected in a broad way. Some key benefits for customers are as follows:

More broadband access choices, especially in areas where there are gaps, such as worldwide urban centers in which building access is difficult, suburban areas where the subscriber is too far from the central office, and rural and low population density areas where infrastructure is poor.

Easy and low-cost method to get connected for the billions who do not even have a basic telephone line (let alone broadband Internet).

More choices for broadband access will create competition, which will result in lower monthly subscription prices.

Payment for actual usage, and the possibility of differential service levels make optimum utility possible because service variables such as quality, speed, etc., can be selected depending upon the user need.

More applications and flexibility are expected later with the mobile version of WiMAX. Mobile WiMAX might bring users more potential added value than what they would get by simply replacing what they have today, e.g., increased mobility, the same provider at home and on the move, and VoIP/Skype on a PDA.

2.2.3 Value to Component and Equipment Makers

WiMAX promises many strategic opportunities for component andequipment makers, not just as a backhaul solution for Wi-Fi, delivering additional bandwidth to hot spots, but potentially for 3G networks too. WiMAX may also become a viable DSL or cable broadband replacement technology for consumers and may even offer nomadic or portable wireless Internet access for consumers and enterprise users. WiMAX will be an important mobile networking technology following the ratification of the 802.16e standard and the availability of WiMAX clients' devices in the year 2007–2008. Operators could also use it to carry VoIP services. The following are the implications for component and equipment makers:

The steady growth of outdoor wireless equipment now and indoor wireless equipment later.

A common platform opens the door for volume component suppliers, which drives down the cost of equipment and also creates a volume opportunity for silicon suppliers.

More rapid innovation because there exists a standards-based, stable platform on which to add new capabilities.

A common platform allows faster innovation and accelerates price/performance improvements unachievable by proprietary approaches.

The amount of risk is reduced because of the economies of scale enabled by the standard. No longer does one need to develop every piece of the end-to-end solution.

2.2.4 Value to Service Providers and Network Operators

WiMAX can give service providers and network operators another cost effective way to offer new high-value services such as multimedia to their subscribers. With the potential to deliver high data rates along with mobility, it can support the sophisticated lifestyle services that are increasingly in demand among consumers, along with the feature rich voice and data services that enterprise customers require. Because it is an IP-based solution, it can be integrated with both wireline and 3G mobile networks. This versatility opens up cost-effective new opportunities for extending bandwidth to customers in a wide range of locations and for delivering new revenue-generating services such as wireless VoIP and video streaming. Other benefits WiMAX can offer operators are as follows:

A common platform that drives down the cost of equipment and accelerates price/performance improvements unachievable with proprietary approaches.

Revenue generation by filling broadband access gaps, provision of services providing true broadband speeds, delivering >1 Mbps per user.

NLOS operations providing strong multi-path protection (indoor self-install).

High link budget enabling higher than 150 to 160 dB of link budget, high number of simultaneous sessions offering hundreds of simultaneous sessions per channel.

Speedy provision of T1/E1 level and on-demand high-margin broadband services.

Reduction of the risk associated with deployment as scalability allows investment to accommodate demand growth; also, equipment will be less expensive because of economies of scale.

Vendor independence as base stations will interoperate with multiple vendors' CPEs.

Chapter 3

3 Global implementation of WiMAX

3.1 Global Market Scenario:

In recent years, Broadband technology has rapidly become an established, global commodity required by a high percentage of the population. In the past two years alone, the demand has risen rapidly, with a worldwide installed base of 57 million lines in 2002 rising to an estimated 80 million lines by the end of 2003. This healthy growth curve is expected to continue steadily over the next few years and reach the 200 million mark by 2006 (see Figure 1 below). DSL operators, who initially focused their deployments in densely-populated urban and metropolitan areas, are now challenged to provide broadband services in suburban and rural areas where new markets are quickly taking root. Governments are prioritizing broadband as a key political objective for all citizens to overcome the “broadband gap” also known as the “digital divide”.

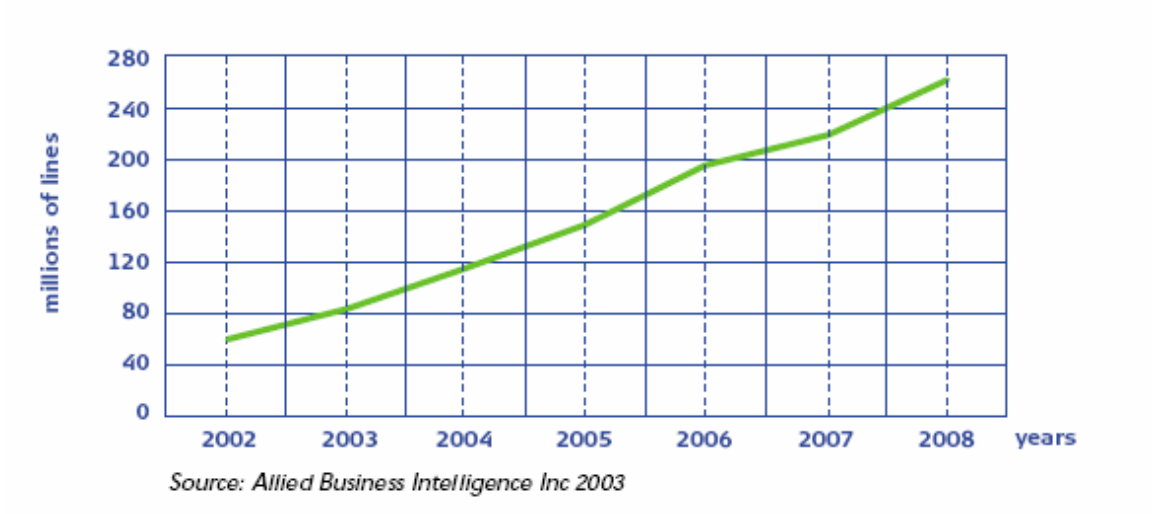

Figure 3.1: Worldwide Broadband Market Growth

Wireless DSL (WDSL) offers an effective, complementary solution to wire line DSL; allowing operators to provide broadband service to additional areas and populations that would otherwise find themselves outside the broadband loop. Government regulatory bodies are realizing the inherent worth in wireless technologies as a means for solving digital-divide challenges in the last mile and have accordingly initiated a deregulation process in recent years for both licensed and unlicensed bands to support this application. Recent technological advancements and the formation of a global standard and interoperability forum - WiMAX, set the stage for wireless broadband access to take a significant role in the broadband market. Revenues from services delivered via Broadband Wireless Access have already reached $323 million and are expected to jump to $1.75 billion by 2006 (see revenue projections in Figure 2 below).

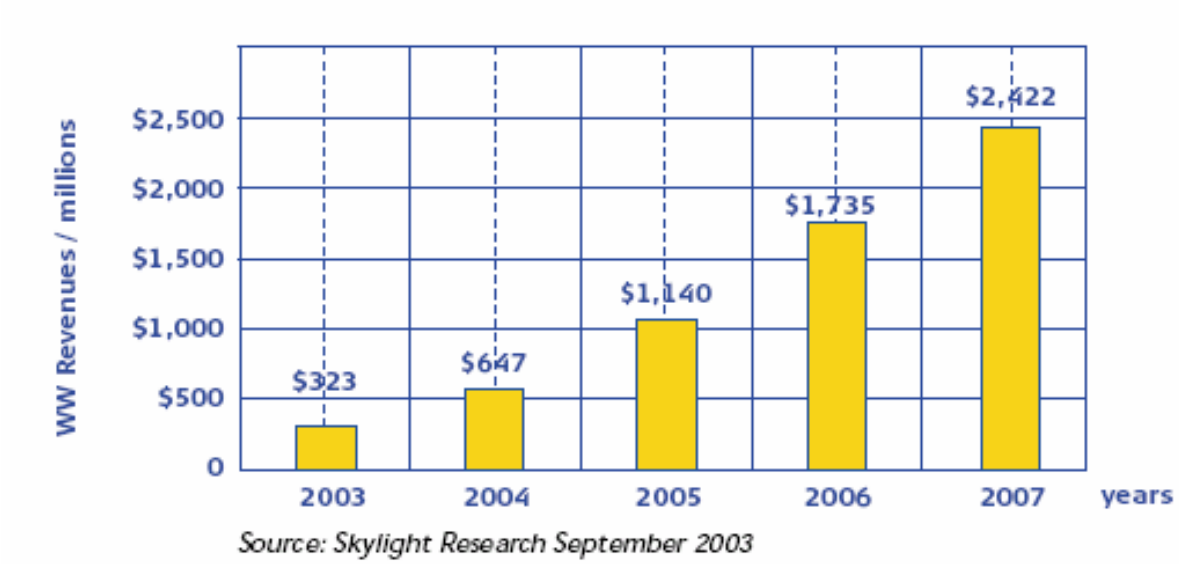

Figure 3.2: Worldwide - Sub-11 GHz PMP Broadband Wireless Access - 5 Year Forecast

The desire for bandwidth-intensive Internet access and other voice and data services has never been greater across all geographies and market segments despite the economic downturn of recent years and the air of uncertainty in

the global telecommunications industry. The DSL market, based on a variety of wireline infrastructures, has succeeded in reaching millions of business and private subscribers and continues on a rapid growth curve. But supplying the quick rollout of infrastructure to the last mile has become a difficult and expensive challenge for carriers who cannot possibly keep pace with the demand. This has brought about a situation wherein subscribers living in developed areas with broadband-ready infrastructure can enjoy all the benefits of DSL services while those who do not, require another technology solution to fill the void. Broadband wireless technology -and specifically the introduction of the new WiMAX standard - fits this agenda perfectly.

