Mobile WiMAX:
The Best Personal Broadband Experience!

June 2006

Executive Summary

Personal broadband is emerging as one of the hottest areas of growth within mobile data. It enables users to enjoy the same user experience they have at home or in the office wherever they go. WiMAX is an innovative technology that will make personal broadband services profitable to service providers and widely available to business and consumer subscribers at affordable prices. The first mobile WiMAX products are expected to be introduced into the market at the end of 2006 or in the first quarter of 2007 and will be followed in the second half of the year by equipment with multiple advanced antenna capabilities—MIMO and beamforming—for higher throughput and capacity.

The WiMAX Forum believes that mobile WiMAX services complement existing and future broadband technologies, both wired and wireless, to best assure the coverage and capacity requirements to meet consumer demand. Clearly any technology that is complementary can also be competitive and it is up to service providers to decide how to best take advantage of WiMAX and how to ensure that their operation remains profitable for the long term.

Among the broad mix of service providers trialing or committed to deploy mobile WiMAX are wireline incumbents, 3G and 2G mobile operators, DSL and cable modem operators, CLECs, WISPs, greenfield operators and MVNOs. Their WiMAX strategies are varied, but they all depend on key WiMAX strengths:

- **Superior performance,** made possible by the adoption of OFDMA multiplexing, which gives WiMAX a performance edge in delivering IP data services compared to 3G technologies.
- **Flexibility,** which allows service providers to support multiple usage models, including fixed and mobile access, over the same WiMAX infrastructure and to operate their networks in multiple spectrum bands.
- **Advanced IP-based architecture,** which includes IMS support to facilitate a rapid, low cost, rollout of new applications and of interworking with 3G and other technologies.
- **Attractive economics,** driven by a standards-based approach, cost-effective infrastructure, mass adoption of low-cost subscriber units, and attractive IPR royalties.

WiMAX modules will be embedded into many data, CE and voice devices, including notebooks, PDAs, Ultra Mobile PCs, games consoles, MP3 players**,** cellular phones and smartphones, as well as devices for vertical application, like CCTV cameras and in-vehicle subscriber stations. WiMAX support for QoS and low latency will translate into

improved support for real-time, low-latency applications like VoIP, video gaming, streaming and video conferencing, all of which are designed to further accelerate the adoption of personal broadband.

WiMAX is a high-capacity IP-based technology based on open standards that can be deployed as a new network installation or as an overlay to complement existing 2G and 3G wireless technologies thus lowering the capex. In either case WiMAX networks will be capable of interworking with cellular and wired networks. High speed Internet access and services and applications supported by WiMAX can deliver higher revenues per user, new subscribers, lower churn, and additional revenues from wholesale and new service partners.

Mobile WiMAX:
The Best Personal Broadband Experience?

Introduction: The market for personal broadband

Mobile Internet[1] has emerged as the latest mobile services and is one of the fastest growing segments in the global telecommunications market. Subscribers value the freedom, immediacy, ease-of-use and power of mobile communications it brings and this will drive explosive growth over the next decade, but the market is still taking its first steps. Service availability is limited today, few subscribers have a true broadband experience with throughput above 1 Mbps, and the cost of service is still too high. However, the increasing penetration of notebooks, PDAs and other portable, data-centric devices is creating a strong propensity for the adoption of mobile Internet services. Mobile data revenues are growing quickly, and in many developed countries, they now account for 20% to 30% of operator revenues, whereas voice revenues are stagnant or falling (Figure 1).

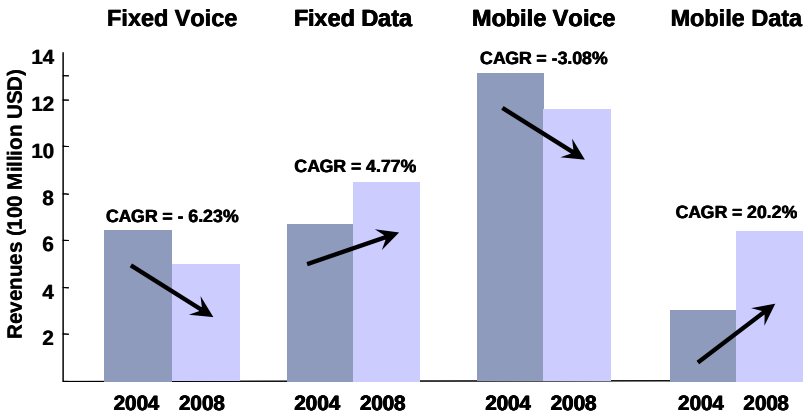

Figure 1. Voice and data revenues in Korea. Source: KISDI, 2004

Most of the growth in mobile data will be driven by personal broadband, which goes beyond basic cellular data services and replicates the functionality of wired broadband in

[1] In this paper, the term mobile Internet refers to fixed, portable and mobile usage scenarios. In mobile scenarios, the subscriber accesses the network while moving: walking, or sitting in a car or a train. In portable scenarios, the subscriber is mainly stationary: sitting at a desk or a coffee shop, waiting in an airport or train station.

a mobile environment. The applications and services now available at home and in the office will become available everywhere. Ubiquitous broadband access will encourage work productivity, personal communications and entertainment on the go. New services and applications that are specifically suited to mobile usage scenarios will also appear: mobile office, on-board entertainment, mobile search, fleet management, surveillance and public safety will be the first to be adopted and more will follow. As with the transition of voice communications from fixed lines to mobile phones, the broadband connection will cease to be tied to a particular location and will become a personal service.

