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WiMAX: The Quintessential Answer to Broadband in India

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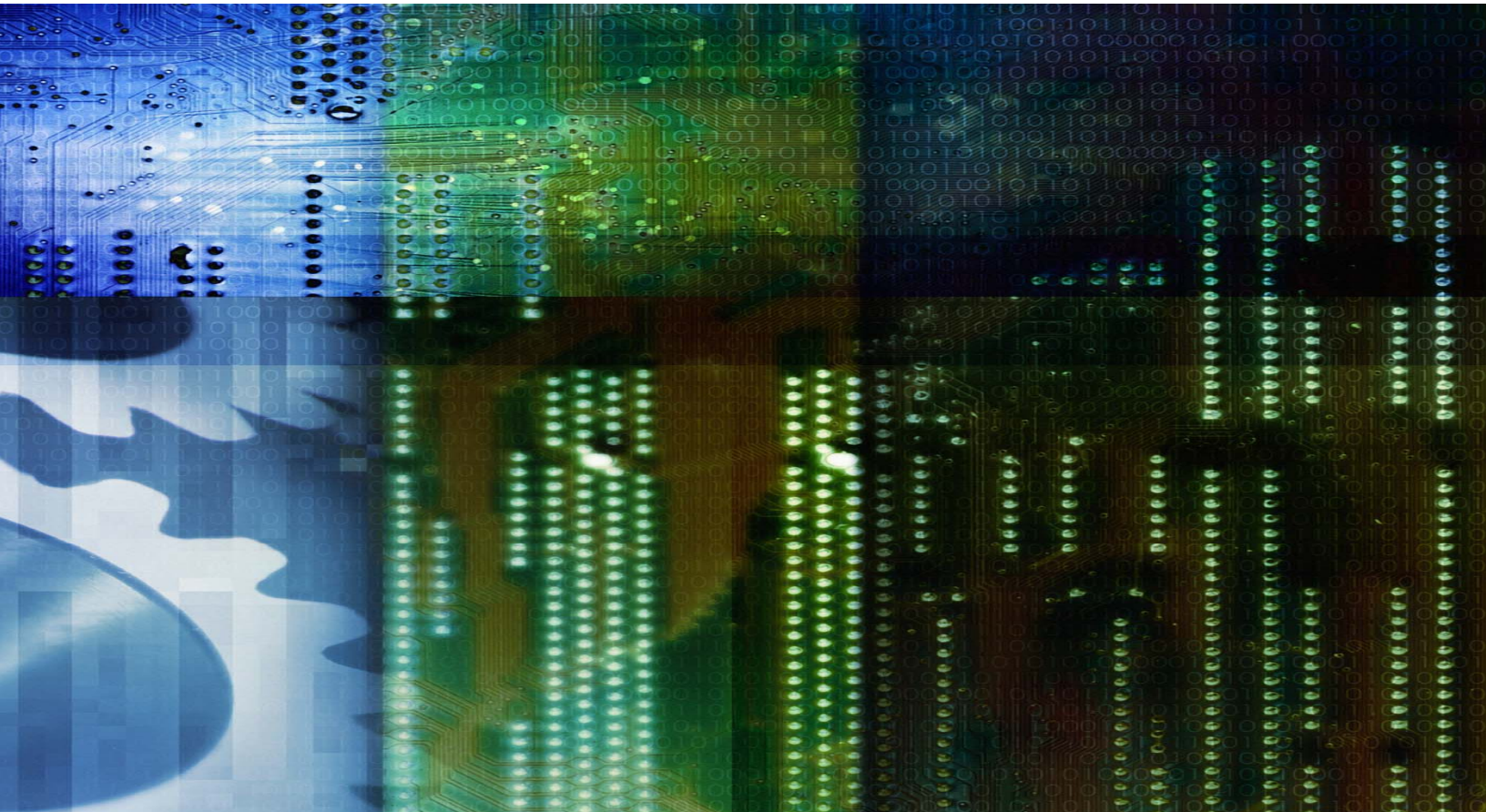

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EXECUTIVE SUMMARY

Broadband Market and Broadband Wireless Access

The lackluster performance of the broadband (BB) market, primarily attributable to the technical and economic nonfeasibility of the fixed line infrastructure in India, indicates that the solution for mass proliferation of broadband in India has to be wireless. Recognising the strong correlation between broadband proliferation and increased economic activity and experience of the burgeoning wireless voice market, the government had announced its Broadband Policy (2004) and most recently the Broadband Wireless Access (BWA) auctions in 2008 to accelerate BB adoption in India. The industry and the country now wait with bated breath to see which wireless technology will be adopted to provide a cost-effective and scalable BB solution to the Indian market, which is ripe with pent up demand for broadband services.

Wireless Broadband – Technology Adoption Parameters

Adoption of any new wireless technology would hinge on affordability, spectral efficiency (on account of scarcity of available spectrum and its high cost), scalability, robustness, range of devices available, evolution roadmap over the next 3-4 years and meeting the BWA policy requirements.

WiMAX – The Quintessential Answer

WiMAX emerges as the quintessential answer to these problems, given its superior performance and lower costs as compared to the existing 3G technologies and futuristic Long Term Evolution (LTE) equivalents. WiMAX was developed for high-speed wireless BB data access and is a 4G technology available today at 3G prices. It presents an ideal choice to Telcos for providing high-speed wireless BB at affordable rates and for the government to meet its growth and social objectives.

The Right Choice for Telcos

WiMAX can be a strong platform for mass adoption of BB in India:

- Estimated returns on investment – equity IRR in the range of 25% - 30% with an NPV of Rs 32 - 37 billion (over a 10 year period) and a subscriber base of 23 million (by 2019);
- Strong coverage and capacity parameters, availability of network elements at competitive prices and lower Capex per subscriber due to an end-to-end (e2e), all-IP architecture and better spectral efficiency;
- WiMAX is stable, tested and proven with a robust and flourishing ecosystem in globally harmonized spectrum bands of 2.3 GHz and 2.5 GHz;
- Will protect investment in 802.16e (the current version to be deployed) as WiMAX has low migration costs to upgrade to 802.16m.

