

## **WI-MAX TECHNOLOGY ARE YOU READY FOR THE SPEED? ANOTHER MILE STONE IN THE FIELD OF INTERNET ACCESS**

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### **Abstract**

Information Technology has made significant stride in the way of acquiring, storing, retrieving, accessing and disseminating information. The advent of computer net works ushers a new path to the Library and gives a new dimension to the traditional job of library such as information retrieval and dissemination. The present paper is describes the over all access of information on computer network using wireless communication called Wi-Max technology. With Wi-Max any body can access internet connectivity any where without physical connection. This article highlights the salient features of Wi-Max technology. Bangalore is the fully wire less city within this year. Only the second city in the world to be fully Wi-Max enabled, after Taipei and compare to other technologies available such as OFC, Broadband, Wi-Fi etc. and also highlights common problems of adoption and absorption of such network technology in India.

**Keywords :** Internet connectivity/ Wi-Fi/ Wi-Max/ Broadband/ Computer networks/ OFC/ Wireless connectivity

### **1. Introduction**

Caught in traffic, late for work again? Well, come January end 2007, that'll hopefully be one less hurdle for workaholics in Tech City. For they'll have wireless broadband access, offering an ingenious, out-of-the box solution to those long commutes on potholed roads. Wi-Max technology will allow Bangaloreans to access work on the net, on the go. In economic parlance, this could mean productivity shooting up manifold. Now if all this productivity talk is a put-off, then how about the romance of downloading heavy movie files in a jiffy under a tree in Cubbon Park, or chatting, blogging and scrapping anytime, anyplace? This is what Wi-Max is expected to do to Bangalore's work-and play lives in a few months from now. Netzens already had a feel of this avant grade technology for eight days, when the annual Bangalore IT.in event was on last week. And they are crying encore. Since it was a trial run of the 'Unwired Bangalore' project, the service was available only in the vicinity of four public areas in the central administrative district- the Vidana Soudha, Vikasa Soudha, High Court and the Palace Grounds. While the Wi-Max experience was on, people quietly came with laptops and surfed the internet

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speeds of 256 kbps (when the system is fully up and running, the speed could even touch 2 mbps). The It department says it received “over 1,200 enthusiastic queries” from the general public when the “experiment” was on.

## 2. What is WiMAX?

WiMAX is defined as Worldwide Interoperability for Microwave Access by the WiMAX Forum, formed in June 2001 to promote conformance and interoperability of the IEEE 802.16 standard, officially known as WirelessMAN. The Forum describes WiMAX as “a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL”.

*“WiMAX is not a technology, but rather a certification mark, or ‘stamp of approval’ given to equipment that meets certain conformity and interoperability tests for the IEEE 802.16 family of standards. A similar confusion surrounds the term Wi-Fi, which like WiMAX, is a certification mark for equipment based on a different set of IEEE standards from the 802.11 working group for wireless local area networks (WLAN). Neither WiMAX, nor Wi-Fi is a technology but their names have been adopted in popular usage to denote the technologies behind them. This is likely due to the difficulty of using terms like ‘IEEE 802.16’ in common speech and writing.”*

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

- 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 (last km) broadband access.
- Providing high-speed mobile data and telecommunications services (4G).
- 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 they are unlikely to be affected by the same service outage.
- Providing Nomadic connectivity.

### 2.1 Broadband Access

Many companies are closely examining WiMAX for “last mile” connectivity at high data rates. This could result in lower pricing for both home and business customers as competition lowers prices.

In areas without pre-existing physical cable or telephone networks, WiMAX will, it appears, be a viable alternative for broadband access that has been economically unavailable. Prior to WiMax, many operators have been using proprietary fixed wireless technologies for broadband services.

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WiMAX subscriber units are available in both indoor and outdoor versions from several manufacturers. Self install indoor units are convenient, but the subscriber must be significantly closer to the WiMAX base station than with professionally installed units. As such, indoor installed units require a much higher infrastructure investment as well as operational cost (site lease, backhaul, maintenance) due to the high number of base stations required to cover a given area. Indoor units are comparable in size to a cable modem or DSL modem. Outdoor units allow for the subscriber to be much further away from the WiMAX base station, but usually require professional installation. Outdoor units are roughly the size of a textbook, and their installation is comparable to a residential satellite dish.