Second and third generation cellular infrastructure is optimized to carry circuit switched voice traffic and is not designed to cope with the growing amount of traffic generated by high-speed and real-time applications until the rollout of Long Term Evolution (LTE) which is expected in 2010. To meet the demand for wireless broadband, mobile operators and other service providers have to explore new technologies when planning for next-generation networks. They want to roll out these services now.

Mobile WiMAX is the technology that best meets the demand for personal broadband services. It is based on a next-generation all-IP core network, that offers low latency, advanced security, QoS (Quality of Service), and worldwide roaming capabilities. Service providers also benefit from the low costs that a technology based on open standards, vendor interoperability, and favorable Intellectual Property Rights (IPR) allows.

WiMAX will coexist and interwork with existing and emerging technologies, both wired and wireless. Even though it can support Voice over IP (VoIP), WiMAX will not replace or compete with 2G or 3G technologies for voice services. Cellular networks provide the extensive coverage that circuit-switched voice services require and that the WiMAX infrastructure is not designed to support. Third generation networks cover many urban and suburban areas, but they will not be able to offer sufficient capacity or throughput (Figure 2) for data applications. Similarly, WiMAX and Wi-Fi are complementary and are expected to be incorporated in dual-mode chipsets in mobile devices, as WiMAX provides wider coverage, while Wi-Fi is better suited for high-throughput, indoor LAN applications. WiMAX also addresses the requirements of those subscribers that want to be able to use their broadband connection regardless of location, a functionality that DSL and cable modem services do not support. The WiMAX Forum has taken a proactive role in ensuring that WiMAX will be capable of interworking with these technologies and in supporting emerging architectures like IP Multimedia Subsystem (IMS) that enable operators to make the same applications and services available across multiple wired and wireless interfaces.

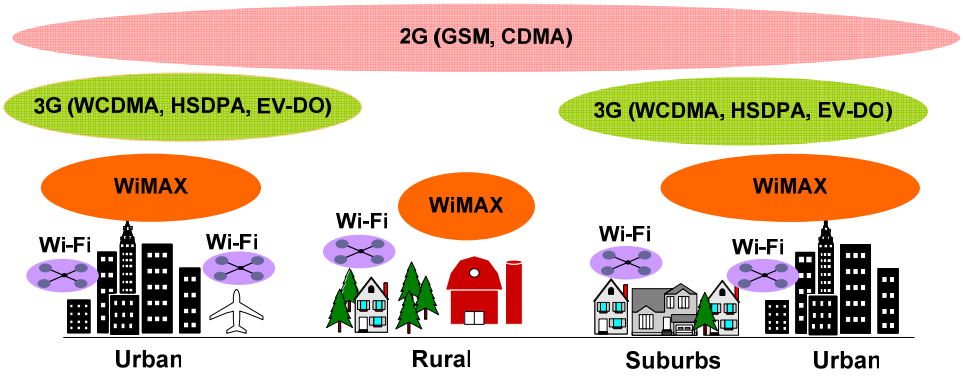

Figure 2. Wi-Fi, WiMAX, 3G and 2G coverage. Source: WiMAX Forum

There is a strong case for mobile and fixed carriers, greenfield operators, Mobile Virtual Network Operators (MVNOs) and other service providers to adopt mobile WiMAX to meet subscriber demand for personal broadband. It offers a compelling business opportunity that many service providers worldwide are carefully assessing or have already embraced. Service providers that are committed to providing the best possible service to their subscribers cannot afford to leave WiMAX out of their roadmap to fourth-generation networks.

The evolution towards mobility in WiMAX

Products compliant with the first fixed WiMAX certification profiles were released in January 2006, but WiMAX achievements started well ahead of product availability. WiMAX has spurred broadband wireless access and mobile infrastructure vendors to work towards a single technology based on open standards and interoperability. The WiMAX Forum, the industry association that defines WiMAX specifications and manages the WiMAX Certified™ program, has attracted 371 members representing the entire value chain, from component and silicon vendors (69 members), to system vendors (76), service providers (138) and other ecosystem players (88). WiMAX has elicited great interest from service providers, reflected in the more than 150 carrier trials under way as of the beginning of 2006.