3.2 Forecast- WiMAX

3.2.1 Assumptions

Worldwide access to Broadband Internet is vital for economic growth and development. All governments must work to ensure that their nations are able to realize the benefits associated with a strong communications infrastructure. Therefore this report assumes that many countries will adopt WiMAX as a wireless Broadband Internet technology to facilitate rapid economic development. It is also assumed that the move to WiMAX, a technology that is ready for deployment now, will be preferable to waiting for alternative technologies that may not be available for three or more years.

Our assumptions for the uptake of WiMAX technology, particularly in developing areas, are based on the difficulties inherent in deploying today's available competing technologies. Wireline technologies are slow and costly to roll out - even in some parts of developed nations. Cellular technology is

often too costly to use, does not deliver true broadband speed and does not scale to the capacity of an all-IP media-centric network. Therefore it is assumed that, throughout the forecast period, particularly aggressive WiMAX growth will take place in countries such as Brazil, China, India and Russia; and in regions such as the Americas, Middle East/Africa, Eastern Europe and Developing Asia Pacific. Initial forecasting assumptions are based on current penetration levels and potential total penetration levels, which take into account current and future economic development potential in each world region. Also, growth in fixed and mobile communications has historically followed an S-curve pattern, and therefore S-curve growth has been applied in these forecasts.

The WiMAX penetration rates in these forecasts vary significantly by region and are based on the following assumptions:

WiMAX will have higher growth and penetration rates where penetration of alternative fixed and mobile broadband systems is low.

The launch date of WiMAX services and their market potential depends • on the availability of suitable spectrum in each region.

WiMAX will have higher growth rates in regions where major operators are already committed to deploying the technology. Emphasis was put on those operators with a large number of existing subscribers to migrate to WiMAX, and what relevant assets (such as base station sites and sales & distribution channels) they have available.

WiMAX penetration will increase as equipment costs—and particularly • device costs—decrease, with the rate of penetration in each region depending on the wider broadband market (e.g. the cost of competing broadband devices) as well as macroeconomic factors such as consumer purchasing power.

WiMAX penetration will increase as service costs decrease, with the ex• act rate depending on the wider broadband and economic landscape of each region.

WiMAX penetration rates in each region have been benchmarked • against comparable historical penetration rates in the fixed broadband, mobile, and mobile broadband markets. More detail on these penetration rates will be available in future reports.

In future forecast revisions our intention is to introduce a dual methodology that includes both a tops-down and a bottom-up approach based on actual deployment data. This will allow for growth assumptions to be tied more closely to the number and growth of national and major regional operators.

3.2.2 User Growth Forecasts

The WiMAX subscription model is similar to that of fixed broadband in that there are multiple business and consumer users connecting per each CPE subscription. The forecasts in Table 1 below take this into account and accordingly show a higher number of users than subscribers. Table 1 set out the user numbers by major world region.

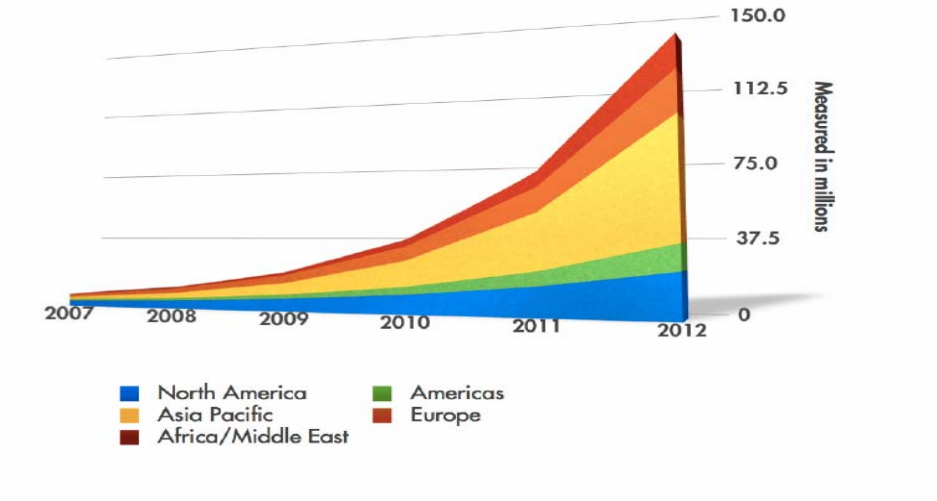

Figure 3.3: WiMAX Users by Region 2007-2012

Table 1: WiMAX* Users by Region (millions) 2007-2012

Users = subscribers adjusted to reflect multiple users per subscription

Region	2007	2008	2009	2010	2011	2012
North America	2.61	4.03	6.25	9.59	14.79	22.62
Americas	0.66	1.18	2.14	3.92	7.17	12.97
Asia Pacific	1.39	2.84	5.99	12.96	28.17	60.45
Europe	1.35	2.34	4.07	7.08	12.23	21.01

Africa/Middle East	0.30	0.65	1.46	3.32	7.50	16.60
TOTAL	6.32	11.04	19.91	36.88	69.87	133.66

Fixed WiMAX™ device subscriptions—for example by outdoor or indoor Customer Premises Equipment (CPE)—will on average service more than one user. This will be most common among business users, but will also prove true in the consumer market. On the other hand, Mobile WiMAX™ device use will be more single-user focused and portable subscriptions will service single users - especially those with notebooks and tablets. Therefore as mobile and portable subscriptions become an increasing part of the subscriber mix, average number of users per subscription will fall.

In our forecasts, certain Asia-Pacific countries (China, India, Japan, and South Korea) have been covered separately, and therefore we use separate multipliers for these rather than an overall regional multiplier. For example, as a result of the combination of different regional patterns for multiple-use and the weighting of the mobile-to-fixed ratios in different regions, our assumptions vary in 2007 from 1.05 in Korea to 1.97 in Developing Asia Pacific countries. By 2012 these have moved towards 1.01 in Korea compared with 1.42 in Developing Asia Pacific countries. Outside of Asia Pacific a regional multiplier is used, as in the Americas (Latin America and the Caribbean), which by 2012 has a multiplier of 1.47.

In developing regions where fixed broadband communications links are currently insufficient and there is the need and drive for rapid rollout of high-speed communications, there will be a greater frequency of multiple-user subscriptions than in economically developed areas. Therefore in countries and regions such as Brazil, China, India, Russia, the Americas, Middle

East/Africa, Eastern Europe and Developing Asia Pacific, WiMAX CPE will account for a higher proportion of subscriptions than in North America and Western Europe throughout the forecast period.

By 2012 the Asia Pacific region will lead the market in total actual users, with North America in second place followed by Europe, Africa/Middle East and the Americas. User numbers in India will overtake those in the USA in 2012, and it is estimated that by then China will have almost as many users as the whole of the Americas region (Latin America & the Caribbean).

3.2.3 WiMAX Operator and Country Growth

The numbers of WiMAX operators and countries shown in Figure 3 are those in which WiMAX service has commenced. Those currently in deployment but not yet operational are taken into account in the forecasts, along with the other operators and countries anticipated to adopt WiMAX technology in the future.