Faster BB Deployment: Government – A Key Benefactor

Government would benefit from the expansion in economic activity manifesting into increased GDP growth rates and revenue generation as has been seen from the improvement in teledensity through wireless cellular telephony. Highlights:

- Revenues of over Rs 260 billion[1] over the decade from auction and taxes etc;
- Employment generation potential of ~ 61 million[2];
- Fulfill societal objectives through better diffusion of economic growth:
    - Improved education – expected expansion of Rs 1,900 billion[3] in national output over the period 2010-2020, due to ubiquitous broadband deployment for e-Literacy and e-Education programmes in vocational and secondary schools
    - Improved health facilities

Consumers – The End Benefactors

High-speed Internet connectivity 'on the go' – anytime, anywhere with a wide array of value-added services at affordable pricing – will help in improving individual productivity and effectiveness.

Conclusion

WiMAX is poised to deliver high-speed wireless broadband at lower costs that will aide mass adoption and thus alleviate problems faced by India's broadband market. Delays in implementing BWA policy and WiMAX adoption are not only denying the Indian diaspora of a cost-effective, high-quality broadband solution but also represent a losing opportunity – the opportunity for India to leapfrog other developed nations, given the correlation between broadband proliferation and economic progress of countries.

This paper examines the advantages of WiMAX among other wireless technology choices available today to espouse the mass proliferation of broadband throughout India and to meet the BWA policy objectives. No other comparable technology to WiMAX is ready today to address problems encompassing broadband diffusion in the country, given its existing infrastructure as well as the needs of the masses.

[1] From 3 operators excluding BSNL/MTNL
[2] Based on CII's 'Broadband Vision 2020' study
[3] Based on CII's 'Broadband Vision 2020' study (present value in 2003 prices)

1. India – Internet Penetration on the Rise

India is projected to become the third largest economy after China and the USA. With continued GDP growth in the range of 6% to 8% pa, expansion of business, consequent rising disposable incomes and one of the youngest population profiles (more than 60% of people are below the age of 30 years[4]), there is a burgeoning demand for broadband services by individuals and corporate users that has not been met by the currently deployed wire-line, cable and wireless technologies such as GSM/EDGE/CDMA/1X EV-DO/3G, etc.

Demand for Internet access, which has shown multifold growth both in urban and rural areas, across individuals and corporations, is expected to remain robust in the future. Statistics reflect that there were about 81 million[5] Internet users in the country (a growth of 1,520% during the period 2000-2008), making India home to the fourth largest number of Internet users in the world, after the USA, China and Japan. According to "The 'I-Cube' (Internet in India) study"[6], the number of PC owners (households) in India grew by 36% in 2008, with 62% of all household PC owners having an Internet subscription. With the DOT[7] setting aggressive targets of reaching 500 million Internet users and 100 million broadband subscribers by 2012, ('Digital Vision – 2012'), significant price declines in terminal equipment and monthly subscriptions coupled with the growing use of Internet for education and commerce means that Internet numbers should dramatically rise over the next 2 to 3 years, a trend that is expected to continue well into the next decade.

1.1 The Burgeoning Demand for Broadband

The Internet is becoming multifarious with rich multimedia. With increasing digitization of content, Internet access increasingly requires broadband/higher speed connections with improved QoS[8] parameters.

Web pages continue to get 'heavier' – the average webpage size has tripled in the last 5 years as over 90% of the web pages requested today contain images. Further, videos now account for 99% of bytes transferred, with the average file size being 10 megabytes. Thus, Internet today requires multiple Mbps connections with superior QoS - in order to provide an uninterrupted Internet experience.

[4] US Bureau of the Census IPC, International Database
[5] Internet Governance Forum
[6] Per survey conducted by IMRB in association with IAMAI
[7] Department of Telecom
[8] Quality of service

Accordingly, the individual Internet access mix has undergone significant transformation in the past 3-4 years. Instead of the traditional primary usage of Internet for e-mails, there is:

- Increasing proportion of Internet usage for information and content sourcing;
- Growing popularity of e-commerce and e-tailing, which are expanding the size and reach of the B2C business model;
- With increased digitization of content and the mounting popularity of user-generated content – YouTube, blogs, reviews and social networking, websites such as facebook.com and orkut.com – broadband demand from individual users has been burgeoning.

Per the Telecom Regulatory Authority of India (TRAI), 31 million (in 2007) and 66 million subscribers (in March 2008) used their GSM and CDMA mobile devices to log onto the Internet[9]. As an increasing number of individuals try accessing Internet 'on the go' (games, e-mail, entertainment, music and sports being the most popular categories with such users) on narrowband connections available through 2G cellular networks, demand for mobile broadband and the gap in its supply are expected to become more pronounced.

Corporate users, too, are increasingly demanding faster and more geographically spread broadband solutions. With the expansion of business operations and demands to reduce operating costs, industries are increasingly focusing on decentralizing operations to lower cost locations. Moreover, with industrialized countries increasingly outsourcing activities to Indian companies to cut costs, the size of the Indian outsourcing industry has grown multifold in the last decade. As reduction in costs is central to the outsourcing concept, a virtuous circle for low cost and superior broadband connectivity solutions has been set in motion, creating a Pan India demand for high-speed connectivity solutions.

Further, with the government (both central and state) on a 'war footing' to facilitate the implementation of societal applications such as e-Governance, telemedicine, distance education, e-commerce and employment generation – particularly in the rural and remote areas to ensure that growth and development 'trickles down' to the masses[10] – availability of a cost-effective and reliable broadband solution across the country is key to the success of such initiatives. This is further widening the gap between the demand and supply of widespread and cost-effective broadband solutions.

[9] Per TRAI from April 2009, there were 101.10 million wireless data subscribers at the end of December 2008 (capable of accessing data services including Internet through mobile handsets (GSM/CDMA))

[10] Recent initiatives by the Department of Telecom and Department of Information Technology include the subsidization of 100,000 common service centers (CSCs), which shall deliver e-governance, entertainment, education, telemedicine, e-commerce, info-services, etc. ubiquitously to the villages/rural areas across India

1.2 Inadequate Existing Infrastructure

Existing fixed infrastructure (wire-line, cable, etc.) in both urban and rural areas is grossly inadequate to meet this growing demand for broadband as only 17%[11] of the existing wire-line infrastructure is capable of broadband provisioning through Digital Subscriber Line (DSL), which would restrict the penetration of broadband. Further, the growing inability of the existing 2G and 2.5G mobile networks[12] to satisfy the broadband hunger due to spectrum and capacity constraints means deployment of new wireless networks to offload data-intensive fixed/mobile broadband applications is inevitable.