Mobile WiMAX is based on IEEE 802.16e-2005 and will initially operate in the 2.3 GHz, 2.5 GHz, 3.3 GHz, 3.4-3.8 GHz spectrum bands. Support for additional bands will be added on the basis of market demand and new spectrum allocations. The WiMAX Forum plans to start the certification of mobile WiMAX equipment in the second half of 2006, with the first certified products expected for the end of 2006 or the first quarter of 2007. All mobile WiMAX products will support handoffs and power-saving mechanisms. More advanced mobile functionality will gradually be added through support for high-speed handoffs, roaming and multiple antenna technologies such as MIMO and beamforming and be available in equipment in the second half of 2007.

The appeal of mobile WiMAX goes well beyond mobility: it offers a true broadband connection that supports multiple usage scenarios, including fixed, portable and mobile access, using the same network infrastructure. This provides an unprecedented degree of flexibility in the range of applications supported and allows WiMAX to move beyond the fixed-versus-mobile dichotomy to offer cost-effective personal broadband services. Initial mobile WiMAX equipment will include notebook-based subscriber units (mini PCMCIA cards, PCI Express, PCI Express mini, USB modules, etc.) and desktop units. The introduction of mobile devices with embedded WiMAX Systems-On-Chips (SOCs), such as notebooks, the Ultra Mobile PC (UMPC), PDAs, phones, smartphones and other wireless devices are expected to follow in 2008.

Why choose mobile WiMAX?

Drivers for adoption vary among service providers, but there are a few crucial factors that give WiMAX an edge over other wired and wireless technologies. These drivers are key to ensuring the mass adoption of end-user devices and widespread infrastructure deployments.

1. Superior performance
WiMAX meets all the requirements for mobile Internet access. It supports multiple handoff mechanisms, ranging from hard handoffs (with break-before-make links) to soft handoffs (with make-before-break links), power-saving mechanisms for mobile devices, advanced QoS and low latency for improved support of real-time applications, and advanced Authorization, Authentication, and Accounting (AAA) functionality.

The advanced performance of mobile WiMAX is largely tied to its use of Orthogonal Frequency Division Multiple Access (OFDMA), a multiplexing technique well suited to multipath environments that gives network operators higher throughput and capacity, great flexibility in managing spectrum resources, and improved indoor coverage (Figure 3).

OFDMA has clearly emerged as the technology of choice for next-generation mobile networks. The Third Generation Partnership Project (3GPP) has incorporated OFDMA in its LTE specification and the Third Generation Partnership Project Two (3GPP2) is moving in the same direction (Figure 4). WiMAX has a two-to-three year time advantage over LTE, which is still in the early stages of development. Furthermore, LTE is expected to use OFDMA only in the downlink, with single-carrier FDMA employed in the uplink. This will impact the uplink throughput from mobile devices and result in lower spectrum efficiency in comparison to WiMAX. The WiMAX Forum is keen to cooperate by interworking with 3GPP and 3GPP2 to provide the maximum value to operators allowing them to reach as many customers as possible.

WiMAX performance is further enhanced by the use of Time Division Duplex (TDD), but it can also support Frequency Division Duplex (FDD) which dominates in 3G networks. Whereas FDD keeps the uplink and the downlink channels separate in frequency, TDD is a less complex, more efficient mechanism that uses a single frequency channel, with uplink and downlink traffic separated by a guard time. In addition, for IP-based services the use of a single channel for the uplink and the downlink makes it substantially less complex and more cost-effective to implement MIMO and beamforming in WiMAX networks than in CDMA-based networks. MIMO and beamforming are expected to bring a substantial improvement in throughput in TDD-based WiMAX networks.