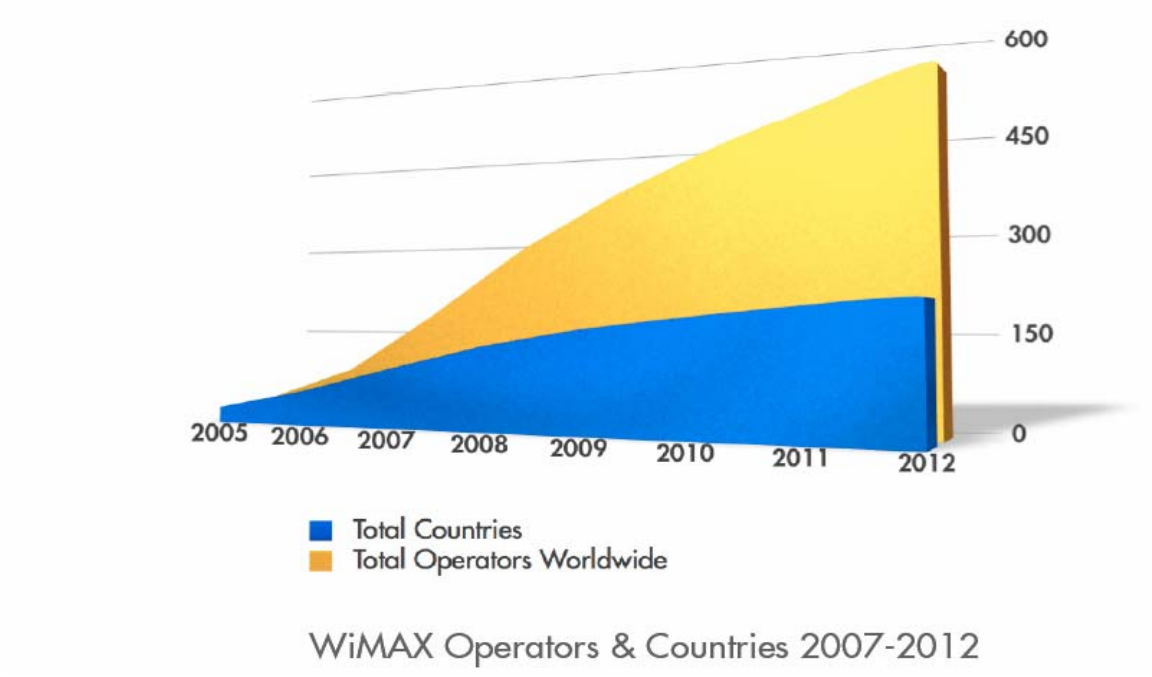

Figure 3.4: WiMAX Operators & Countries 2007-2012

The end of 2007 showed a total of 181 WiMAX operators globally. This number is expected to rise to 538 operators by 2012. The number of countries with WiMAX is anticipated to rise from 94 (out of total 234 countries) at the end of 2007 to 201 in 2012.

Europe is anticipated to have the largest number of operators, followed by Asia Pacific, Africa/Middle East, Americas and North America. However, Africa/Middle East is expected to have the highest number of WiMAX operator countries, followed by Europe, Americas, Asia Pacific and North America.

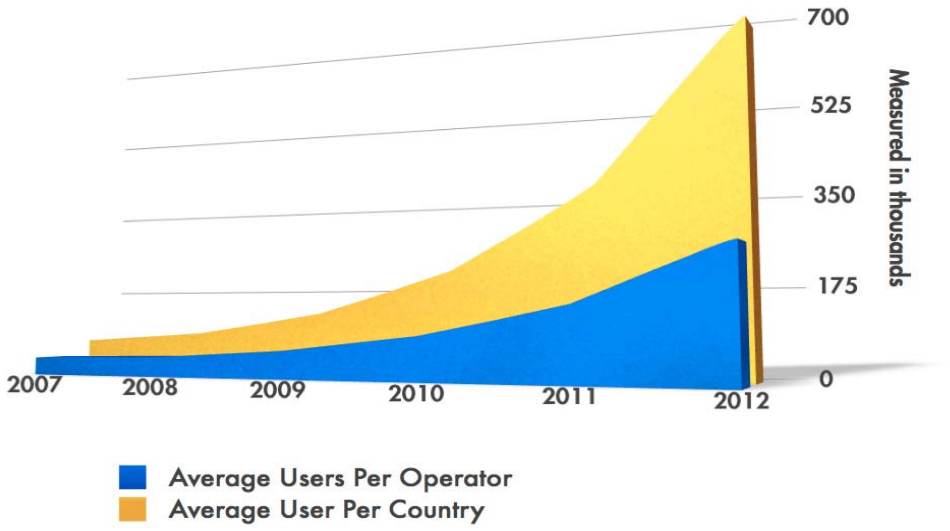

Figure 3.5: Average WiMAX Users by Operator & Country 2007-2012

3.2.4 Evolution of the Forecast

This forecast is an ongoing project of the WiMAX Forum that will continue to be used to educate the market as the WiMAX ecosystem expands. Future iterations of this report will be more robust, with more details on numbers and methodology. As WiMAX continues to flourish on the worldwide market, future reports will in particular focus on operator and country growth.

Chapter 4

4.1 Bangladesh Regulatory Environment:

BANGLADESH TELECOMMUNICATION REGULATORY COMMISSION (BTRC) first invites the private organizations on 26-08-2008 by giving the invitation proposal with regulation term and condition. Here they announced, In order to ensure proper competition among the BWA Services licensees, total 3 (three) licenses will be issued to provide nationwide BWA Services in 2.3 GHz and 2.5 GHz spectrum bands. Another two important facts were as follows:

(1) The mobile operators (CDMA and GSM) having the cellular mobile licenses from BTRC will not be eligible to apply for this license.

(2) One entity will be allowed to get only one BWA Services License.

After that Network and Services of the proposals were considerable, on the following discussion we will now focus on this. The network and services proposal were as follows:

The Licensee(s) is authorized to develop and operate a telecommunications network to provide nationwide BWA services based on IEEE 802.16e standards. The system can be point-to-multipoint or mesh radio systems consisting of BWA distribution hub stations and their associated subscriber stations (or BWA access devices). The last mile solution may be done in conjunction with WiFi.

At least 128 kbps per subscriber should be ensured at all time.

The operators and end-users are allowed to use their equipment in fixed locations, in a nomadic manner or with a fully mobile capability, at their choice.

Technical characteristics of equipment used in BWA systems shall be in conformity with the WiMAX forum standards and International Telecommunications Union (ITU) and its radio regulations. The operator must deploy certified equipments from the accredited certified vendors (e.g. WiMAX Forum Certification). The certification must conform to standard IEEE 802.16e or higher specification at the time of rollout.

BWA services are intended for providing wireless broadband connectivity to subscribers including voice application.

Coordination initiatives in order to maximize the best utilization of the spectrum and minimize interference without reducing quality of service.

If any interference occurs, it will be the responsibility of the new entrant to adjust its system or to make necessary arrangement to overcome the interference.

All the licensed operators have to share the same tower and the existing infrastructures.

EIRP of Central Station (Hub) should not exceed +40dBm per RF channel. On each central station (Hub) basis, higher EIRP may be allowed if acceptable technical justification is provided. Should harmful interference is caused to other radio systems/stations; the Central station may be required to modify its radiated power.

Without reducing the QoS, the operators are encouraged to ensure spectral efficiency. The QoS shall be monitored by the Commission from time to time.

The licensee(s) is allowed to provide IP Telephony services bundled with the instant license. The licensee(s) shall optimize their QoS for providing voice along with basic data services. The minimum compression Codec to be used as equivalent to Q. 729.

The operator shall have the capability to provide domestic roaming within its own network. They have to provide inter-operator (BWA) roaming when it is available.

Voice Application will be provided with separate numbering plan. All voice calls shall be routed through ICX and IGW as per ILDTS Policy 2007. The licensee will route their data though IIG.

The Applicant(s) shall indicate its proposed technology, network topology and its designed capacity (number of subscribers and bandwidth that can be offered to each subscriber etc.).

The Licensee(s) shall provide roaming facilities within its allocated band but would be encouraged to provide roaming between 2.3 and 2.5 GHz Band.

All BWA installation must comply with the safety rules as defined by the Commission’s regulation.

The licensee(s) shall conform to the BTRC regulation on geographical border area coverage coordination.
The applicable numbering plan shall be assigned to the licensees by the commission.

Next important part of the proposal was the spectrum distribution segment, The point on spectrum distribution were as follows:

Spectrum bands 2.3 GHz and 2.5 GHz have been considered for BWA Service License.
A contiguous 30 MHz of unpaired spectrum from 2.3 GHz band (23xx-23xx MHz and 23xx-23xx MHz) will be assigned to 2 licensees.
A contiguous 30 MHz of unpaired spectrum from 2.5 GHz band (25xx-26xx MHz) will be assigned to 1 licensee. 2615-2620 MHz is kept as guard block between TDD and future FDD assignment.
30MHz contiguous channel will be allocated to each operator to provide BWA services. Per channel bandwidth should be either 5 or 10 MHz.
The spectrum assignment will be inclusive of guard bands needed for the operation of the equipments to avoid causing harmful interference to adjacent equipments operating in adjacent bands. No separate spectrum shall be kept as guard band between two assignments in 2.3 GHz band.
The operators will synchronize among themselves in case of any interference.
The Successful Applicant(s) shall abide by the coordination agreements, either current or future, which shall ensure the harmonization of spectrum usage.
The Commission reserves the rights to make any rearrangement in the assignment within the band if required in future and the equipments shall have the provision to readjust according to that rearrangement.
In the event that the interference remained unresolved by the operators, the affected parties may escalate the matter to the commission for a resolution. The commission will decide the necessary modifications and schedule of modifications to resolve the dispute.

Subject to the availability, two pair of frequency will be assigned form any of the 18, 23, 26 and 38 GHz band to build their own point to point link.

From the proposal we can find some scope for the Existing Licenses such as:
The existing ISP license holders operating in 2.3, 3.5, 5.2, 5.4 GHz and 700 MHz will be allowed to continue their wireless Internet services for 5 (five) years with pre-WiMAX equipments (which they have already imported). The 5 years time shall start from the date of issuance of first BWA licenses. They will not be allowed to provide mobile broadband wireless service as offered in IEEE 802.16e international standard. Moreover, they will not be allowed to import/replace equipments for providing mobile Broadband Wireless Access.