Thus, there is a crying need for deploying a cost-effective and scalable wireless broadband technology across the length and breadth of the country to meet the broadband hunger of the classes as well as the masses while fulfilling policy objectives of the government. While 3G and BWA spectrum auctions in the 2.3 and 2.5 GHz bands announced by the government in 2008 are a giant step towards enabling mass proliferation of broadband in India, the larger issue faced by the telcos and policy makers is deciding which technology should be adopted, given the uniqueness of the Indian market to address diverse sections of the population while being scalable.

1.3 WiMAX – The Quintessential Answer

WiMAX, with its relatively superior performance and lower cost structure is, perhaps, the answer to India's broadband proliferation problem. WiMAX was evolved for high-speed wireless data access (fixed and mobile) as compared to currently deployed cellular technologies that were developed for voice. WiMAX:

- Enables a faster wireless broadband service – WiMAX Release 1.0 has a higher peak rate and two to three times greater down link (DL) sector throughput than HSPA Release 6[13], which means higher data transfer capacity in the same quantum of spectrum allotted
- Has a lower cost structure (CAPEX and operating costs):
  - An all IP, flat network architecture;
  - With the adoption of globally harmonized spectrum bands[14] for BWA in India, costs of equipment (operator and customer premises) will remain low due to significant economies of scale achieved through a well-developed global ecosystem; and
  - Has the highest spectral efficiency[15] (refer to Table 1)

[11] TRAI Broadband Policy 2004 - There are more than 40 million copper loops in the country available with BSNL and MTNL out of which approximately 7 million loops can be leveraged for providing broadband services

[12] While 2G and 2.5G networks continue to enable users to access data on their handsets and laptops, increased digitization of content and surge in applications will lead to these networks being capacity constrained as usage increases - mobile data traffic is expected to grow by a factor of 10x between 2010 – 2015

[13] Throughput advantage depends on ratio of DL to UL traffic; for a more detailed analysis, see white paper: "Mobile WiMAX – Part II: A Comparative Analysis", available on the WiMAX Forum website

[14] 2.3 and 2.5 GHz

[15] As compared to HSPA and HSPA+, Source: WiMAX Forum

- Is scalable by ten times for speed capability and three times for spectral efficiency improvements, and has a defined evolution path for 802.16m with minimal upgrade costs, thus protecting investments made for today's 802.16e.

With superior data delivery performance at a lower cost as compared to 3G technologies available today, WiMAX provides a cost-effective solution to mass proliferation of high-speed BB in India.

Further, per the 3G auction guidelines, only 10 MHz of spectrum is to be allotted per operator, assuming operators dedicate this spectrum to broadband usage; at an oversubscription rate of 1:30[16], and 2 Mbps speed per subscriber, broad computation reveals that approximately 72 subscribers can use this spectrum for broadband connections as compared to 264 subscribers for WiMAX with the same specifications[17]. Another important consideration is that with no additional 2G spectrum available with the government – and given the scorching pace of voice subscriber additions across the existing operators – this 3G spectrum would in all probability be dedicated to sufficing the needs of the burgeoning voice subscribers. Thus, 3G could be an expensive solution and may not be used by operators for alleviating India's broadband hunger.

Initial WiMAX deployments were made in the 3.2 GHz band by select operators due to its sheer capability and performance. However, WiMAX-based mass adoption of wireless broadband could not scale up primarily due to nonadoption of a globally harmonized spectrum band (which led to high infrastructure and device costs as no benefit could be derived from economies of scale). The BWA policy of the government around 2.3 and 2.5 GHz globally harmonized bands has helped Indian telcos to seriously consider and embrace WiMAX due to the global level of maturity offered by WiMAX and its ecosystem within these frequency bands.

Thus, the stage is set for WiMAX adoption in India by Indian telcos and the Indian diaspora can enjoy wireless broadband at the right QoE[18] and QoS levels.

[16] TRAI Guidelines for service providers providing Internet/broadband services for ensuring better quality of service (press note dated March 2, 2009) - maximum oversubscription of 1:50 for home users and 1:30 for business users
[17] Refer to Table 1 for details of specifications
[18] Quality of Experience

2. Technology Comparison: The WiMAX Edge

Mobile WiMAX is based upon Orthogonal Frequency Division Multiple Access (OFDMA), an access technology that has become commonly accepted as the basis for the evolution of mobile technology in 4G – thus, matured and proven 4G technology exists today. A single WiMAX 802.16e-2005 (16e) platform can support fixed, portable and mobile broadband services. It has the capability to operate in scalable channel bandwidths from 5 to 20 MHz to comply with various IMT-2000 standards-based spectrum allocations. WiMAX supports the best-in-class security features through mutual device/user authentication, flexible key management protocols, strong traffic encryption and security protocol optimizations for fast handovers. Further, with an all-IP end-to-end network (which will only be incorporated in the 4G version of cellular technologies), currently WiMAX has lower network operating costs as compared to higher cost circuits switched networks for HSPA/HSPA+.

Spectral Efficiency and Sector Throughput – Key to Lowering Costs

With spectrum being the most critical component of the business model for telcos on account of its costs and scarcity, BWA technology adoption decisions hinge on spectral efficiency.

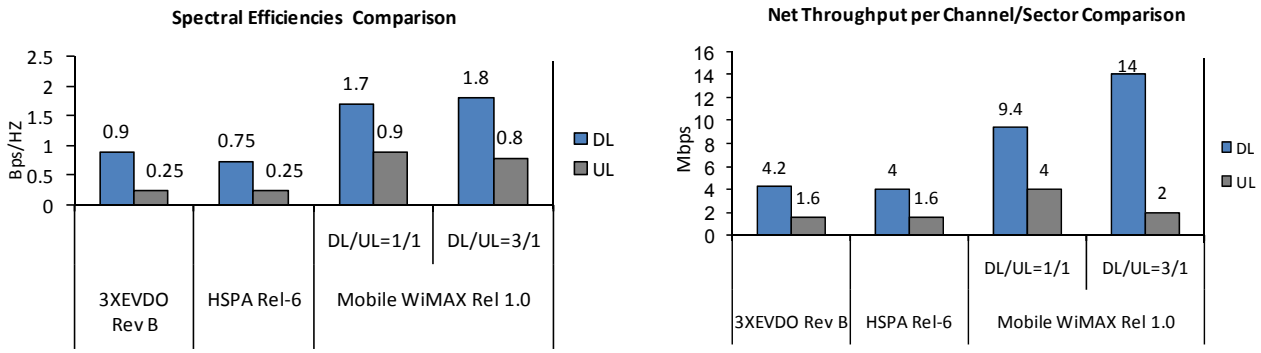
Spectral efficiency has a favourable impact on the business case as it:

- Lowers deployment cost per Megabit, which would be key to dense urban, suburban, rural and remote area deployments
- Enables higher network capacity to support new value-added services for increased operator revenues

Further, sector data throughput [DL and Uplink (UL)] performance is also important as it directly impacts investment in capital equipment.