## **2.2 Limitations**

A commonly held misconception is that WiMAX will deliver 70 Mbit/s, over 70 miles (112.6 kilometers). Each of these is true individually, given ideal circumstances, but they are not simultaneously true. In practice this means that in Line of sight environments you could deliver symmetrical speeds of 10Mbps at 10Km but in Urban Environments it is more likely that 30% of installations may be Non Line of sight and therefore Users may only receive 10Mbps over 2Km. WiMAX has some similarities to DSL in this respect, where one can either have high bandwidth or long reach, but not both simultaneously. The other feature to consider with WiMAX is that available bandwidth is shared between users in a given radio sector, so if there are many active users in a single sector, each will get reduced bandwidth. However, unlike SDSL where contention is very noticeable at a 5:1 ratio if you are sharing your connection with a large media firm for example WiMax does not have this problem. Typically each cell has a 100Mbps backhaul so there is no contention here. On the radio side in practice many users will have a range of 2,4,6,8 or 10Mbps services and the bandwidth can be shared. If the network becomes busy the business model is more like GSM or UMTS than DSL in that it is easy to predict the capacity requirements as you sign more customers and additional radio cards can be added on the same sector to increase the capacity.

## **2.3 Mobile applications**

Some cellular companies are evaluating WiMAX as a means of increasing bandwidth for a variety of data-intensive applications; indeed, Sprint Nextel has announced in mid-2006 that it will be investing about US\$ 3 billion in a WiMAX technology buildout over the next few years.

In line with these possible applications is the technology's ability to serve as a high bandwidth "backhaul" for Internet or cellular phone traffic from remote areas back to an internet backbone. Although the cost-effectiveness of WiMAX in a remote application will be higher, it is not limited to such applications, and may be an answer to reducing the cost of T1/E1 backhaul as well. Given the limited wired infrastructure in some developing countries, the costs to install a WiMAX station in conjunction with an existing cellular tower or even as a solitary hub are likely to be small in comparison to developing

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a wired solution. Areas of low population density and flat terrain are particularly suited to WiMAX and its range. For countries that have skipped wired infrastructure as a result of inhibitive costs and unsympathetic geography, WiMAX can enhance wireless infrastructure in an inexpensive, decentralized, deployment-friendly and effective manner.

### **3. Technical info**

WiMAX is a term coined to describe standard, interoperable implementations of IEEE 802.16 wireless networks, in a rather similar way to Wi-Fi being interoperable implementations of the IEEE 802.11 Wireless LAN standard. However, WiMAX is very different from Wi-Fi in the way it works.

#### **3.1 MAC layer**

In Wi-Fi the media access controller (MAC) uses contention access — all subscriber stations that wish to pass data through a wireless access point (AP) are competing for the AP's attention on a random interrupt basis. This can cause subscriber stations distant from the AP to be repeatedly interrupted by closer stations, greatly reducing their throughput. This makes services such as Voice over IP (VoIP) or IPTV, which depend on an essentially constant Quality of Service (QoS) depending on data rate and interruptibility, difficult to maintain for more than a few simultaneous users.

In contrast, the 802.16 MAC uses a scheduling algorithm for which the subscriber station need compete once (for initial entry into the network). After that it is allocated an access slot by the base station. The time slot can enlarge and contract, but remains assigned to the subscriber station which means that other subscribers cannot use it. The 802.16 scheduling algorithm is stable under overload and over-subscription (unlike 802.11). It can also be more bandwidth efficient. The scheduling algorithm also allows the base station to control QoS parameters by balancing the time-slot assignments among the application needs of the subscriber stations.