No further assignment of spectrum will be allowed from 2.3, 3.5, 5.2, 5.4 GHz and 700 MHz band to ISP for terrestrial point-to-point and point-to-multipoint systems.

The duration of the Licenses, shall initially be for a term of 15 (fifteen) years. Upon expiry of the initial term, the License may be renewed for subsequent terms, each of 5 years in duration, subject to the approval from the Commission and to such conditions, including the payment of any fees, as may be specified herein and/or by the Commission under the Act.

4.2 Approved Company

Three companies, Bangla Lion Communications, Brac Bdmail Network Ltd and Augere Wireless Broadband Bangladesh Ltd, have won licensees to operate WiMAX or Broadband Wireless Access in Bangladesh. The three firms purchased the licensees in auction for Tk 215 crore. The three companies that won will run WiMAX (Worldwide Interoperability for Microwave Access) technology that allows wireless data to travel over long distances by various means, from point-to-point links to full mobile cellular type access.

Bangladesh Telecommunication Regulatory Commission, who will issue the three licenses, has estimated that once WiMAX is functional the number of internet users across the country will cross 1 crore. Internet service providers had originally asked the government to open up WiMAX licensing to Bangladeshi organizations qualifying on merit. Mobile operators in Bangladesh and anyone having invested in them were barred from bidding for a BWA license. According to the licence conditions, the winning companies will set up at least 90 base stations in the first year, and the whole country will have to be brought under WiMAX network within three years. Foreign investment in the licenced companies should not be more than 60 percent and non resident Bangladeshis are allowed to invest at 70 percent ownership.

4.3 Spectrum Distribution

Spectrum Distribution (opted by companies):

I) BanglaLion Communications:	**2585 - 2620 MHz**
II) BRAC BDMail Network Limited:	**2320 - 2365 MHz**
III) Augere Wireless Broadband Bangladesh:	**2365 - 2400 MHz**

Among the given names Banglalion Communication is only company who can start their operation when they want to operate. Due to due fees to government rest two are not permitted to operate at this moment. The given frequencies are already distributed by the government and companies are also permitted to setup the WiMAX network.

4.4 Important suppliers / Organization

In order to ensure the success of our proposed WiMAX wireless technology as a stable, viable and cost effective alternative for delivering broadband access services in the last mile and to ensure the continuity of supply, the participation of many key-industry players is essential. The companies that have already joined the WiMAX Forum represent over 75% of revenues in the global BWA market. Moreover, membership of the WiMAX Forum is not limited to industry leading BWA providers, numerous multinational enterprises like Intel and Fujitsu have also joined the WiMAX Forum.

The Forum represents a cross-industry group of valued partners, including chip set manufacturers, component makers and service providers. All of these organizations recognize the long-term benefits of working with standardized, interoperable equipment and are committed to the design, development and implementation of WiMAX-compliant solutions. Furthermore, the fact that Intel, the world's leading developer of microprocessor chips, and Alvarion, the foremost global provider of BWA systems, are both putting their full weight behind the Forum and its agenda, just further attests to the expected demand and success of WiMAX.

The following is a partial list of key members of the WiMAX Forum:

Alvarion
Andrew Corporation
AT&T Wireless
Atheros Communications, Inc.
China Motion Telecom
Compliance Certification Services
Filtronics
Fujitsu Microelectronics America
Hughes Network Systems
Intel

NEWS IQ
Nextel
FDM Forum
Raytheon RF Components
RF Integration Inc.
RF Magic
The Telnecity Group
Winova Wireless
Yahoo!

The preferred supplier is Intel Corporation for chips and equipments. Alvarion's industry leading expertise and vast experience as a pure-play wireless vendor makes it the logical choice to be the first to work in conjunction with Intel on producing a product line that integrates WiMAX technology. By merging our industry leading strengths, we hope to live up to the promise of a stable, interoperable standard as set forth in the WiMAX Forum mission. The Alvarion-Intel system cooperation is a strategic relationship launched by the two vendors to produce superior wireless chips (Intel) and systems (Alvarion) that will serve as a benchmark for all other wireless vendors as they move towards a comprehensive adoption of the WiMAX standard. Intel will design the chip, guided by our system definition and design, which will be incorporated in our product line over the coming year.

4.5 Technical Overview

RF Systems

4.5.1 Point to Multipoint Configuration

Figure shows the overall system diagram for point to multipoint communication. Detailed network capacity and RF planning is necessary to determine the optimum solution for a specific customer requirement.

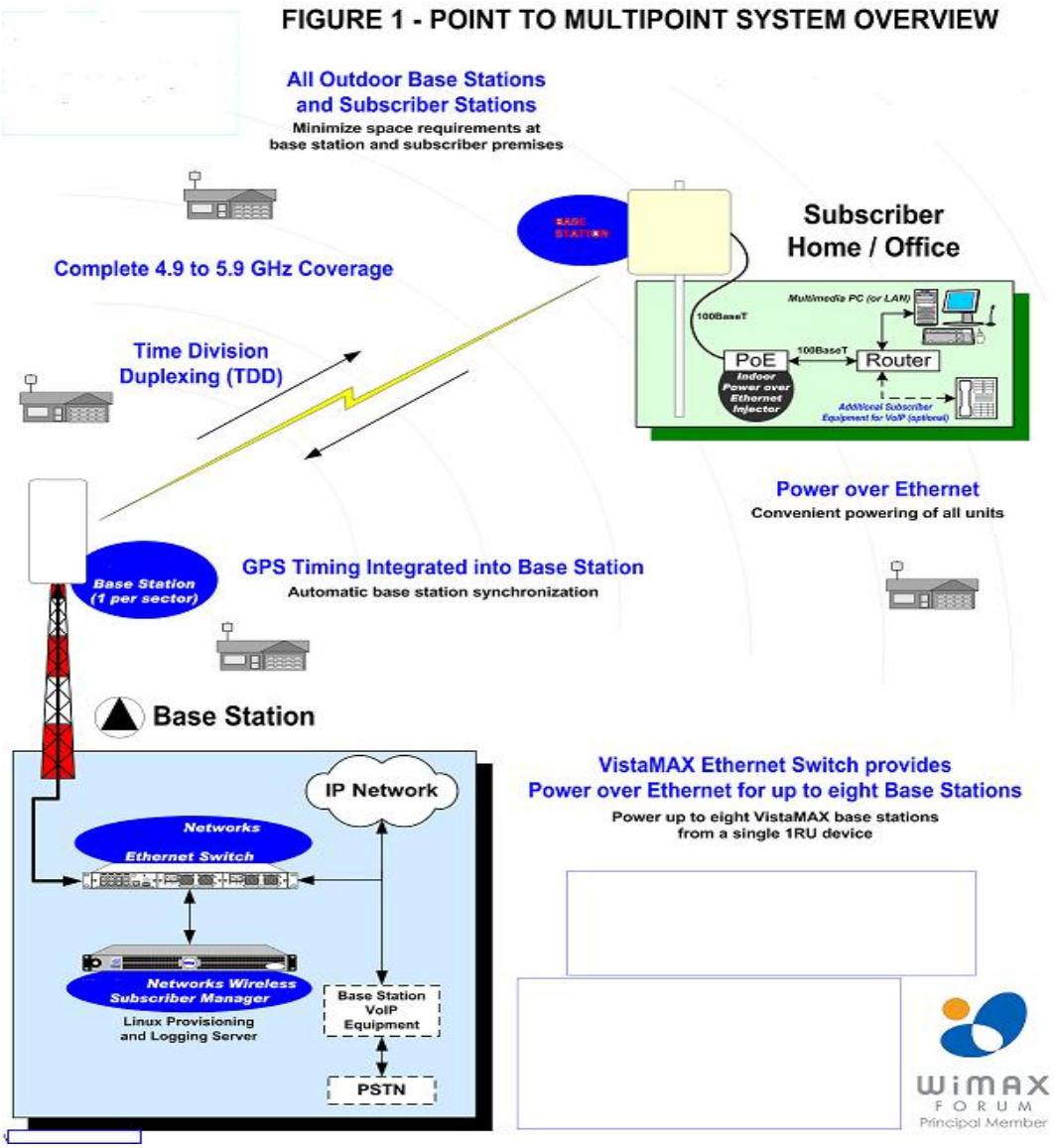

Figure 4.1:

4.5.2 Base Station

Figure shows a detailed diagram of a 5 GHz base station sector. A self-contained outdoor base station can be configured with an integrated antenna (60 or 90 degree) or with an external antenna connector to allow for Omni directional configurations. Connection to the outdoor unit requires only a single Ethernet cable for power and data. All MAC, baseband modulation and radio functionality is integrated into the single outdoor unit. The 5 GHz system requires an additional indoor WES800 Ethernet Switch to provide power to sectors using the

units and serve as the network connection point. Connections to the backbone network and between outdoor elements are made through the integrated Ethernet switch in the WES800. An RJ-45 10/100/1000 Ethernet uplink port is included in the WES800 and an optional SFP module for 10/100/1000BaseT copper or 1000BaseX fiber connections can be purchased.