WiMAX outscores existing 3G technologies on these metrics. Further, with 16m (Release 2.0) of WiMAX reporting twice the spectral efficiency of Release 1.5, WiMAX will be ahead of the current LTE prototypes/versions of cellular technologies being developed. Comparisons between Mobile WiMAX 16e (Release 1.0) with 3G enhancements [High Speed Packet Access (HSPA) Release 6 and Evolution Data Optimized (EV-DO) Rev B] reflect that Mobile WiMAX Release 1.0 [TDD, 10 MHz Channel Bandwidth (BW)] has higher peak rates and two to three times greater DL[19] sector throughput than HSPA Release-6. This translates to higher data transfer capacity in the same quantum of spectrum and lesser numbers of base stations, thus lowering overall capital investments.

[19] Throughput advantage depends on ratio of DL to UL traffic, see white paper: “Mobile WiMAX – Part II: A Comparative Analysis”, available on the WiMAX Forum website, for a more detailed analysis



Source: WiMAX Forum

Further, comparisons between WiMAX Release 1.5 and the next-generation 3GPP20 technology releases (HSPA and HSPA+), show WiMAX exceeds in the given performance parameters:

Table 1

Data Network	WiMAX	HSPA+	HSPA
Total Amount of Spectrum	30Mhz	30Mhz	30Mhz
Spectral Efficiency per BTS	3.3* bps / Hz	2.0 bps / Hz	1.2 bps / Hz
Base Station Total Throughput (Mbps)	99	59	36
Downlink / Uplink	66.7%	50.0%	50.0%
Network Loading %	80%	80%	80%
Available downlink throughput (Mbps)	52.8	23.4	14.4
QoS requirement per subscriber (Mbps)	**2.0**	**2.0**	**2.0**
Number of simultaneous subs	26.4	11.7	7.2
Total subscribers per BTS	**1,000**	**1,000**	**1,000**
Oversubscription	38	85	139
Average kbps per subscriber	53	23	14

Source: WiMAX Forum

* *Based on 2008 IEEE 802.16m SRD specifications defining 802.16e spectral efficiency*

To summarise the above table:

- WiMAX demonstrates higher spectral efficiency;
- WiMAX has a higher DL performance for the same Modulation, Coding and Channel BW as HSPA+;

[20] The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations to make a globally applicable third generation (3G) mobile phone system specification within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU). 3GPP specifications are based on evolved Global System for Mobile Communications (GSM) specifications. 3GPP standardization encompasses Radio, Core Network and Service architecture.

- HSPA+ is constrained to 2 x 5 MHz channels in traditional 3G spectrum assignments;
- WiMAX supports channel BWs up to 20 MHz, Frequency Divisions Duplex (FDD) and Time Division Duplex (TDD);
- WiMAX has lower CAPEX per subscriber; to support 1,000 subscribers/base transceiver stations (BTS), the oversubscription factor for WiMAX is 38 versus 85 for HSPA+, despite a 60% lower average kbps per subscriber data rate for HSPA+.

Another way of viewing this is with 30 MHz of spectrum, constant downlink speed and oversubscription (1:30[21]), 2.26x and 3.67x BTSs of HSPA+ and HSPA respectively would be required to support the same number of subscribers as 1 BTS of WiMAX (refer to comparative table below).

Data Network	WiMAX	HSPA+	HSPA
Total Amount of Spectrum	30Mhz	30Mhz	30Mhz
Available downlink throughput (Mbps)	52.8	23.4	14.4
Average kbps per subscriber	**50**	**50**	**50**
Concurrent Users	1,081	479	295
Number of BTS required (keeping WiMAX as a base)	**1x**	**2.26x**	**3.67x**

** Please refer to Table 1 for specifications*

Thus, the cost of providing broadband services on the WiMAX platform is expected to be lower than on 3G technologies. Moreover, migrating from the current 2G and 3G technology to 4G LTE technology demands increased investment in network-related architecture due to multiple fresh equipments to be inducted into the existing Radio Access Network (RAN), Edge, Backhaul and Core network layers, while the transition of WiMAX Release 1.5 (16e) to WiMAX Release 2.0 (16m), will be more cost-effective (as it is backward compatible with Release 1.0 and Release 1.5) and has a smoother and lower incremental investment in RAN as it utilizes the same Edge and Core network.

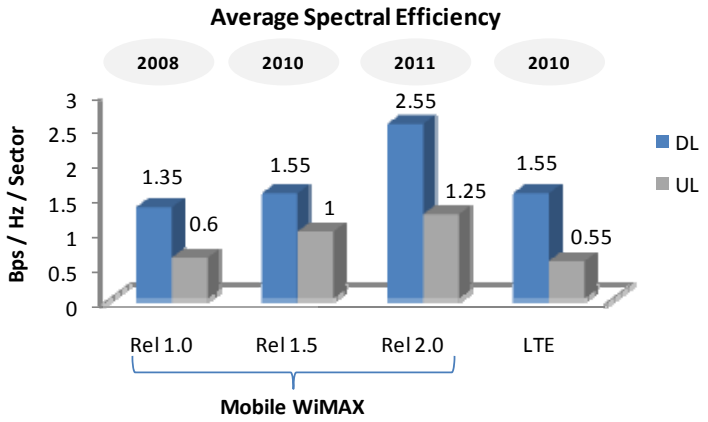
3. Next Generation – Long Term Evolution (LTE)

The LTE radio air interface and network design standard is still in the standards development process, with expected freezing of standards only by late 2009/Q1 2010. LTE is yet to attain a globally harmonized status around a common spectrum band. Additionally, LTE-based silicon and chipsets ensuring conformance to such standards will launch around mid-2010 and will start showing the right yield levels only by 2011, post which the device ecosystem and RAN ecosystem would be economically viable. Also, the silicon and the devices have to be designed to support backward compatibility for 3G for Voice/HSPA for Data/HSPA+ for IP DATA/MIMO (multiple input, multiple output) processing, which increases the device complexity and adds to the cost significantly. Initial prototype infrastructure solutions for RAN from LTE technology is expected from vendors in late 2010 with initial trial deployments of LTE in 2011 or later.