#### **3.2 Physical layer**

The original WiMAX standard (IEEE 802.16) specified WiMAX for the 10 to 66 GHz range. 802.16a, updated in 2004 to 802.16-2004 (also known as 802.16d), added specification for the 2 to 11 GHz range. 802.16d (also known as “fixed WiMAX”) was updated to 802.16e in 2005 (known as “mobile WiMAX”). and uses scalable orthogonal frequency-division multiplexing (OFDM) as opposed to the OFDM version with 256 sub-carriers used in 802.16d. This brings potential benefits in terms of coverage, self installation, power consumption, frequency re-use and bandwidth efficiency. 802.16e also adds a capability for full mobility support. The WiMAX certification allows vendors with 802.16d products to sell their equipment as WiMAX certified, thus ensuring a level of interoperability with other certified products, as long as they fit the same profile.

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Most interest will probably be in the 802.16d and .16e standards, since the lower frequencies suffer less from inherent signal attenuation and therefore give improved range and in-building penetration. Already today, a number of networks throughout the World are in commercial operation using certified WiMAX equipment compliant with the 802.16d standard.

#### **4. Advantages over Wi-Fi**

- The WiMAX specification provides symmetrical bandwidth over many kilometers and range with stronger encryption (TDES or AES) and typically less interference. Wi-Fi is short range (app. 10's of metres) has WEP or WPP encryption and suffers from interference as in metropolitan areas where there are many users.
- Wi-Fi Hotspots are typically backhauled over ADSL in most coffee shops therefore Wi-Fi access is typically highly contended and has poor upload speeds between the router and the internet.
- It provides connectivity between network endpoints without the need for direct line of sight in favourable circumstances. The non-line-of-sight propagation (NLOS) performance requires the .16d or .16e revisions, since the lower frequencies are needed. It relies upon multi-path signals, somewhat in the manner of 802.11n.

#### **5. Spectrum Allocations issues**

The 802.16 specification applies across a wide swath of the RF spectrum. However, specification is not the same as permission to use. There is no uniform global licensed spectrum for WiMAX. In the US, the biggest segment available is around 2.5 GHz, and is already assigned, primarily to Sprint Nextel and Clearwire. Elsewhere in the world, the most likely bands used will be around 3.5 GHz, 2.3/2.5 GHz, or 5 GHz, with 2.3/2.5 GHz probably being most important in Asia. In addition, several companies have announced plans to utilize the WiMAX standard in the 1.7/2.1 GHz spectrum band recently auctioned by the FCC, for deployment of "Advanced Wireless Services" (AWS).

There is some prospect in the U. S. that some of a 700 MHz band might be made available for WiMAX use, but it is currently assigned to analog TV and awaits the complete rollout of digital TV before it can become available, likely by 2009. In any case, there will be other uses suggested for that spectrum if and when it actually becomes open.

It seems likely that there will be several variants of 802.16, depending on local regulatory conditions and thus on which spectrum is used, even if everything but the underlying radio frequencies is the same. WiMAX equipment will not, therefore, be as portable as it might have been - perhaps even less so than WiFi, whose assigned channels in unlicensed spectrum vary little from jurisdiction to jurisdiction.

The actual radio bandwidth of spectrum allocations is also likely to vary. Typical allocations are likely to provide channels of 5 MHz or 7 MHz. In principle the larger the bandwidth allocation of the spectrum, the higher the bandwidth that WiMAX can support for user traffic.

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## 6. Standards

The 802.16 standard IEEE Std 802.16e-2005, approved in December 2005 follows on from IEEE Std 802.16-2004, which replaced IEEE Standards 802.16-2001, 802.16c-2002, and 802.16a-2003.

IEEE Std 802.16-2004 (802.16d) addresses only fixed systems. 802.16e adds mobility components to the standard.

### 6.1 IEEE 802.16e

IEEE 802.16e-2005 (formerly named, but still best known as, 802.16e or Mobile WiMAX) provides an improvement on the modulation schemes stipulated in the original (fixed) WiMAX standard. It allows for fixed wireless and mobile Non Line of Sight (NLOS) applications primarily by enhancing the OFDMA (Orthogonal Frequency Division Multiple Access).