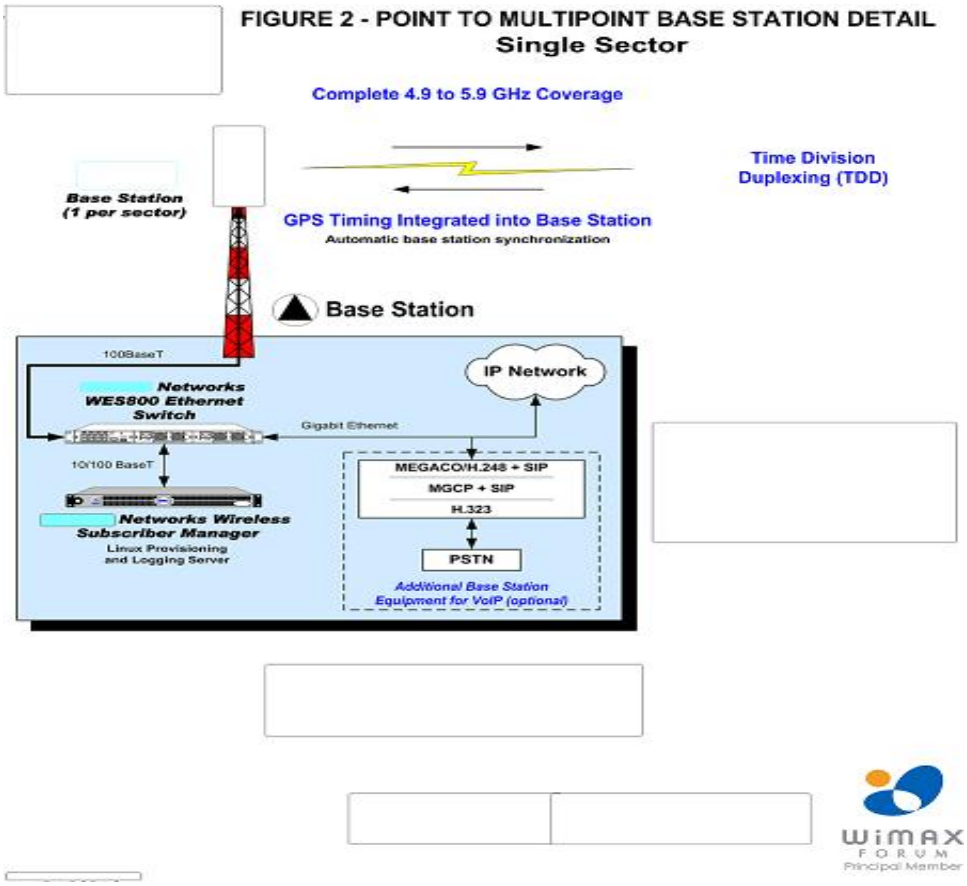

Figure 4.2:

The base station configuration is flexible enough to allow for high density urban deployments, point-point backhaul and low density rural rollouts.

Point-point backhaul can be used to connect the cell with other cells, main backbone interconnection points or create multiple point-point links to high data rate subscribers.

4.5.3 Subscriber

Figure details the configuration for a standard subscriber installation.

The subscriber transceiver is a self-contained outdoor unit which comprised the network interface, MAC, baseband PHY and radio portions of the solution. A single Ethernet cable provides both power and data to the outdoor unit.

FIGURE 3 - POINT TO MULTIPOINT SUBSCRIBER DETAIL
Subscriber Home/Office

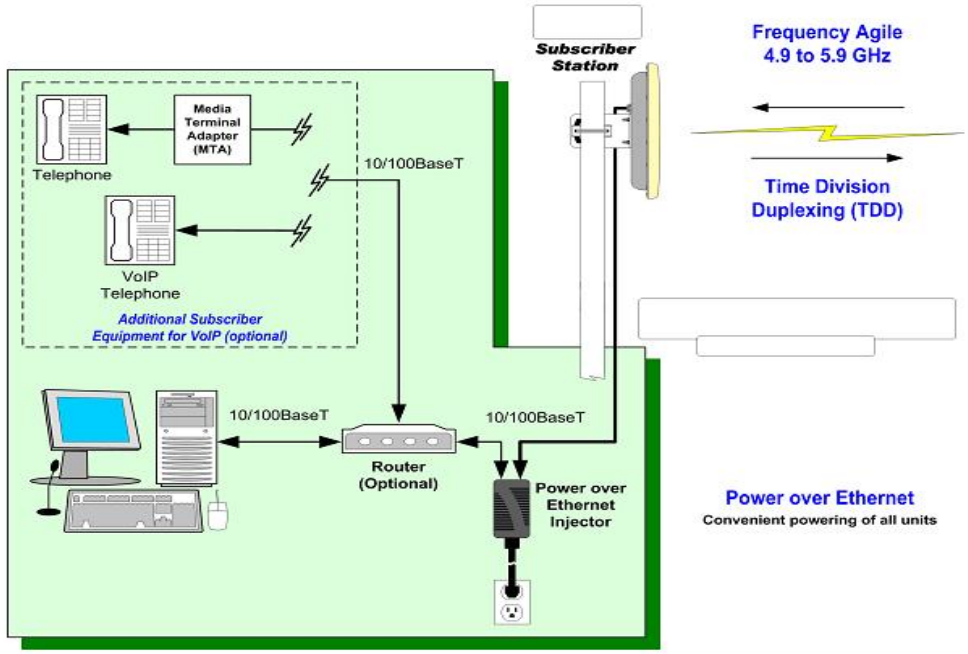

Figure 4.3:

4.6 Product Analysis:

Depending on the basis network architecture many companies proposed many solutions among them we pick the Alcatel-lucent solution for our analysis purpose. On the following figure you can see that one basic diagram of WiMAX architecture, in this figure we can see the whole scenario but technical task is

done by some major equipment which can be divided into three parts, they are as follows:

Base Station Portfolio.

WiMAX Access Controller.

Operation and Maintenance Suite

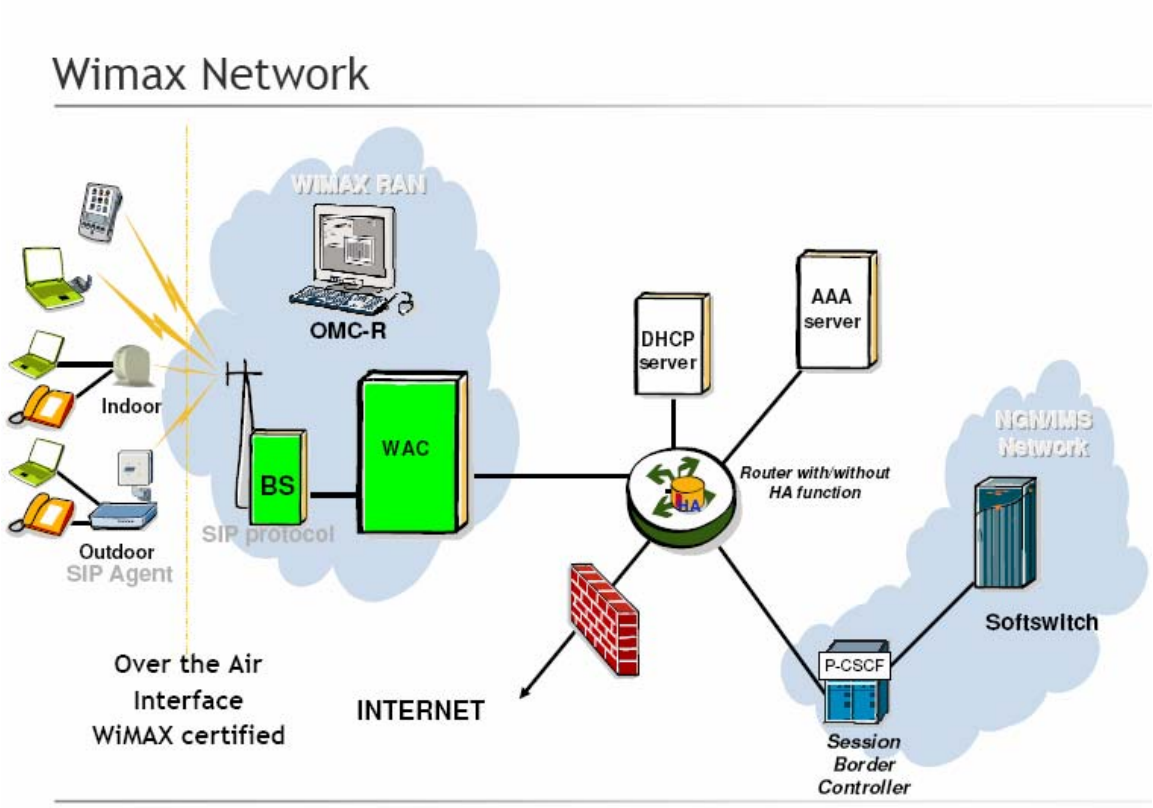

Figure 4.4: WiMAX network (Alcatel - Lucent)

4.6.1 Base Station Portfolio:

C-WBS

High Capacity Single sector with 4TX/RX

L-WBS & L2-WBS

Small form factor Single sector with 2TX/RX

M-WBS

Indoor / Outdoor, High Capacity, High Power, Multi-Sector

D-WBS

Remote Radio Heads based on L-WBS

Central cabinet hosting O&M functions, backhauling, BBU…

Above products may give better radio performance, easy to install & operate opportunity etc.