[21] TRAI Guidelines for service providers providing Internet/broadband services for ensuring better quality of service (press note dated March 2, 2009) - maximum oversubscription of 1:50 for home users and 1:30 for business users

This technology is hence still in its infancy and thus the silicon (chipsets) – BTS as well as devices – would not get commercially stable status until mid-2012. As any technology takes at least 2-3 years to become commercially available, particularly in the Indian context given the price sensitivity for mass adoption, WiMAX has a clear 3-4 year time advantage over LTE.

Further, with 16m (Release 2.0) of WiMAX reporting twice the spectral efficiency of Release 1.5, WiMAX appears to be far ahead in the war of the technologies for wireless high-speed data traffic handling capability.



Source: WiMAX Forum

WiMAX transitional costs are expected to be lower than any other comparable 4G technology:

- LTE is adopting technology and features like OFDMA already available with Mobile WiMAX.
- Mobile WiMAX provides a simple, all-IP flat network, with all Internet Engineering Task Force (IETF) protocols, which will only be available in LTE and LTE advanced and not in existing cellular technologies such as 3G, which are circuit-switched.
- Further, an LTE network is a more complex multi-layer network burdened with proprietary 3G cellular protocols that will make it more expensive to operate.
- A major advantage WiMAX offers is lower cost of IP, allowing new entrants to compete with major telecom vendors and bring innovative and lower cost devices to market
- Further, the Open Patent Alliance (OPA) formed by Alcatel-Lucent, Cisco, Clearwire, Intel, Samsung, Sprint, Alvarion and Huwaei[22] – with the objective of offering an Intellectual Property Rights solution that will further support competitive development and widespread adoption of WiMAX worldwide – is another big plus for WiMAX in lowering the cost of broadband solutions.

Thus, with the release of the WiMAX 16m standard in 2010, WiMAX is expected to maintain the technological lead as LTE-based 4G technologies become available in the next 3 to 4 years.

[22] Huawei and Alvarion joined the OPA in February 2009

4. WiMAX-Enabled Devices and Their Roadmap

Price points and availability of BWA CPEs[23] remain key factors in the mass adoption of new wireless technology in India, as evidenced by the growth of mobile communications. Accordingly, affordability and availability of BWA CPEs would be key in deciding which technology would hold the turf.

WiMAX has an already established global ecosystem for device manufacture and support, which services over 455 commercial WiMAX networks in 135 countries covering 430 million people. Further, with over 1,700 Global Spectrum Auctions in 140 countries – held since 2006 to date – and expected 133 million customers worldwide (including 19 million in India) by 2012, there is significant commitment in the growing system to ensure that further economies of scale will benefit customers through declining prices and greater choice of devices.

Highlights of this global ecosystem for WiMAX include:

- 25 silicon chip manufacturers; approximately 35 base station vendors;
- More than 40 companies providing PC cards, USB modems, MIDS, WiMAX Embedded Note Books (WENBs), NetTops and WiMAX Indoor Modem cum Routers;
- Seven of the top eight device manufacturers (Samsung, LG, HTC, Motorola, HP, etc.) have launched products already and are innovating further;
- More than 40 notebooks from leading PC manufacturers have already been launched, with another 100+ models expected by 2010; and
- Nearly 200 service providers

4.1 Types of Devices Available

Manufacturing for WiMAX devices has already reached maturity, with over 530 member companies committed to high-speed, mobile Internet success, and the ecosystem continues to evolve. WiMAX access devices currently available in the market include:

- Mini PCMCIA[24] cards
- USB modules
- WiMAX + GSM/CDMA phones and personal digital assistants (PDAs)
- Dual Mode (HSPA- and WiMAX-enabled) PCM cards, USB dongles, handsets, ultra-mobile PCs and embedded notebooks
- Mobile Internet Devices (MIDs) [25]
- Consumer electronic devices: game consoles, MP3 players
- 50 PC SKUs certified for various WiMAX networks; over 1000+ devices are expected by end of 2010 with WiMAX Forum Certification

The integration of Wi-Fi and WiMAX in a single chipset is expected to contribute to an even deeper cost reduction for devices/subscriber units. The commitment by chipset

[23] Customer Premises Equipment
[24] Personal Computer Memory Card International Association
[25] More popularly called Mobile Internet Devices (MIDs) and defined as pocketable Internet devices for "in-hand" usage, MIDs not only offer a superior Internet experience, but are also designed to provide entertainment, information and location-based services for the consumer 'on the go'.

manufacturers, such as Intel, to integrate WiMAX interfaces into computer OEM new products (laptops, NetTOPs, PCs, MIDs, WiMAX Embedded Note Books (WENBs) and Net books,) should help resolve a perennial 'chicken and egg problem' between carriers and equipment manufacturers – that is, lack of network coverage vs. lack of sufficient numbers of affordable devices. This argument becomes more pronounced in a cost-conscious market, such as India.

4.2 Pricing Trends[26]

According to the WiMAX Forum, a significant price reduction in WiMAX-enabled devices is expected over the next 3-5 years as the cost of open-standards equipment (upon which WiMAX is based) tends to decrease rapidly with the increase in volume on mass adoption. Current pricing trends of WiMAX-enabled devices based on functionality, device type and features are projected in the table below:

Device	Current Price*	Expected Price – 2012**
Indoor WiMAX CPE with WiFI & Router function (Modem)	US$ 65 – US$ 85[1]	US$ 54[1]
GSM +WiMAX Phone	US$ 309 – US$ 388[2]	US$ 213 [2]
NET BooKs & Notebooks with WiMAX/ WiFi	US$ 265- US$ 735[3]	US$ 160 to US$ 640 [3]
Basic USB with SIM card capability	US$ 64[4]	US$ 32 to US$ 43 [4]
Mobile Internet Devices (MID's)	US$ 480[5]	US$ 213 to US$ 425 [5]

[1]Depending on features
[2]Depending on features, battery life, screen size etc
[3]Depending on the LCD Screen size and HD capacity and type like HDD or Flash
[4]With additional memory and Over the Air Provisioning (OTA)
[5]Depending on features, battery life, screen size etc

**WiMAX Forum, primarily based on BSNL tender prices*
***WiMAX Forum estimates*

Comparative 3G USB modem prices available today range between US$70-75[27] and are expected to decline, as volumes increase.