SOFDMA (Scalable OFDMA) improves upon OFDM256 for NLOS applications by

- Improving NLOS coverage by utilizing advanced antenna diversity schemes, and hybrid-Automatic Retransmission Request (hARQ)
- Increasing system gain by use of denser sub-channelization, thereby improving indoor penetration
- Introducing high-performance coding techniques such as Turbo Coding and Low-Density Parity Check (LDPC), enhancing security and NLOS performance
- Introducing downlink sub-channelization, allowing administrators to trade coverage for capacity or vice versa
- Improving coverage by introducing Adaptive Antenna Systems (AAS) and Multiple Input Multiple Output (MIMO) technology
- Eliminating channel bandwidth dependencies on sub-carrier spacing, allowing for equal performance under any RF channel spacing (1.25-14 MHz)
- Enhanced Fast Fourier transform (FFT) algorithm can tolerate larger delay spreads, increasing resistance to multipath interference

On the other hand, 802.16-2004 (fixed WiMAX) offers the benefit of available commercial products and implementations optimized for fixed access. Fixed WiMAX is a popular standard among alternative service providers and operators in developing areas due to its low cost of deployment and advanced performance in a fixed environment. Fixed WiMax is also seen as a potential standard for backhaul of wireless base stations such as cellular, WiFi or even mobile WiMAX.

SOFDMA and OFDMA256 are not compatible so most equipment will have to be replaced. However, some manufacturers are planning to provide a migration path for older equipment to SOFDMA compatibility which would ease the transition for those networks which have already made the OFDMA256 investment. This effects a relatively small number users and operators.

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## **6.2 HIPERMAN**

The equivalent of 802.16 in Europe is HIPERMAN. The WiMAX Forum is working to ensure that 802.16 and HIPERMAN inter-operate seamlessly.

## **6.3 WiBro**

Korea's electronics and telecommunication industry spearheaded by Samsung Electronics and ETRI has developed its own standard, WiBro. In late 2004, Intel and LG Electronics have agreed on interoperability between WiBro and WiMAX.

WiBro has South Korean government support with the requirement for each carrier to spend over US\$1 billion for deployments. The Koreans sought to develop WiBro as a regional and potentially international alternative to 3.5G or 4G cellular systems. But given the lack of momentum as a standard, WiBro has joined WiMAX and agreed to harmonize with the similar OFDMA 802.16e version of the standard. What makes WiBro roll-outs a good 'test case' for the overall WiMAX effort is that it is mobile, well thought out for delivery of wireless broadband services, and the fact that the deployment is taking place in a highly sophisticated, broadband-saturated market. WiBro will go up against 3G and very high bandwidth wire-line services rather than as gap-filler or rural under-served market deployments as is often exemplified as the 'best fit' markets for WiMAX.

## **7. Associations**

### **7.1 WiMAX Forum**

The WiMAX Forum is "the exclusive organization dedicated to certifying the interoperability of BWA products, the WiMAX Forum defines and conducts conformance and interoperability testing to ensure that different vendor systems work seamlessly with one another." Those that pass conformance and interoperability testing achieve the "WiMAX Forum Certified" designation and display this mark on their products and marketing materials. Vendors claiming their equipment is "WiMAX-ready", "WiMAX-compliant", or "pre-WiMAX" are not WiMAX Forum Certified, according to the Forum.

### **7.2 WiMAX Spectrum Owners Alliance - WiSOA**

WiSOA is the first global organisation composed exclusively of owners of WiMAX spectrum. WiSOA is focussed on the regulation, commercialisation, and deployment of WiMAX spectrum in the 2.3–2.5 GHz and the 3.4–3.5 GHz ranges. WiSOA are dedicated to educating and informing its members, industry representatives and government regulators of the importance of WiMAX spectrum, its use, and the potential for WiMAX to revolutionise broadband.

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## 8. Competing technologies

WiMAX is a framework for wireless development based on a forward-looking core set of technologies. More recently 3GPP cellular's 4G, 802.22 Cognitive Radio RAN (Rural Area Network), and 802.20, the High Speed Mobile Broadband Wireless Access (MBWA) Working Group, have shifted toward use of similar constructs of multi-channel scalable OFDM, HARQ, FEC, MIMO-AAS and other complementary technologies as are part of WiMAX.