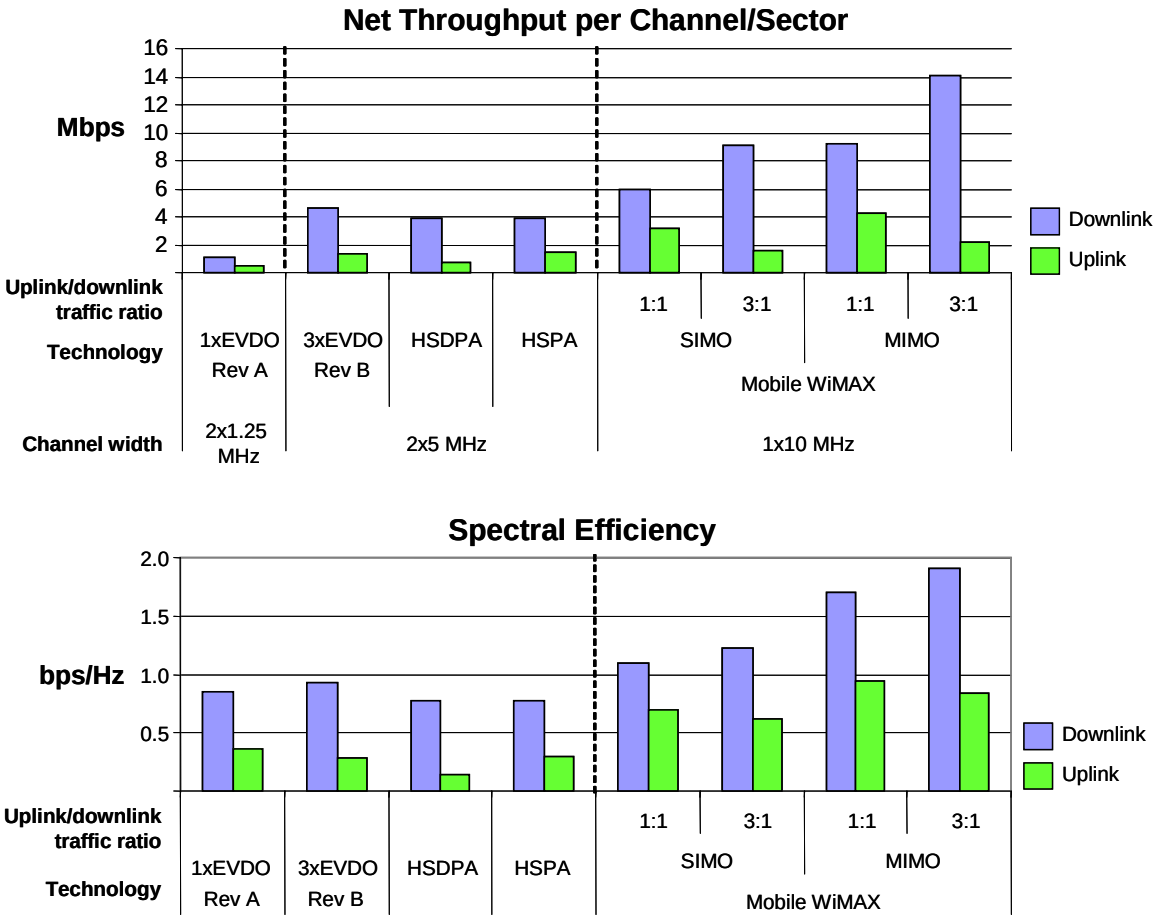

Figure 3. Performance comparison between WiMAX and 3G technologies. Note: 1xEV-DO uses one 1.25 MHz channel for the uplink and one for the downlink, 3xEV-DO uses three 1.25 MHz channels for the uplink and three for the downlink. Source: WiMAX Forum [5]. Single Input, Multiple Output (SIMO) refers to the use of multiple (in this case two) receiver chains at the mobile unit. No results for beamforming are shown as they are dependent on the base station implementation and the results can vary with the deployment scenarios.

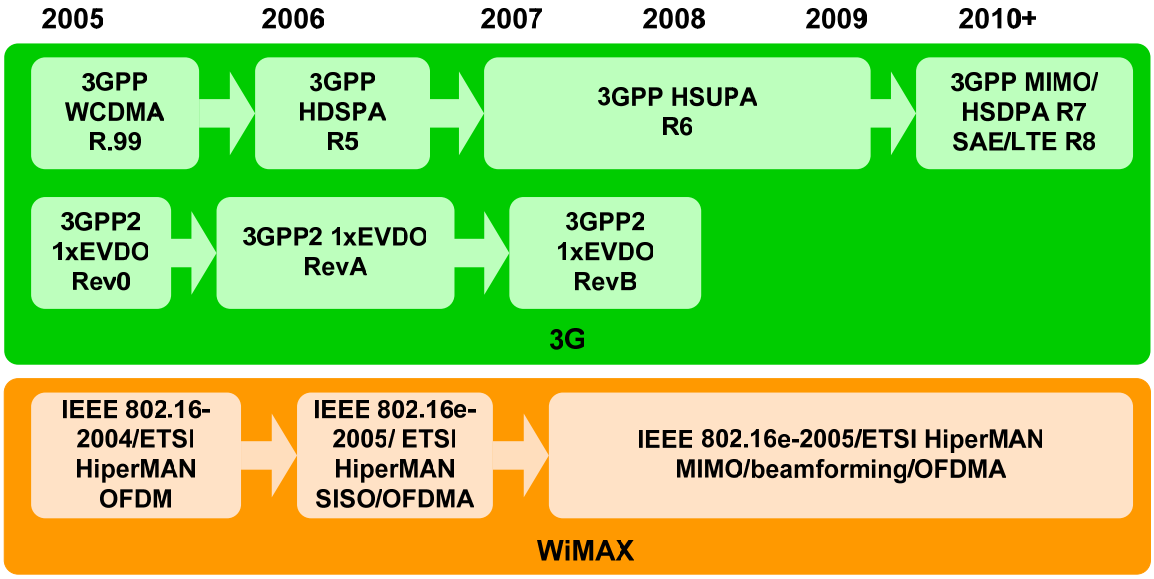

Figure 4. Evolution of 3G and WiMAX. Source: WiMAX Forum

2. Flexibility

WiMAX was designed from the ground up to be an all-IP technology that is optimized for high-throughput, real-time data applications and that is not beholden to a legacy infrastructure. WiMAX can be deployed both in greenfield deployments, where network operators rely exclusively on WiMAX for the edge infrastructure, and in overlay or complementary networks, where operators embed WiMAX within their networks to increase capacity and throughput as necessary to deliver true wireless broadband service.