4.6.2 WiMAX Access Controller:

Figure 4.5: WiMAX Access Controller (WAC) cabinet

Above products will provides authentication & accounting to the users, enforces Service Level Agreements manages mobility, Single Cabinet that integrates Home Agent, AAA Servers, DHCP/DNS & High Traffic aggregation up to 600Ksubs / 10Gbps, Connectivity up to 2000 Radio Cells.

4.6.3 Operation and Maintenance Suite:

This panel mainly is maintenance panel which monitors the whole system by analytical and accessible information through available software management.

Figure 4.6: Operation and Maintenance Suite

Some other tasks of this panel are:

- Value-Added QoS analysis
- Scalable Radio Access Management
- Process driven Radio Configuration
- Continuous diagnosis.

Chapter 5

5 Business Model Proposition

5.1 Financial arrangement:

Scenario 1: Residential Market Segment in a Metro Area Environment

Spectrum	
Frequency band	3.5 GHz
Channel BW in MHz	3.50
Spectrum Required in MHz	28
Addressable Market	
Households Covered	400,000
Businesses Covered	None
Market Penetration (5th yr)	
Market Adoption Curve	5-year
Residential Market (Regular Services)	8.5 %
Residential Regular & Voice Services	9 %
SME Market	None
WiFi Hot Spots Backhauled	None
Development Information	
Wi-Max Base Stations Deployed	40+2
Aggregate Payload in Mbps	2010
Population in Coverage Area	1,000,000

Subscriber Growth in year basis: (Residential Internet Service+ Voice Service)

Year 2008: 1.0 % of 400,000 i.e., 4,000
Year 2009: 2.5 % of 400,000 i.e., 10,000
Year 2010: 4.5 % of 400,000 i.e., 18,000
Year 2011: 7.0 % of 400,000 i.e., 28,000
Year 2012: 8.5 % of 400,000 i.e. 34,000

Subscriber Growth in year basis: (Residential Internet Service)

Year 2008: 1.5 % of 400,000 i.e., 6,000
Year 2009: 3.0 % of 400,000 i.e., 12,000
Year 2010: 5.0 % of 400,000 i.e., 20,000
Year 2011: 7.5 % of 400,000 i.e., 30,000
Year 2012: 9.0 % of 400,000 i.e. 36,000

CAPEX:

Description	Cost Information
Wimax Equipment	$35K per BS
Other Base station Equipments	$15K per BS
Backhaul Link	$25K for a PtP Microwave Link
Core & Edge Equipment	$400K
Spectrum License	$280K
Base Station Acquisition, Installation & Civil Works	$50K avg per BS

Calculation:
CAPEX = (40*35)+(15*40)+25+400+280+(50*40)= $4705K=$3.705 M
Support for 2 extra BS Equipments: (2*35) +(2*15) + 400 = $ 500K
Total Capex = 4705+500= $ 4205K=$ 5.205 M

CPE Capex:

CPE Type	Yr 1 Capex	Annual Price Reduction	% of CPEs provided by Operator
Residential CPE	$ 250	15%	80%

Calculation:

Year 2008: (4000+6000)* 250 * 0.8 = 2000K= 2 M
Year 2009: (10000+12000)* 250 * 0.8 * 0.85 =3740K =3.7 M
Year 2010: (18000+20000)* 250 * 0.8 * 0.85* 0.85 = 5491K= 5.491 M
Year 2011: (28000+30000)* 250 * 0.8 *0.85* 0.85* 0.85 = 7124K=7.124 M
Year 2012: (34000+36000)* 250 * 0.8 *0.85* 0.85 * 0.85 * 0.85 =7308K= 7.308 M

Revenue:

End Customer	Service Description	1st Yr Monthly ARPU	Other Revenue	ARPU Reduction
Residential Internet	Best Effort (Avg. Throughput 384 Kbps)	$30 monthly fee for unlimited use	$10/month for Equipment lease & $50 One-time activation fee	5% per year
Residential Internet plus POTS	Best effort Internet plus Voice Telephony POTs Service	$45 monthly fee	$10/month for Equipment lease & $50 One-time activation fee	5% per year

Revenue Calculation:

Year 2008:

6000*(30+10)*12+ 6000*50+ 4000*(45+10)*12 + 4000*50 = $6.02 M

Year 2009:

12000*(30+10)*12*0.95+ 10000*(45+10)*12*0.95 = $ 11.742 M

Year 2010:

20000*(30+10)*12*0.95*0.95+ 18000*(45+10)*12*0.95*0.95 = $ 19.39 M

Year 2011:

30000*(30+10)*12*0.95*0.95*0.95+ 28000*(45+10)*12*0.95*0.95*0.95 = $28.2 M

Year 2012:

36000*(30+10)*12*0.95*0.95*0.95*0.95+ 34000*(45+10)*12*0.95*0.95*0.95*0.95 = $ 32.352 M

OPEX :

Opex Items	Business Case Cost Assumptions
Sales & Marketing (Including Staff training & Salaries, Customer technical Support, Marketing of Product)	20% of Gross Revenue in year 1 dropping to 11% in Year 5.
Network Operations (Including Technical Staff Training & Salaries.)	15% of Gross Revenue in year 1 dropping to 10% in Year 5
Equipment Maintenance	5% of CAPEX for Base Station ; 7% of Operator owned CPE CAPEX
Base Station Site Lease Expense	$18000/year/BS

OPEX Calculation:

Year 2008:

$6.02 M *(20+15) % + $5.205 M* 5% + $ 2 M* 7% + $18000*40/1000000 = $ 3.28 M

Year 2009:

$11.742 M *(18+14) % + $5.205 M* 5% + $ 3.7 M* 7% + $18000*40/1000000 = $ 5 M

Year 2010:

$19.39 M *(16+13) % + $5.205 M* 5% + $ 5.491 M* 7% + $18000*40/1000000 = $ 6.99 M

Year 2011:

$28.2 M *(14+11.5) % + $5.205 M* 5% + $ 7.124 M* 7% + $18000*40/1000000 = $ 8.67 M

Year 2012:

$32.352 M *(12+10) % + $5.205 M* 5% + $ 7.308 M* 7% + $18000*40/1000000 = $ 8.61 M

Financial Analysis:

	2007 $M	2008 $M	2009 $M	2010 $M	2011 $M	2012 $M
Revenue	0	6.02	11.472	19.39	28.2	32.352
CAPEX	5.205	0	0	0	0	0
CPE CAPEX	0	2	3.7	5.491	7.124	7.308
OPEX	0	3.28	5	6.99	8.67	8.61
Net Cash Flow	-5.205	0.74	2.772	6.9	12.406	16.434
Discount Factor @ 12%	1	0.893	0.797	0.712	0.6355	0.567
Discounted Cash Flow	-5.205	0.661	2.207	4.913	7.884	9.318

NPV= $19.778 M

IRR= 72 %

Scenario 2: Small & Medium Enterprise + Wifi Hotspots Backhaul

Spectrum	
Frequency band	3.5 GHz
Channel BW in MHz	3.50
Spectrum Required in MHz	28
Addressable Market	
Households Covered	None
Businesses Covered	60780
Market Penetration (5th yr)	
Market Adoption Curve	5-year
Residential Market	None
SME Internet Services	14.5%
SME POT Services	20% (Avg. Throughout)
WiFi Hot Spots Backhauled	30
Development Information	
Wi-Max Base Stations Deployed	25+2

Subscriber Growth in year basis: (SME Service)

Year 2008: 3.2 % of 60780 i.e., 1945
Year 2009: 5.5 % of 60780 i.e., 3950
Year 2010: 9.5 % of 60780 i.e., 5774
Year 2011: 12.8 % of 60780 i.e., 7780
Year 2012: 14.5 % of 60780 i.e. 8814

The use of SME POT is limited to 20% of addressable Market on average throughout the 5-year business life-cycle.

Small Business Subscribers are 60% of total subscribers where Medium Business Subscribers comprise the rest 40%.