Within the marketplace, WiMAX's main competition comes from widely deployed wireless systems with overlapping functionality such as UMTS and CDMA2000, as well as a number of Internet oriented systems such as HIPERMAN and WiBro.

### 8.1 Cellular Phone Systems 3G and 4G

Both of the two major 3G systems, CDMA2000 and UMTS, compete with WiMAX. Both offer DSL-class Internet access in addition to phone service. UMTS has also been enhanced to compete directly with WiMAX in the form of UMTS-TDD, which can use WiMAX oriented spectrum and provides a more consistent, if lower bandwidth at peak, user experience than WiMAX. Moving forward, similar air interface technologies to those used by WiMAX are being considered for the 4G evolution of UMTS.

3G cellular phone systems usually benefit from already having entrenched infrastructure, being upgrades from earlier systems. Users can usually fall back to older systems when they move out of range of upgraded equipment, often relatively seamlessly.

In addition to obvious competition, in some areas of the world the wide availability of UMTS and a general desire for standardization has meant spectrum has not been allocated for WiMAX: in July 2005, the EU-wide frequency allocation for WiMAX was blocked by France and Finland, where manufacturers have invested heavily in UMTS technology. In September 2006, frequency bidding in Malaysia was stopped and any allocation of WiMAX has been suspended indefinitely. The ITU has, however, advised agnostic use of spectrum for IMT-2000 and is considering WiMAX as an alternative specified use for IMT-2000 and IMT-Advanced. Growing interest among operators is building for 'technology agnostic' allocation of spectrum in which operators are free to make best use of their large investments and insure against regulated obsolescence.

### 8.2 Internet Oriented Systems

Early WMAN standards, the European standard HIPERMAN and Korean standard WiBro have been harmonized as part of WiMAX and are no longer seen as competition but as complimentary. All networks now being deployed in Korea, the home of the Wibro standard, are now WiMAX.

As a short-range mobile internet solution, such as in cafes and at transportation hubs like airports, the popular WiFi 802.11g system is widely deployed, and provides enough coverage for some users to feel subscription to a WiMAX service is unnecessary.

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## 9. Comparison

Comparison of Mobile Internet Access methods

Standard	Family	Primary Use	Radio Tech	Down link (Mbps)	Up link (Mbps)	Notes
802.16e	WiMAX	Mobile Internet	SOFDMA	70	70	Quoted speeds only achievable at short range more practically 10Mbps at 10Km.
HIPERMAN	HIPERMAN	Mobile Internet	OFDM	56.9	56.9	
WiBro	WiBro	Mobile Internet	OFDM	50	50	Short range (<5km)
UMTS W-CDMA HSDPA+HS UPA	UMTS/3 GSM	Mobile phone	CDMA/FDD	0.384 3.6	0.384 5.76	HSDPA downlink widely deployed. Roadmap shows HSDPA up to 28.8Mbps from the basestation . Users can expect down-loads of 400 to 600 Kbps but around 100Kbps up-link speeds.
UMTS-TDD	UMTS/3 GSM	Mobile Internet	CDMA/TDD	16	16	Reported speeds according to IPWireless
LTE UTMS	UMTS/4 GSM	General 4G	OFDM/ MIMO (HSOPA)	>100	>50	Still in development
1xRTT	CDMA 2000	Mobile phone	CDMA	0.144	0.144	Obsoleted by EV-DO
EV-DO 1x Rev. 0 Rev. A	CDMA 2000	Mobile phone	CDMA/FDD	2.45 3.1	0.15 1.8	Proposed Rev. B improves downlink to nearly5Mbps.

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In early 2007, when Wi-Max is introduced to Bangalore city-in the final plan it'll cover 696 km of the city and 470 km in the surrounding town and municipal regions- it will be only the second city in the world to be fully Wi-Max enabled, after Taipei. Even the original Silicon Valley in the US can't boast of this "Cities like Los Angeles or San Francisco or the Silicon Valley have it in bits and pieces but Bangalore will be fully enabled," Says IT secretary M.N. vidyashankar. Chennai, Pune, Delhi and Hyderabad are talking of Wi-Max, Mysore has it in a small region, but the kind of demonstration put up during the IT.in event was a first for India.