Cellular networks based on GSM, CDMA, WCDMA and EV-DO use spectrum resources that are limited and typically too expensive for cost effective high capacity and high-throughput broadband services. Mobile WiMAX broadband networks will offer service providers a profitable model to deploy multiple value-added services that bring in additional revenues streams. The additional cost of bundling new mobile services with existing ones is low, as the operators already have an established relationship with the subscriber and can leverage their existing marketing, branding and customer service operations to support the new services.

Global roaming among WiMAX service providers will allow subscribers to access different networks using the same device and a single, familiar interface. Global roaming will become an essential feature of the mobile service offering that will increase the attractiveness to the subscribers and generate additional revenues. If they offer access through their partners using roaming agreements similar to those in place for cellular

networks, service providers will be able to get the desired footprint in their market without having to build an extensive infrastructure. The WiMAX Forum is working towards a framework that will encourage the establishment of global roaming relationships among service providers.

Spectrum is a limited resource and network operators that want to deploy WiMAX typically do not have a choice when deciding which frequency band to use. Mobile WiMAX can be deployed in several licensed bands (2.3 GHz, 2.5 GHz, 3.3 GHz, 3.4-3.8 GHz) with channel sizes ranging from 3.5 MHz to 10 MHz. This gives operators the flexibility to use WiMAX in multiple spectrum bands and with the amount of spectrum they have. WiMAX Forum Certified equipment will be approved in additional spectrum bands in response to the needs of operators worldwide.

The WiMAX Forum recognizes the importance of spectrum availability to network operators and is taking a proactive role in promoting an increased availability of spectrum for WiMAX deployments. It is a member of the ITU and it is working with the International Mobile Telecommunications (IMT) community to develop the definition for the forthcoming IMT-Advanced technologies. At the same time, the Forum is actively engaged with telecom regulators in many countries to ensure that the most suitable and flexible regulatory environment exists for WiMAX deployment in the frequency bands of interest. Regulators worldwide have shown a keen interest in developing novel regulatory approaches that promote WiMAX adoption as they feel the technology will be a driver towards higher Internet penetration and help position their countries at the forefront of innovation. For example, Japan has recently approved WiMAX technology in the 2.5 GHz spectrum to complement UMTS in other spectrum bands.

3. Advanced IP-based architecture

WiMAX is a next-generation technology that will facilitate the cellular operators' transition to all-IP networks. Cellular networks are also moving towards an IP core with the LTE and System Architecture Evolution (SAE) efforts, but this activity is in its early stages with service expected to be rolled out in 2010.

WiMAX fully supports IMS[2] and its 3GPP2 counterpart, MultiMedia Domain (MMD), emerging architectures that will enable service providers to introduce a wide range of rich voice and data applications rapidly and at a low marginal cost (Figure 5). With IMS and MMD, service providers can develop applications independently of the access technology within a flexible layered architecture in which application modules can be easily modified or reused.

2. WiMAX does not require IMS for its operations. Network operators that do not need IMS functionality can still take advantage of the core capabilities of WiMAX.

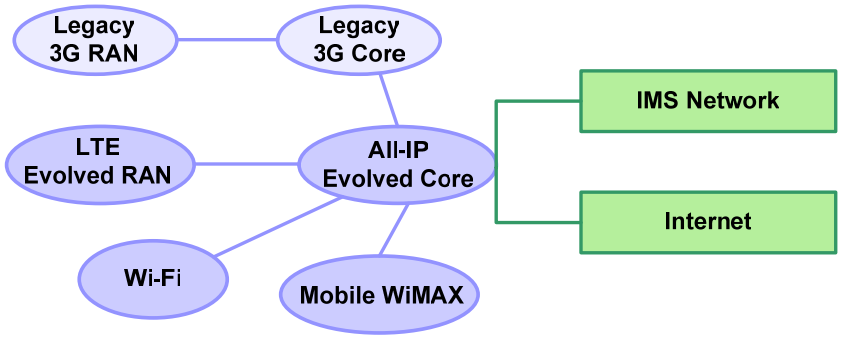

Figure 5. Role of IMS in a network with 3G, Wi-Fi and WiMAX. Source: WiMAX Forum

The IP core network at the basis of WiMAX will simplify interworking with other IP technologies. Support for IMS and MMD will further facilitate interworking and remove existing redundancies in the core network. At the beginning, however, WiMAX will have to be seamlessly integrated with existing cellular networks, which still lack an IP core. To foster integration with other technologies, the WiMAX Forum has established the Networking Working Group which closely collaborates with service providers, the IEEE, ETSI, 3GPP and 3GPP2, to assure a unified network architecture that facilitates interworking, roaming and infrastructure sharing with current and emerging cellular and wired technologies.