WiMAX – The Right Choice

As evidenced in the sections above, WiMAX has an edge amongst the BWA technologies currently available. Delays in WiMAX for BWA adoption are not only denying the Indian diaspora of a cost-effective and improved broadband solution, but also represent a losing opportunity – the opportunity for India to leapfrog other developed nations given the correlation between broadband proliferation and economic progress of countries.

[26] 1US$ = INR 47
[27] BSNL EV-DO USB modem retail price

5. Benefits to Key Stakeholders

5.1 Operators

Operators could look at a 25%[28]+ IRR on investments in WiMAX technology. Key assumptions include:

Market Expectations

- Initial roll-out in 100 cities within 3 years
- Approximately 80-90 million WiMAX subscribers by 2019 (Year 10) in India
- Given the four operator models for BWA, operators would aim to secure 25 percent market share
- Target customer base
    - Individuals using PCs, desktops, laptops and mobile Internet devices (MIDs)
    - Corporate users

Subscribers and Average Revenue per Unit (ARPU)

- 7-9 million subscribers by 2014 (Year 5) and 20-23 million subscribers by 2019 (Year 10) per operator
    - ARPU (assuming speed of 512kbps initially, 1mbps from Year 6 onwards and 2mbps from Year 9 onwards with unlimited usage) Rs 700~1,100/month currently, declining to Rs 560~880/month by 2019 (Year 10)

CAPEX

- Green field operator – Sites to be leased from infrastructure owning companies. No CAPEX for site infrastructure is assumed other than electronics and radio equipment
- Spectrum license cost of Rs 15,150 million (1.5 times of auction reserve price for a Pan India license)
- 10,700 and 32,300 BTS by Year 5 and 10 respectively (including micro and pico sites)
- Maximum loading of 720~840 subscribers per BTS

[28] Based on spectrum license cost of 1.5 times of the auction reserve price – Rs 15,150 million

- CAPEX/subscriber (excluding spectrum license cost) of:
    - Rs 1,900 ~ Rs 2,100 by 2014 (Year 5) [net off subsidy towards CPE]
    - Rs 2,150 ~ Rs 2,250 by 2014 (Year 5) [gross of subsidy towards CPE]
- CPE device costs[29] have been assumed to be a 'pass through' to subscribers starting Year 3 (2012). For the first 2 years a subsidy of 25% (customer to pay for 75% cost) has been assumed for initial promotion. Post that, expected CPE price declines and computers (laptops and desktops) embedded with WiMAX-enabled chipsets being available in the market, no additional investment should be required in CPEs by operators.

Financial Highlights

Snapshot		
	Year 5 (2014)	**Year 10 (2019)**
Revenue (In Rs bn)	47 - 52	140 - 150
EBITDA	30% - 40%	15% - 20%
PAT	20% - 25%	8% - 10%

- EBITDA and PAT break-even in 3~5 years
- 10 year Equity IRR in the range of 25%-30% (including terminal value assumed at a growth rate of 3%) at a spectrum license cost of 1.5 times of auction reserve price[30]
- Net present value (including terminal value assumed at a growth rate of 3%) of Rs 32 billion – Rs 37 billion at a WACC[31] of 16.2 % p.a.
- Peak cash requirement of approximately Rs 18 billion in the year of commencement of operations

5.2 Government

At the macro level, mass proliferation of broadband is expected to spread economic efficiency and productivity, and assist in diversifying income. Further, it is a vital ingredient to push government's initiatives of e-Governance, improved educational opportunities and health services in rural and remote locations. Over and above, there would be significant revenue generation from spectrum auctions, taxes on services, and import of equipment. Thus, broadband connectivity and services can be a key driver for several socio-economic gains. Studies reflect this:

- Planning Commission's Vision 2020 visualises ubiquitous broadband as playing a strategic role
- CII's 'India's Broadband Economy: Vision 2010' study directs to significant value creation both in terms of growth in national output and improved education, health and empowerment

[29] CPE is basic USB modem with SIM card capability
[30] Increase in spectrum reserve price to 2 times would yield an IRR in the range of 20%-25% (including terminal value at a growth rate of 3%)
[31] Weighted Average Cost of Capital - Debt : Equity of 55:45; cost of debt – 13.5, cost of equity – 25%

This is expected to manifest in increased GDP growth and improved standards of living.

Macro Economic Benefits

Expanding broadband networks to non-metro areas, where a majority of the country's small- and medium-sized businesses are run, can spread economic efficiency and productivity, and help in diversifying income. Further, decentralization of businesses would help reduce cost of operations thereby improving business efficiency.

Revenues

Time lags will delay sustained contributions to government revenues from:

- **Spectrum allocation and usage charges:** The government would look to add a minimum of Rs 30 billion (US$645 million[32] – reserve price for auction) in its kitty as a one-time allocation fee through the impending spectrum auction for the three (in addition to BSNL/MTNL) spectrum licenses in the 2.3 and 2.5 GHz blocks. Further, spectrum usage charges of 1% of AGR[33] would mean an additional Rs 14 billion in aggregate over the decade (2010–2019) from the three operators[34] (excluding BSNL/MTNL).
- **Import duties and taxes:** Duties and taxes are applicable on WiMAX base stations and other equipment. At aggregate CAPEX investments (primarily imported) of approximately Rs 137 billion[35] over the next 10 years across the three operators[36], import duty[37] levied by the government is expected to add Rs 13.7 billion to the government's cash flows.
- **Service tax and others**: Aggregate revenues of approximately Rs 1,980 billion (from three operators[38]) would translate to Rs 204 billion of service tax[39] revenue over the decade (2010–2019). Further, additional revenue shall accrue to the government from tax on sale of end user equipment such as CPEs, MIDs, PCMCIA cards, etc.

[32] 1US$ = INR 47
[33] Adjusted gross revenue: Revenues – bandwidth costs
[34] Assumed to work on similar revenue model, as the one discussed herein
[35] Assumed at US$50/subscriber and an estimated subscriber base of 23 million Pan India with a 75% share for the three operators other than BSNL
[36] Excluding BSNL/MTNL
[37] Import duty @ 10%
[38] Excluding BSNL/MTNL
[39] Assumed at 10.3% of revenues

Social Benefits:

- **Employment generation:** Potential of approximately 2 million people in direct employment and approximately 59 million people in indirect employment[40].
- **Public Policy initiatives:** Provision of ubiquitous broadband services would be key to success and furtherance of e-Governance, e-Literacy, e-Health programmes and other social services in remote regions across India. It would also ensure connectivity to 100,000 common service centers (CSCs), a recent initiative by the Department of Telecom and Department of Information Technology to accelerate delivery of e-Governance, entertainment, education, telemedicine, e-commerce, info-services, etc. to villages/rural areas across India.