So what makes Wi-Max revolutionary? Well, until recently, we used a dial-up connection to access the internet. The connection was frail, the speed frustrating. Then came broadband, when we started drawing optical fiber cables (OFC) to our doorstep for an 'always on' connection, bigger bandwidth and higher speed. But these two had productivity issues. What use a laptop if you cannot access your network from wherever you are? Then there was Wi-Fi (wireless fidelity), but it was an indoor application restricted to hotspots like the airport, cafes, corporate offices or five-star hotels. The Wi-Fi operated within a small area of 50-100 meters in 2.4 GHz bandwidth, a frequency that did not require licenses to run. The next big leap-to surmount problems of confined access- was Wi-Max, acronym for Worldwide Interoperability for Microwave Access. Global standards for this technology, even as regards equipment, were set only as recently as 2005-06. Wi-Max assures nomadic access, its coverage are spoken in terms of kilometers, not metres. It is also an indoor/outdoor application and the bandwidth per user is very high.

Prof S. Sadagopan of IIT-B, who heads the state's Wi-Max technical advisory panel, gives the analogy of a mobile phone to drive home the point: "Wi-Max is to data communication as mobile telephony is to voice communication. It'll let users roam around multiple networks for miles, like we do with our mobile phones, without the connection dropping." There will also be 30-metre towers and base stations, similar to the ones for mobile phones, at strategic points in the city to transmit and receive signals. Vidyshankar adds: "Wi-Max on a laptop will have seamless access to the web, you can call it a mobile laptop."

Speaking of the social utility that the technology will make possible, Kalyan Raman, senior V-P of Microsene (a short listed firm for the Unwired Bangalore project), says: "As a revolutionary wireless technology, Wi-Max will make broadband access possible in rural and far-flung areas. This means an unprecedented level of access to e-governance, digital information and content services by rural and disadvantaged sections, schools and public access facilities. It'll empower individuals, institutions libraries, information centres and business like never before."

Given the fact that Internet penetration in India is very low, Wi-Max technology comes in handy because it saves the trouble of creating a physical broadband infrastructure by laying cables, a very expensive proposition at any rate. "India has a target of 40 million Net subscribers, 20 million of which should be broadband ones. This will happen only if nearly 30 per cent of broadband users are wireless-enabled. Otherwise the urban-rural digital divide will increase further," adds Kalyan.

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Expanding on Wi-Max's utility, Vidya Shankar says: "It'll increase productivity/efficiency at all levels by a minimum of 33 per cent plus from day one. Let me give a rudimentary example: say you get into the car at 8 am, you take one hour to reach office. The moment Wi-Max is up, your work begins when you get into the car. If I am now working 8 hours a day, it becomes 8 plus 2. The additional two hours itself give you 25 per cent flat increase in productivity."

Wi-Max will also bat for the common man in the health, education and infrastructure sectors. "Tele-medicine is a good example- with Wi-Max connectivity, it will become possible for a doctor to see the patient in rural area on his screen, literally diagnose across the table and prescribe medicine. Similarly, there can be virtual classrooms, shopfloors," Vidyshankar adds.

What would be the costs involved for an individual customer? It would depend on the size of the market but "very minimal". Say officials. The companies vying for the project are also demanding that the government be a big customer so that there is some revenue stability. Prof Sadgopan says: "Pricing will depend on a number of factors, but we expect it to be cheaper than wired broadband, about Rs 250 per month with the added advantage of wireless and a better speed." The hardware costs are different though. By December '06, notebook computers with built-in Wi-Max chips are expected to be in the market. Here again there would not be much cost variation because a Wi-Fi chip in 1999 cost US \$800. Now it's practically free in notebook motherboards.

Finally, what kind of culture will Wi-Max bring into the city? "we have to wait and see, but even five years back no one thought one could book train tickets through SMS, or auto and taxi drives would use the 'missed call' to communicate to effectively," says Prof Sadagopan. Vidyashankar adds: "With Wi-Max around, I visualize the laptop clientele percolating down to college students and high school kids. That will be the level of attraction." All in all as Kalyan puts it, "the possibilities for fruitful innovation are endless."