4. Attractive economics

WiMAX meets the growing mass-market demand for cost-effective, high-throughput broadband wireless services. The business case for WiMAX is attractive as the cost of the equipment is kept low by a combination of interoperable components based on open standards, mass adoption of subscriber units, an attractive IPR structure, and a high base station capacity. In turn, its contained infrastructure costs and efficient spectrum utilization allow service providers to address demand from the mass market, by offering personal broadband services at a price point that both business and consumer users will find attractive.

Mobile WiMAX equipment is based on IEEE 802.16e-2005 and ETSI HiperMAN 1.3.2, and is certified by the WiMAX Forum to be interoperable with other equipment in the same spectrum band. Interoperability brings more choices to network operators and increases competition among vendors. Network operators are not dependent on a single vendor to provide both base stations and subscriber units, or to decide the pace and availability of upgrades.

The cost of open-standards equipment tends to decrease rapidly with the increase in volume and the market entry of high-volume, low-cost, vendors. The integration of Wi-Fi and WiMAX in a single chipset and the commitment by device manufacturers to incorporate a WiMAX interface into their new products are expected to contribute to an

even deeper cost reduction for subscriber units. The availability of low-cost subscriber units will further encourage adoption from subscribers, and in turn the presence of a large installed base will make deployment of the infrastructure more attractive to network operators. Wide scale deployments of WiMAX and Wi-Fi in notebook computers are expected for 2008.

An attractive IPR structure is another advantage of WiMAX compared to 3G technologies. Royalties paid by manufacturers on WCDMA phones are an average of 10% to 15% of the Average Selling Price (ASP) of a handset, compared to a telecommunication industry norm of 2% to 5% [1][2]. A less onerous IPR model will lead to a substantial reduction in equipment prices and fair treatment of vendors without essential IPR, which in turn will increase competition in the market and the attractiveness of WiMAX to network operators. The WiMAX Forum is currently exploring, and will endorse, solutions to provide a fair and reasonable rate and framework that will benefit both IPR holders and other vendors.

On the network side, open standards, interoperability and lower IPR royalties are responsible for only a part of the cost savings. While the cost of installing each base station and the density of base stations are similar for 3G and WiMAX, the capacity that a WiMAX base station provides is substantially higher both because of the use of OFDMA in wider channels, and advanced antenna technologies like MIMO and beamforming.

The basis of WiMAX success: new devices and applications

WiMAX will promote the adoption of new devices and applications that take advantage of its high-throughput, low latency and QoS functionality and the support for mobile access. Among the mobile devices expected to have a WiMAX interface are:

- **Data centric devices**: notebooks, PDAs, Ultra Mobile PCs
- **CE devices**: games consoles, MP3 players
- **Voice and voice/data devices**: cellular phones, smartphones
- **Vertical applications devices**: CCTV cameras, in-vehicle devices.

Furthermore, WiMAX will encourage manufacturers to explore new form factors that current cellular technologies cannot support because of the capacity limitations or because of the cost of traffic transport.

WiMAX will complement other wired and wireless interfaces. Most notebooks, PDAs and handsets will include an integrated Wi-Fi and WiMAX chipset and allow subscribers to connect to the best available network. Subscribers will no longer face a trade-off

between coverage and throughput: with a dual-mode WiMAX and cellular device, for instance, they will be able to connect to the WiMAX network in urban areas, to the 3G network in suburban areas and still retain basic connectivity through 2G GSM or CDMA networks when in rural areas.

When it comes to applications, WiMAX means freedom to both subscribers and service providers. Service providers are not forced to develop special applications for WiMAX, because those already existing will work in a WiMAX network just as they do on the wired one, without any modification. However WiMAX will encourage the early emergence of mobile applications that address the specific needs of mobile Internet users. Furthermore, WiMAX support for IMS will facilitate the ubiquitous deployment of managed services for subscribers across wired and wireless platforms.

VoIP is expected to be one of the most popular WiMAX applications. Its value proposition is immediate to most users: with a data connection plan, VoIP calls can be received or placed at a very low or, in some cases, no additional cost. While WiMAX is not designed for switched cellular voice traffic as cellular technologies like CDMA and WCDMA are, it will provide full support for VoIP traffic thanks to QoS functionality and low latency. WiMAX will not challenge the voice revenues of mobile operators, as cellular networks offer a cost-effective infrastructure for voice communications with an extensive coverage that WiMAX is not designed to replace. However a mobile operator may move some voice traffic to the WiMAX infrastructure due to capacity constraints.