Thus, government can ill-afford delays in implementing the BWA, which would negatively impact economic growth, success of social improvements plans and revenue generation for the government, if the broadband market does not 'take off'.

5.3 Customers and End Users

- **High-speed Internet connectivity 'on the go' – anytime, anywhere:** WiMAX would ensure high-speed mobile wireless access to broadband, enabling a 'connected' community.
- **Affordable services:** With a wide array of value-added services and applications, WiMAX is a 4G technology available at affordable prices, thus lending itself to mass adoption.

6. Successful/Recent Deployments[41] – WiMAX Live!

WiMAX is soon becoming the technology of choice for many telecom carriers and end users in deploying and using next-generation networks. The reason for the widespread interest is clear enough – if WiMAX lives up to its promise, it will respond to challenges faced by carriers and users alike. Examples of few successful and recent WiMAX deployments globally include:

KT, Korea: Post a commercial launch in April 2007, KT – the first company in Korea to explore wireless broadband services – had deployed approximately 600 base stations covering 12 million people, and had established itself as the wireless broadband leader with 106,000 subscribers representing a 43% mobile broadband data market share. As of June 2008, KT had acquired over 200,000 subscribers by providing an introductory rate of USD 21 per month for a 30GB monthly download and USD 11 per month for a 1GB monthly download.

Clearwire, U.S.: Clearwire serves markets in the United States (the second largest holder of spectrum with 100 MHz in the 2.5 GHz band), Ireland, Belgium, Spain, Denmark (with Danske Telecom) and Mexico (with MVSNet). Branded as 'Clear', the company, on January

[40] Study by ASSOCHAM & CII
[41] Source - WiMAX Forum

6th, unveiled Portland, Oregon as its first 4G WiMAX wireless broadband market. Clear residential modems offer up to 6 Mbps download speeds while mobile Internet customers can also expect to receive up to 6 Mbps download speeds. Following up on its Portland launch, the company, on March 5th 2009, announced that it would expand its 4G WiMAX network to nine additional markets in 2009. The company targets to acquire 35 million subscribers in 2009 and 120 million subscribers in 2010 across the globe.

Yota, Russia: The first mobile WiMAX network in Russia (with 30 MHz of spectrum in 2.5 GHz frequency) launched in September 2008, with current services covering a total population of 20 million people. It offers Internet speeds of up to 10 Mbps per user device. By the end of 2008, the company had successfully installed 150 base stations in Moscow and 80 base stations in St. Petersburg with peak data rates of about 180 Gbit per second*. Yota's 2009 focus is on regional expansion – deploying mobile WiMAX networks in 40 Russian cities.

BSNL, India: BSNL has 20 MHz of BWA spectrum (in each of the 22 services areas in the country) in the 2.5 GHz frequency. With a successful launch in Goa in July 2009, BSNL now targets to launch the service in Kerala and Punjab on August 15, 2009. Having completed an initial deployment of 1,000 base stations already, the company plans to launch another 1,600 base stations by the end of 2009 (and recently contracted with Huawei and Harris Stratex at an investment of Rs 5.6 billion for the purchase of network and radio equipment), with a capacity to service 1.1 million subscribers. To support its upcoming launch, BSNL has successfully tested the service at speeds of 2 Mbps and 1 Mbps at a distance of 2 km and 8 km respectively in urban areas, and 2 Mbps and 1 Mbps at a distance of 2.5 km and 15 km respectively in rural areas.

UQ Communications, Japan: The only telecommunications company in Japan that provides nationwide mobile services based on WiMAX, on February 26, 2009, UQ started its full mobile WiMAX service in 23 Tokyo wards, Yokohama and Kawasaki – targeting a download speed of 3+ Mbps. The company has been securing regional spectrum licenses in the 2.5 GHz band across Japan, and aims to provide WiMAX coverage to 90% of the country by 2012.

VMAX, Taiwan: A joint venture between 3G mobile carrier Vibo Telecom Inc. and broadband wireless telecom equipment maker Tecom Co., VMAX is one of six major WiMAX spectrum holders (30 MHz of spectrum in the 2.5 GHz frequency) in Taiwan.

*In backhaul

VMAX won a 6-year license for 30MHz of spectrum in the 2.5 – 2.69 GHz band to deploy WiMAX to Taiwan's northern region. With an initial planned deployment of 200 - 250 base stations, the company plans to cover 70% of Taipei. In addition, VMAX plans to launch a wide selection of available devices by the end of 2009.

Packet One Networks (P1), Malaysia: The first operator to launch commercial WiMAX operations in Malaysia in August 2008. By the end of 2008, P1 had successfully acquired 100,000 subscribers. The Company operates in the 2.3 GHz band and plans to increase its subscribers by 250% in 2009, and an investment of USD 290 million in the next 5 years. It is currently offering a 1.2 Mpbs package at USD 44 / month[42], with promotional packages being offered currently at USD 28 / month[42], for 1.2 Mbps and USD 64 / month[42], for 2.4 Mbps with a 24 month commitment.

Wateen Telecom, Pakistan: Headquartered in the city of Lahore, Pakistan, Wateen telecom has successfully deployed one of the biggest nationwide WiMAX networks with 42 MHz of Spectrum. With the deployments of more than 842 four sector base stations across 22 cities, the network covers over 20% of Pakistan's 164 million inhabitants. Since its commercial launch in December 2007, the operator has signed up 52,000 subscribers. Monthly tariffs for Internet access begin at USD 6.30, with a onetime connection fee.

With examples such as the above, the wireless broadband telecommunications marketplace is set to undergo a fundamental shift.