After Korea and China, India is emerging as the Asian country having the highest number of broadband users. This, coupled with the fact that the Indian market is utilizing merely one per cent of the available bandwidth, is great news for the service providers and consumers alike.

The world 'broadband' is a contraction of 'Broad band width'- commonly defined as a way of providing high-speed internet access at a minimum speed of 512 Mbps. Broadband can be accessed via the phone line (known as 'asymmetric digital subscriber line') or by cable, wireless or satellite.

Since it has the capability to use a single medium that can carry several channels simultaneously and at indefinitely high speeds, users can stay online 24x7, enjoying all the magic the internet offers, at a minimal cost. The other obvious advantages include easy download of heavier bytes, continuous access to WebPages and no fear of being logged out. The major technologies in use today may be divided into wireless and wired technologies. In the wired applications are:

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## 10. Wireline delivery

Wireline includes telephone network copper pairs and the coaxial cable used by cable operators. The cost of wireline technologies is significantly affected by the labour and access to a right-of-way. The technologies in the wired application segment follow:

Hybrid fiber coaxes (HFC). HFC is the current generation of cable system technology. It is deployed to provide some mix of television, data and voice services. HFC systems carry analogue signals as well as digital signals encoded onto analogue signals carrying digital video programming and upstream and downstream data. The system is divided into a number of small coaxial segments with a fiber-optic cable used to feed each segment, thereby improving the performance and reliability of the system significantly.

The ability of the present generation of technology to offer video, voice and high-speed data services has attracted new incumbents in the broadband space. With increasing volumes, a single standard (DOCSIS) and single-chip solutions, the cost of cable modems has reduce further as demand increases.

Digital subscriber line (DSL). The main advantage of this technology is minimal disruption due to usage of twisted-pair phone cable and even though it uses existing phone cables, the telephone can still be used.

DSL uses an advanced coding scheme enabling the transmission of packet-switched traffic over the twisted copper pair at much higher speed than a dial-up Internet access service can offer. To make the coding scheme used by DSL compatible with existing switches, new electronics known as DSL access multiplexer (DSLAM) has to be installed in any central office where DSL is to be offered. The DSLAM is, in turn, connected to a switched data network that ultimately connects the central office to the Internet.

DSL can operate at megabits per second depending on the quality and length of particular cable. The present generation of DSL products can reach 1.5 to 8 Mbps downstream and 150 to 600 kbps upstream and 150 to 600 kbps upstream. G lie, a related technology that permits customer self installation on the same line as used for analogue voice service, supports up to 1.5 Mbps downstream.

The actual speed obtainable over a DSL link depends upon line length, noise as well as the maximum speed supported by the particular service provider. Higher-speed versions of DSL, known as 'very-high-data-rate DSL' (VDSL), shorten the copper loop length to enable tens of megabits per second in both directions.

DSL currently comes in two forms:

1. Asymmetrical DSL (ASDL), which is most widely used in India. Due to its high 'downstream' (data flowing from the service provider to the user) bandwidth, it is good for most of the popular applications, like Web browsing video streaming and FTP downloads. ADSL currently supports a maximum of 8 Mbps down

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## 11. Conclusion:

WiMax is perfectly positioned to solve the last-mile problem in developing countries which telcos and cellular providers are facing—the inability to quickly provide service in areas that are hard for wired infrastructure to reach.

In India, where the telecom infrastructure is poor and last-mile connections are typically through copper cable, DSL and fibre optic, installation costs are high as it requires ripping up streets to lay cables. The ability to provide these connections wirelessly, without laying wire or cable in the ground, greatly lowers the cost of providing these services. This is why WiMax is an attractive alternative for providing last-mile connection in wireless metropolitan area networks, especially in cellular back hauls. In developing countries that lack a well-developed wired infrastructure, 802.16 offers a practical way to extend broadband Internet service to many different parts of the country. WiMax could thus bring broadband access into the Libraries, Information centres, homes and businesses of millions of people in rural and developing markets.

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