Other real-time applications like mobile video and audio streaming, videoconferencing and gaming, will greatly benefit from QoS and low latency. They will become increasingly important as new devices optimized for these applications are introduced. Broadcast is another potential WiMAX application. Work is currently under way within the WiMAX Forum to further develop the Multicast and Broadcast Services (MBS) protocols within the standard to allow efficient multicasting of content.

Vertical applications like surveillance, public safety, connectivity to remote devices, inventory tracking, fleet management and educational services can also be supported by mobile WiMAX networks with little or no incremental cost to network operators. These applications require robust and reliable connectivity, but in most cases it would be prohibitively expensive to build separate networks to support them. A WiMAX operator is well placed to support these applications and to secure new revenue streams either by providing the service to new market segments, or by establishing wholesale relationships with service providers that focus on specific verticals.

Figure 6. Global carriers that have announced WiMAX trials. Source WiMAX Forum

Who will deploy mobile WiMAX?

The WiMAX Forum has seen a strong interest in WiMAX from a broad range of service providers, the largest group among Forum members (Figure 6). Their business models are varied, but many of their goals are common:

- Minimize traffic costs to deliver mobile data services.
- Improve efficiency of spectrum utilization.
- Offer new high-bandwidth, low-latency services to mobile users, over an IP-based network, that support real-time applications like VoIP, content streaming and gaming.
- Choose a technology that delivers a positive Return on Investment (ROI).

Some of the most common approaches to WiMAX are listed below:

- **Fixed and mobile operators** (e.g. KT in Korea and Telecom Italia in Italy) see a great opportunity in mass-market personal broadband services based on new data-centric, mobile devices. KT in Korea has already started to deploy WiBro services,

based on mobile WiMAX, that are designed to complement its MVNO and fixed broadband services. Alberto Ciarniello, VP of Technology Innovation at Telecom Italia, explains that "Telecom Italia's preferred option for mobile WiMAX is its inclusion within 3GPP as an IP technology for LTE. Mobile WiMAX is a very interesting technology for our convergent broadband development roadmap." Telecom Italia ran a WiMAX trial during the Olympics in Turin to showcase innovative and entertainment "triple play" service concepts.

- **3G mobile operators** (e.g. KDDI in Japan, Telecom Italia in Italy) are evaluating WiMAX as an overlay to their 3G networks, with plans to deploy it when additional capacity is needed. KDDI plans to roll out mobile WiMAX as an overlay to EV-DO and has already successfully demonstrated handovers between the two technologies. Tadashi Shinohara, Senior Manager at KDDI, sees mobile WiMAX "as the first step towards an IP-core supporting MMD," and identifies VoIP, downloads and streaming of music and video as key applications that WiMAX will support in a cost-effective way. As an added bonus, the range of WiMAX base stations is comparable to that of 3G base stations operating in nearby spectrum bands, thus making an overlay network particularly attractive, as the existing cellular infrastructure can be extensively reused.
- **2G mobile operators** that do not operate a 3G network typically plan to deploy a new technology that supports mobile Internet. For them, WiMAX is one of the best choices (as in the case of Yozan in Japan) and, free of a 3G legacy, they will have the opportunity to leap ahead of 3G operators and head directly towards a next-generation technology that is cheaper to deploy, affords a better performance, and smoothes the transition to an IP-core network and to fourth-generation networks.
- **Wireline DSL and cable modem operators** (e.g. Comcast in the US, France Telecom in France, Omnivision in Venezuela, TVA Sistema de Televisao, Brazil) have control over the fixed infrastructure and may want to deploy fixed WiMAX in areas of limited coverage, with a view to deploying mobile WiMAX later as a complement to their fixed broadband services. In some cases, they may elect to focus exclusively on mobile WiMAX. WiMAX operators can bundle personal broadband as an extension of the current services that allows subscribers to take the service with them wherever they go. In this case, WiMAX enables these operators to differentiate their products from wired competitors and to gain additional revenues without the cost and effort of becoming a fully-fledged mobile operator.
- **CLECs (Competitive Local Exchange Carrier), ISPs (Internet Service Providers) and WISPs (Wireless ISPs)** (e.g. Covad in the US, Ertach in Argentina, Iberbanda in Spain, Irish Broadband in Ireland, Pipex in the UK) plan to deploy WiMAX in the near future to capitalize on unmet demand for broadband connectivity in underserved areas without having to rely on the incumbent's DSL infrastructure. Once the infrastructure is in place, the transition to mobility will be attractive as it will enable them to extend their product range or offer wholesale access to their

network to MVNOs. Dual-mode equipment will also enable operators to gradually transition from fixed to mobile WiMAX and extend the range of services they offer to include portable and mobile access.