6.1 Select Risk Factors

Certain risks may hamper the mass adoption of WiMAX:

- **CPE/equipment pricing:** CPE costs play a key role in mass adoption of any technology. While WiMAX CPEs are available at competitive prices currently, they need to decline significantly to facilitate mass adoption particularly in Tier 2/3 cities and rural India. Similarly, decline in landed cost of equipment to ensure lower CAPEX investment by WiMAX operators is important to ensure a viable business model.
- **Availability of adequate spectrum at the right price:** The government had announced 20 MHz of BWA spectrum to be made available to four successful bidders with a reserve price of Rs 1,010 crore (Rs 10 billion) for Pan India licensing – less spectrum per operator means higher investment in CAPEX (for the number of base stations) to support the same subscribers. There is still no defined timeline for the BWA auctions to be held. Further, current news in circulation is that Pan India 3G license costs are expected to be twice that (Rs 4,040 cr) of the earlier announced reserve price of Rs 2,020 cr. If the BWA spectrum reserve price is revised upwards, it would negatively impact the business case.

[42] 1USD= 0.2806 RM

- **Availability of passive infrastructure:** WiMAX operators will be competing primarily with new/expanding GSM telecom operators for tower space to install their active infrastructure. While the passive infrastructure assets are built gradually over time the aggressive expansion plans of the new four to six operators and incumbents may cause a situation of demand in that supply for towers in the short/medium run could escalate operating costs – particularly for greenfield WiMAX operators or those WiMAX operators that do not own passive infrastructure – thus stressing project returns and negatively impacting business plans.

These risks would lead to a higher cost of delivery of service and would negatively impact the business model for WiMAX operators.

Conclusion

With empirical evidence of correlation between broadband penetration and economic progress of countries manifesting in several ways worldwide, India cannot further delay adopting WiMAX for accelerated proliferation of broadband. This would both 'unlock' value and meet social objectives of current and future governments by increasing productivity of assets and improvements in learning/education programmes, healthcare and other social services, which are critical to bringing social and economic prosperity in rural areas wherein 70% of India's population resides.

WiMAX provides the quintessential answer to BWA in India and its immediate deployment presents a golden opportunity to leapfrog other developed nations by providing seamless connectivity.

WiMAX's superior performance, lower costs and defined evolutionary path give it an edge over other cellular technologies. Further, its well developed global ecosystem and consequent aggressive device pricing will prevent it from suffering from the initial 'hiccups' in mass adoption faced by cellular technologies in the 1990s.

The stage is well set for implementing the BWA policy. WiMAX is what 'the doctor has ordered' to alleviate India's broadband penetration woes and further delays will only mean denying both the masses and the classes.

7. Recommendations to the Government and Regulators

A firm governmental commitment with private sector partnerships can go a long way in helping India achieve the many benefits of mass proliferation of broadband. Following are a few recommendations:

- **Recognize the strong correlation between broadband penetration and economic prosperity:** It is critical to capitalize on low-cost connectivity to improve India's global competitiveness. Thus, we can ill-afford further delays in implementing BWA policy.
- **Immediately release spectrum:** Releasing spectrum is key to implementing the BWA policy. While spectrum auctions will generate one-time revenues, sustained spectrum utilization will generate periodic revenues.
- **Supportive measures:** Without encouragement and incentives, operators are unlikely to roll out broadband networks in non-urban areas, where the majority of citizens live. To make such roll-outs cost-effective, governments can take a number of actions, such as offering tax and duty benefit incentives for BWA devices, subsidy from the USO fund to telcos, etc.
- **Encourage competition:** Promoting a competitive environment can help attract investment as well as drive down prices – ensuring a cost-effective and affordable roll out of large-scale, wireless broadband services.

8. Q&A

Is WiMAX ready?

WiMAX is ready. The technology is stable, time-tested and proven with an already established ecosystem that is strong, robust and flourishing among more than 455 commercial WiMAX networks in 135 countries covering 430 million people. Further, over 1,700 Global Spectrum Auctions in 140 countries have been held since 2006, and 25 silicon chip manufacturers, approximately 35 base station vendors and more than 40 companies currently offer/support various WiMAX-related devices. Clearly, a global level of maturity has already been achieved, making costs of deployment cheap and end user accessibility, affordable.

Why do we need wireless broadband?

Given the current state of fixed infrastructure in India, only 17% of the 40 million copper lines are capable of broadband provisioning through DSL. Further cost of deploying fixed wire-line infrastructure in urban, rural and remote areas would not provide a cost-effective solution to enable mass proliferation of broadband. Hence, wireless is the way to go as has been historically proven in the case of voice.

Why would deployment costs of WiMAX in India be lower than those in the U.S.?

The macroeconomic factors/deployment costs in India are different from those in the U.S.:

- Higher density of population and subsequently lower number of coverage sites to be built in India compared with the U.S. In order to reach 200 million people in the U.S., an area of approximately 300K sq km needs to be covered, whereas in India, only about 17k sq km needs to be covered. Accordingly, investment in CAPEX in India is bound to be lower.
- Lower CAPEX due to APAC-based vendors (especially Chinese) offering RAN at much affordable rates as compared to European/American vendor rates for RAN. Lower costs of network commissioning due to lower manpower costs.
- Lower cost of fiber as well as lower cost of laying fiber.
- Lower site costs. With increased tower population and regulatory approval for sharing of towers, investment in CAPEX for tower roll-out and rentals in India have reduced significantly. In the U.S., not only is tower access difficult but rental costs are almost six times as high as those in India.

With 3G already present, why do we need WiMAX?

With spectrum being scarce in India, technology-adoption decisions hinge on spectral efficiency. Spectral efficiency has a favourable impact on the business case as it:

- Lowers deployment cost per Megabit, which is key to rural and remote area deployments
- Offers increased network capacity to support new value-added services for increased operator revenues

Mobile WiMAX Release 1.0 (TDD, 10 MHz Channel BW) has higher peak rates and two to three times greater DL[43] sector throughput than HSPA Release 6 available today. With 10MHz of 3G spectrum, assuming an oversubscription rate of 1:30, and 2 Mbps speed per subscriber, only 72 subscribers can be supported per base station as compared to 264 for WiMAX. This would mean that 3G will need three times the number of base stations to cover the same number of subscribers as WiMAX. Another key factor is that with no additional 2G spectrum available and given the scorching pace of voice subscriber additions across the existing operators, 3G spectrum allotted to existing operators would in all probability be dedicated for sufficing the needs of the burgeoning voice subscribers. Thus, 3G would neither be a cost-effective solution nor would it be used by operators for alleviating India's broadband hunger.

[43] Throughput advantage depends on ratio of DL to UL traffic. For a more detailed analysis, see the white paper: "Mobile WiMAX – Part II: A Comparative Analysis", available on the WiMAX Forum website: http://www.wimaxforum.org/technology/downloads/Mobile_WiMAX_Part2_Comparative_Analysis.pdf

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