Small Business Subscribers:	Medium Business Subscribers:
Yr 1: 1167	Yr 1: 778
Yr 2: 2370 ,	Yr 2: 1580
Yr 3: 3464 ,	Yr 3: 2310
Yr 4: 4668 ,	Yr 4: 3112
Yr 5: 5278	Yr 5: 3525

CAPEX

Description	Cost Information
Wimax Equipment	$35K per BS
Other Base station Equipments	$15K per BS
Backhaul Link	$25K for a PtP Microwave Link
Core & Edge Equipment	$500K
Spectrum License	$280K
Base Station Acquisition, Installation & Civil Works	$50K avg per BS

Calculation:

Capex = (35*25)+(15*25)+25+500+280+(50*25)= $3305K=$3.305
Support for 2 extra BS Equipments: (2*35) +(2*15) + 500 = $ 600K
Total Capex = 3305+600= $ 3905K=$ 3.905 M

CPE CAPEX:

CPE Type	Yr 1 Capex	Annual Price Reduction	% of CPEs provided by Operator
Small Business CPE	$ 700	5%	50%
Medium Business CPE	$ 1400	5%	50%

For Small Business:

Year 2008 : $700* (1166/2) = $ 0.408 M
Year 2009: $700* (2370/2)*0.95 = $ 0.788 M
Year 2010 : $700* (3464/2) *0.95*0.95= $ 1.094 M
Year 2011: $700* (4668/2) *0.95*0.95*0.95 = $ 1.4 M
Year 2012: $700* (5278/2) *0.95*0.95*0.95*0.95 = $ 1.504 M

For Medium Business:

Year 2008: $1400 *(778/2) = $0.5446 M
Year 2009: $1400 *(1580/2)*0.95 = $1.05 M
Year 2010: $1400 *(2310/2)*0.95*0.95 = $1.458 M
Year 2011: $1400 *(3112/2)*0.95*0.95*0.95 = $ 1.867 M
Year 2012: $1400 *(3526/2)*0.95*0.95*0.95*0.95 = $2 M

Total CPE CAPEX:

Year 2008: 0.5446+0.408 = $ 0.9526 M
Year 2009: 0.788+1.05 = $1.838M
Year 2010: 1.094+ 1.458 =$ 2.552M

Year 2011: 1.4+ 1.867 =$ 3.267M

Year 2012: 1.504+ 2 = $3.504M

Revenue:

End Customer	Service Description	1st Yr Monthly ARPU	Other Revenue	ARPU Reduction
Small Business	1.0 Mbps CIR, 2.5 Mbps PIR	$350 monthly fee for unlimited use	$35/month for Equipment lease $100 Activation fee One-time	5% per year
Medium Business	2.5 Mbps CIR 5.0 Mbps PIR	$450 monthly fee for unlimited use	$35/month for Equipment lease & $150 One-time activation fee.	5% per year

For Small Business:

Year 2008: ($350*1167 + $35*583 + $200*1167*0.2)*12 + $100*583= $5.7583 M

Year2009: ($332.5*2370 + 1185 * $35 + $190*2370*0.2)*12 + $100 * 1185= $11.118 M

Year 2010: ($315.8 *3464 + 1732*$35 + $ 180.5*3464*0.2)* 12 + $100 * 1732= $15.53 M

Year 2011: ($300*4668 + $35*2334 + $ 171.5* 4668*0.2)* 12 + $100 *2334= $19.91 M

Year 2012: ($285* 5278 +$35 *2639 + $ 162.92*5278*0.2)* 12 + $100* 2639= $ 21.51 M

For Medium Business:

Year 2008: ($450*778 + $35*389 + $200*778*0.2)*12 + $150*389 = $4.78 M
Year 2009: ($427.5*1580 + 790 * $35 + $190*1580*0.2)*12 + $150*790= $9.27 M
Year 2010: ($406.2 *2309 + 1154*$35 + $ 180.5*2309*0.2)* 12 + $150*1154= $12.89 M
Year 2011: ($385.5*3112 + $35*1556 + $ 171.5* 3112*0.2)* 12 + $150* 1556= $16.55 M
Year 2012: ($285* 3525 +$35 *1763 + $ 162.92*3325*0.2)* 12 + $150*1763= $ 17.78 M

Total Revenue:

Year 2008: 5.758+4.73= $10.88 M
Year 2009: 11.118+9.27= $20.388 M
Year 2010: 15.53+ 12.89= $ 28.42 M
Year 2011: 19.91+ 16.55= $36.46 M
Year 2012: 21.51+ 17.78= $ 38.29M

OPEX:

Opex Items	Business Case Cost Assumptions
Sales & Marketing (Including Staff training & Salaries, Customer technical Support, Marketing of Product)	20% of Gross Revenue in year 1 dropping to 11% in Year 5.
Network Operations (Including Technical Staff Training & Salaries.)	15% of Gross Revenue in year 1 dropping to 10% in Year 5
Equipment Maintenance	5% of CAPEX for Base Station ; 7% of Operator owned CPE CAPEX
Base Station Site Lease Expense	$18000/year/BS
Customer Site Lease Expense	$600 per year on avg.

OPEX Calculation:

Year 2008:

$ 10.88 M *(20+15) % + $3.905 M* 0.05 + $ 0.9526 M* 0.07 + $18000*25/1000000 + $600*25/1000000 = $ 4.54 M

Year 2009:

$20.39 M *(18+14) % + $3.905 M* 0.05 + $ 1.84 M* 0.07 + $18000*25/1000000 + 600*25/1000000 = $ 7.314 M

Year 2010:

$28.42 M *(16+13) % + $3.905 M* 0.05 + $ 2.55 M* 0.07 + $18000*25/1000000 +600*25/1000000 = $ 9.1 M

Year 2011:

$36.46 M *(14+11.5) % + $3.905 M* 0.05 + $ 3.27 M* 0.07 + $18000*25/1000000+600*25/1000000 = $ 10.2 M

Year 2012:

$38.29 M *(12+10) % + $3.905 M* 0.05 + $ 3.5M* 0.07 + $18000*25/1000000+600*25/1000000 = $ 9.33 M

Wifi Hotspot Back-haul:

Wifi Hot-spots = 30

CPEs provided to Customer premises = 50% of 30,i.e.,15.

Cost of per CPE is $300 with 5% annual depreciation.

Capex CPE:

Year 1: $300*10 =$3000

Year 2: $300*10*0.95 =$2850

Year 3: $300*13*(0.95)^2 = $3520

Year 4: $300*13*(.-0.95)^3 = $3858

Year 5: $300*15*(0.95)^4 = $3685

Opex:

7% of CPE Capex + $600 for Customer Site Lease Expense per year.

Year 1: $ 210 + $600*10 = $6210

Year 2: $ 199.5+ $600*10= $6199.5

Year 3: $ 246.4+ $600*13= $ 8046.4

Year 4: $ 270+ $600*13= $8070

Year 5: $ 256+ $600*15 = $9256

Revenue:

End Customer	Service Description	1st Yr Monthly ARPU	Other Revenue	ARPU Reduction
Wifi Hot-Spots	1.5 Mbps CIR 10 Mbps PIR	$ 650 per month	$25 per month equipment lease fee & $500 Onetime activation fee	5% annually

Year 1:
(10*650+10*25)*12 +500 = 81,000 + 500 = $81,500
Year 2:
(10*650 + 10*25)* 0.95 = 6412 * 12 = $ 76,944
Year 3:
(13*650 + 13*25) * (0.95) ^2 = 7920* 12 = $ 95,040
Year 4:
(15*650 + 15*25) * (0.95) ^3 = 8681* 12 = $ 104,172

Year 5:

(15* 650 + 15*25) * (0.95) ^4 = 8247 * 12 = $ 98,963

Complete Financial Analysis for Scenario 2: Small & Medium Business & Wifi hotspots in metropolitan city area.

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
	$M	$M	$M	$M	$M	$M
Revenue	0	10.96	20.465	28.515	36.564	38.39
CAPEX	3.905	0	0	0	0	0
CPE CAPEX	0	.953	1.844	2.55	3.273	3.507
OPEX	0	4.55	7.32	9.106	10.21	9.34
Net Cash Flow	-3.905	5.457	11.301	16.859	23.081	25.543
Discount Factor @ 12%	1	0.893	0.797	0.712	0.6355	0.567
Discounted Cash Flow	-3.905	4.873	9	12	14.66	14.48

NPV= $ 51.1 M

IRR= 150%

Now if we combine the above two scenario then our Analysis will be as following:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
	$M	$M	$M	$M	$M	$M
Revenue	0	16.9	31.9	47.9	64.7	70.7
CAPEX	9.11	0	0	0	0	0
CPE CAPEX	0	3	5.55	8.1	10.4	11
OPEX	0	7.83	12.32	16.2	19	18
Net Cash Flow	-9.11	6.07	14.03	23.6	35.3	41.7
Discount Factor @ 12%	1	0.893	0.797	0.712	0.6355	0.567
Discounted Cash Flow	-9.11	5.42	11.82	16.8	22.43	23.64

NPV = $ 70.38 M

IRR = 140%

Calculation of NPV and IRR for the Business Case

We know that,

$$NPV = \sum_{t=1}^{n} \frac{Ct}{(1+k)^t} - Co$$

Here, NPV = (0.139 + 5.478+ 5.133+ 4.685+ 4.340) - 10.2

= 19.775-10.2

= 9.575

We also know that,

IRR is the Discount Rate that makes the NPV= 0

$$NPV = \sum_{t=1}^{n} \frac{Ct}{(1+k)^t} - Co = 0$$

or

$$Co = \sum_{t=1}^{n} \frac{Ct}{(1+IRR)^t} = 0$$

Now let's advance by taking the discount rate of 12%

So, NPV@12% = 70.38

NPV@50% = 20.63

NPV@90% = 5.8

NPV@120% = 1.08

NPV@130% = .03

NPV @ 131% = -0.06

So we conclude that 0.2 has a close proximity with 0 and we have taken 33.4% as the Discount Rate where the NPV approaches Zero, hence it is the IRR of this proposal.