- **MVNOs** may want to offer personal broadband services, but they have no interest in building their own WiMAX networks. Instead they will look to enter wholesale deals with multiple WiMAX operators to obtain a large footprint, which may extend beyond their country. MVNOs may include cellular MVNOs (e.g. Virgin in the UK and in the US, Helio in the US), content providers (e.g. ESPN, Disney in the US), and satellite operators (e.g. DirectTV, Echostar in the US). Among the wide range of companies interested in becoming an MVNO, the key common asset is an existing, strong relationship with subscribers, which the MVNO hopes to extend to new services.
- **Greenfield operators** (e.g. operators participating in the M-Taiwan project, WiMAX Telecom in Austria, Slovakia and Croatia) have started to emerge as new licenses are awarded for broadband wireless access and new operators have stepped forward either to start with fixed services and move to mobility later, or to target mobile users from the start. In some cases they may want to market personal broadband directly to subscribers, in others they may elect to create a wholesale platform to sell to MVNOs. M-Taiwan, for instance, includes several network operators that plan to cover 8 million people and to offer seamless roaming capabilities to their subscribers from the beginning. The network will support public access, as well as multiple government, safety and educational services.

Conclusions: WiMAX in the mobile wireless ecosystem

Is there room for yet another wireless data technology in the market? In the Wireless Metropolitan Area Network (WMAN), WiMAX is an excellent complement to other wireless technologies that are designed to work in the LAN (Wi-Fi) or that offer wider coverage but with more limited capacity (GSM, CDMA, WCDMA, EV-DO). The increasing demand for wireless services and the more exacting requirements of emerging applications have created a market in which multiple wireless technologies, each with its own core advantages, can and need to coexist to meet subscriber expectations. The key challenge for service providers is to understand what role is best for each technology, how different technologies complement each other and how they meet their requirements in a cost-effective way.

As they develop a strategy to add personal broadband to the services they offer, network operators will find the advantages that WiMAX brings in performance, cost, flexibility and innovation crucial in maintaining a leading position in their markets. When compared to other wireless technologies, WiMAX offers superior performance, a more flexible network architecture that encourages interworking and roaming, and cost-effective,

interoperable equipment. This allows WiMAX to support any bandwidth-intensive, real-time application on any device, using a common user interface.

WiMAX operators will be the first to offer personal broadband value-added services to their subscribers. Personal broadband makes accessible anywhere any data and voice application that subscribers are accustomed to using from home or the office, plus additional ones designed for mobile users. With WiMAX, network operators will be able to capitalize on the explosive demand for personal broadband among business and consumer users that existing wired and wireless technologies cannot satisfy in a cost-effective way, and they will generate new revenue streams from new services.

Further reading

[1] Credit Swiss First Boston (2005): 3G Economics. IPR Extending Competitive Advantage.
[2] David J. Goodman, Robert A. Myers (2005): 3G Cellular Standards and Patents. Proceedings of 2005 IEEE Wireless Communications and Networking Conference, June 13-16.
[3] WiMAX Forum (2005): Fixed, nomadic, portable ad mobile applications for 802.16-2004 and 802.16e WiMAX networks. Available at www.wimaxforum.org
[4] WiMAX Forum (2006): Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation. Available at www.wimaxforum.org
[5] WiMAX Forum (2006): Mobile WiMAX – Part II: Competitive Analysis. Available at www.wimaxforum.org
[6] WiMAX Forum (2006): Mobile WiMAX Usage Scenarios. Available at www.wimaxforum.org

Acronyms

2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project Two
AAA	Authorization, Authentication and Accounting
ASP	Average Selling Price
CCTV	Closed Circuit TV
CDMA	Code Division Multiple Access
CE	Consumer Electronics
CLEC	Competitive Local Exchange Carrier
DSL	Digital Subscriber Line
ETSI	European Telecommunications Standards Institute
EV-DO	EVolution Data Optimized
FDD	Frequency Division Duplex

GSM	Global System for Mobile communications
HiperMAN	High Performance Radio Metropolitan Area Network
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
IEEE	Institute of Electrical and Electronics Engineers
IMS	IP Multimedia Subsystem
IMT	International Mobile Telecommunications
IP	Internet Protocol
IPR	Intellectual Property Rights
ISP	Internet Service Provider
ITU	International Telecommunication Union
LAN	Local Area Network
LTE	Long Term Evolution
MBS	Multicast and Broadcast Services
MIMO	Multiple Input, Multiple Output
MMD	MultiMedia Domain
MP3	MPEG (Moving Pictures Experts Group) Layer 3
MVNO	Mobile Virtual Network Operator
OFDMA	Orthogonal Frequency Division Multiple Access
PCI	Peripheral Component Interconnect
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal Digital Assistant
QoS	Quality of Service
RAN	Radio Access Network
ROI	Return On Investment
SAE	System Architecture Evolution
SIMO	Single Input, Multiple Output
SISO	Single Input, Single Output
SOC	System-On-a-Chip
TDD	Time Division Duplex
UMPC	Ultra Mobile PC
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus

VoIP	Voice over Internet Protocol
WCDMA	Wideband CDMA
WiBro	Wireless Broadband
WiMAX	World Interoperability for Microwave Access
WISP	Wireless Internet Service Provider
WMAN	Wireless Metropolitan Area Network