Scenario 3: Residential & SME in rurally located towns or small cities.

Spectrum	
Frequency band	5.8 GHz Unlicensed Band
Channel BW in MHz	10
Spectrum Required in MHz	60
Addressable Market	
Households Covered	10000
Businesses Covered	750
Market Penetration (5th yr)	
Market Adoption Curve	5-year
Residential Market (Internet Services)	20%
Residential Voice(Only) Services	30%
SME Market (Internet Service)	15%
SME Market (Only Voice Service)	40%
Development Information	
Wi-Max Base Stations Deployed	4
Aggregate Payload in Mbps	100
Population in Coverage Area	25000

Customer growth:

Market	Year 1 $M	Year 2 $M	Year 3 $M	Year 4 $M	Year 5 $M
Res. Internet	4%	8%	12%	16%	20%
Res. Voice	6%	12%	18%	24%	30%
SME Internet	3%	6%	10%	12%	15%
SME Voice	7%	14%	24%	34%	40%

CAPEX:

Description	Cost Information
Wimax Equipment	$35K per BS
Other Base station Equipments	$15K per BS
Backhaul Link	$100K for a PtP Microwave Link
Core & Edge Equipment	$400K
Spectrum License	None (Unlicensed Band)
Base Station Acquisition, Installation & Civil Works	$50K avg per BS

Capex = 35K*4+ 15K*4 + 100K + 400K + 50K*4 = 900K

CPE CAPEX:

CPE Type	Yr 1 Capex	Annual Price Reduction	% of CPEs provided by Operator
Res. CPE	$ 300	15%	80%
SME CPE	$ 1000	5%	50%

CPE Capex:

Year 2008: $300*400*0.8 + 1000* 750*0.03*0.5 = $0.108 M

Year 2009: $300*800*0.8*0.85 + 1000* 750*0.06*0.5*0.95 = $0.186 M

Year 2010: $300*1200*0.8*0.85^2 + 1000* 750*0.1*0.5*0.95^2 = $0.242 M

Year 2011: $300*1600*0.8*0.85^3 + 1000* 750*0.12*0.5*0.95^3 = $0.275 M

Year 2012: $300*2000*0.8*085^4 + 1000* 750*0.15*0.5*0.95^4 = $0.296 M

Revenue:

Market	ARPU	Other Revenue	Annual Reduction
Res. Internet	$25 per month	$10 Equipment Fee per month	5%
Res. Voice	$15 per month		
SME Internet	$250 per month	$30 Equipment Fee per month	5%
SME Voice	$150 per month		

Revenue:

Year	Revenue $M
2008	5.1
2009	10.
2010	15.2
2011	19.7
2012	23.4

Sample Calculation:

Year 2010: ($25*0.95*0.95*1200 + $10*1200*0.8 + $15*0.95*0.95*1800 + $250*0.95*0.95*750*0.1 + $30*750*0.1*0.5 + 150*750*0.24) *12 = $1.272 M *12 = $15.2 M

Opex:

Opex Items	Business Case Cost Assumptions
Sales & Marketing (Including Staff training & Salaries, Customer technical Support, Marketing of Product)	20% of Gross Revenue in year 1 dropping to 11% in Year 5.
Network Operations (Including Technical Staff Training & Salaries.)	17% of Gross Revenue in year 1 dropping to 10% in Year 5
Equipment Maintenance	5% of CAPEX for Base Station ; 7% of Operator owned CPE CAPEX
Base Station Site Lease Expense	$12000/year/BS
Customer Site Lease Expense	$400 per year on avg.

2008: 37% * 5.16 + 5% * 0.9 + 7% *0.108 + 0.0124 =1.96

2009: 33% * 10.02 + 5% * 0.9 + 7% *0.186 + 0.0124 =3.37

2010: 29% * 15.264 + 5% * 0.9 + 7% *0.242 + 0.0124 =4.34

2011: 23% * 19.704 + 5% * 0.9 + 7% *0.275 + 0.0124 =4.54

2012: 21% * 23.46 + 5% * 0.9+ 7% *0.296 + 0.0124 =5.03

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
	$M	$M	$M	$M	$M	$M
Revenue	0	5.1	10	15.2	19.7	23.4
CAPEX	0.9	0	0	0	0	0
CPE CAPEX	0	0.108	0.186	0.242	0.275	0.296
OPEX	0	1.96	3.37	4.34	4.54	5.03
Net Cash Flow	-0.9	3.09	6.464	10.68	14.88	18.13
Discount Factor @ 12%	1	0.893	0.797	0.712	0.6355	0.567
Discounted Cash Flow	-0.9	2.75	5.15	7.6	9.4	10.27

NPV= $34.3 M

IRR= 400%

Calculation of NPV and IRR for the Business Case

We know that,

$$NPV = \sum_{t=1}^{n} \frac{Ct}{(1+k)^t} - Co$$

Here, NPV = (0.139 + 5.478+ 5.133+ 4.685+ 4.340) - 10.2

= 19.775-10.2

= 9.575

We also know that,

IRR is the Discount Rate that makes the NPV= 0

$$NPV = \sum_{t=1}^{n} \frac{Ct}{(1+k)^t} - Co = 0$$

or

$$Co = \sum_{t=1}^{n} \frac{Ct}{(1+IRR)^t} = 0$$

Now let’s advance by taking the discount rate of 12%

So, NPV@12% = 34.35

NPV@50% = 12.52

NPV@100% = 5.09

NPV@200% = 1.5

NPV@300% = 0.518

NPV @ 400% = 0.09

So we conclude that 0.09 has a close proximity with 0 and we have taken 400% as the Discount Rate where the NPV approaches Zero, hence it is the IRR of this proposal.

5.2 Project Management / Monitoring and Accountability:

The success criteria for this proposal are set to be as following:

- Project key issues are implemented on time and within approved budget.
- Projected NPV of 8.1% and IRR of 33.4% are achieved on the desired track.
- Flawless launching of wireless broadband access with in the projected time period.
- Proper campaigning of the new technology.
- Target revenue of BDT 8.35 crore p.a. achieved by the specific date.

It will be the responsibilities of the group of Project Managers to keep records of all the events and make sure everything is being reported to concerned higher officials on regular basis.

5.3 Funding Requirements:

Recommendation:

It is highly recommended that the proposal for launching wireless broadband access based on WiMAX technology be approved and we take the advantage of our present infrastructure to grab the huge potential market for WiMAX. The proposal requires capital expenditure of BDT 10.2 crore and operating expenses of BDT 16 crore over the next 5 years which is very much affordable by BTTB at its current status.

Upon approval the funding requirements for this business case will be factored into the business plans for the relevant years.

Chapter 6

6.1 SWOT Analysis

Strengths

Based on proven OFDM techniques (inherent robustness against multipath fading and narrowband interference):

Low cost to deploy and operate

High speed (75 Mbps) and long range (50 km)

Adaptable and self-configurable

Centralized control in MAC enables simultaneous, varied QoS flows

Weaknesses

Currently high power consuming (still far from penetrating portable mobile devices)

Mobility not yet fully specified — could become complex to implement

Opportunities

High-speed wireless infrastructure

Cellular infrastructure for converged networks

Last mile solution for broadband wireless access

Threats

DSL/ADSL technologies widely deployed

Cellular penetration is very high, and growing

Possible wide deployment of 3G

Widespread success of 802.20 standards

6.2 Conclusion:

WiMAX technology brought revolution in both fixed and mobile wireless communication. In present communication world, wireless communication does not mean only data and voice transmission. It also supports high data rate transmission which supports various types of service (voice, data, multimedia).
Since, WiMAX supports high data rate transmission. So it can fulfill the demand of the present end users. Wi-Fi system is widely being used in the first world countries. WiMAX embedded devices support the Wi-Fi standards. So the people who are using Wi-Fi can easily switch to WiMAX technology. Moreover in the developing countries where high data rate wireless communication infra structure is not strong enough. WiMAX can be a good solution for these countries which is more secured, reliable and cheap. For these reasons the user of this technology is increasing day by day. As WiMAX is the latest technology and better solution in the wireless communication world, we have chosen this technology for our thesis. Our objective was to analyze the basic concept of this technology and propose a business solution based on WiMAX technology for Bangladesh.

6.3 References:

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Interviews:

- Teachers & Students of BRAC University
- Mr. Junaed, Executive Officer, Augere Wireless Broadband Bangladesh.