

# The emergence of WiMAX

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## Introduction

WiMAX, one of the most anticipated wireless technologies in recent years, is here. It has finally become a fully commercial technology and is being deployed worldwide. The first certified WiMAX products were announced in January 2006 and support for mobility will be added starting from 2007. There is a lot of excitement in the market, as network operators announce more trials and deployments, and the moment for the technology to finally prove itself on the ground has arrived.

Its superior performance over competing technologies combined with the promise of lower deployment costs, are likely to encourage the emergence of new services and applications, devices and business models. WiMAX offers unrivalled scope for services, as it can provide both fixed and mobile access over the same wireless interface. This gives network operators greater flexibility and the opportunity for economies of scale.

As awareness of WiMAX grows in the market, it is crucial to understand the major benefits that WiMAX brings to operators and the market opportunity it presents. This paper provides an introduction to the technology and a comparison with other wireless technologies. It also includes a quick update on the latest market and technology developments within the WiMAX community.

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## The technology

WiMAX is the technology best positioned to move broadband wireless access from a niche market to the mainstream, and to find its way into a wide array of devices, ranging from high-power outdoor CPEs to laptops, to mobile devices including phones and CE devices.

The strength of WiMAX is not due to a single technological innovation, but rather to the confluence of multiple technology and market factors that gives it an advantage over other technologies. These include the following:

- **Orthogonal Frequency Division Multiplexing (OFDM) and Scalable Orthogonal Frequency Division Multiple Access (SOFDMA) modulation**, leading to a more efficient spectrum use in the uplink and downlink. High uplink capacity is valuable for applications using subscriber-generated content.
- **Wide spectrum channels**, supporting high throughput.
- **Low latency**, needed to support real-time applications like VoIP and content streaming.
- **Support for advanced antenna technologies** like Multiple Input Multiple Output (MIMO) which brings a further increase in throughput.

- **Standards-based technology** which relies on the IEEE 802.16 standard. WiMAX certification ensures interoperability among vendors and economies of scale.
- **Wide industry support**, ensuring that a wide variety of end-user devices will become commercially available.

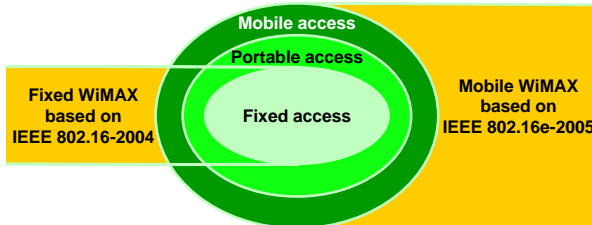


Figure 1. Fixed and Mobile WiMAX. Source: Senza Fili Consulting

There are two versions of WiMAX, as shown in Figure 1:

- **Fixed WiMAX**, which supports fixed and nomadic services and can operate in the 3.5 GHz and 5.8 GHz band.
- **Mobile WiMAX**, which supports fixed, portable and mobile services and can operate in multiple frequencies below 3.7 GHz.

The table below shows the key differences between the two versions. Mobile WiMAX is slated to become the dominant version of WiMAX as it supports both fixed and mobile services and operates in a wider range of frequencies. However, Fixed WiMAX enjoys a time-to-market advantage, as certified products are already available, which gives it an initial advantage.

	Fixed WiMAX	Mobile WiMAX
<b>Standard</b>	IEEE 802.16-2004	IEEE 802.16e-2005
<b>Access</b>	Fixed	Fixed, portable and mobile
<b>Modulation</b>	OFDM	SOFDMA
<b>Duplexing</b>	TDD, FDD	TDD, possibly FDD
<b>Handoffs</b>	No	Yes
<b>Subscriber unit</b>	Outdoor or indoor CPEs, eventually PCMCIA cards	Indoor CPEs, embedded in laptops, phones, mobile and CE devices
<b>Spectrum bands</b>	3.5 GHz, 5.8 GHz	2.3-2.4 GHz, 2.5-2.7 GHz, 3.3-3.4 GHz, 3.4-3.8 GHz
<b>Certified products</b>	January 2006	1Q2007 (Expected)

Despite all the benefits that WiMAX brings to network operators, we do not expect it to replace currently available wireless technologies. Rather it will complement or compete with them.

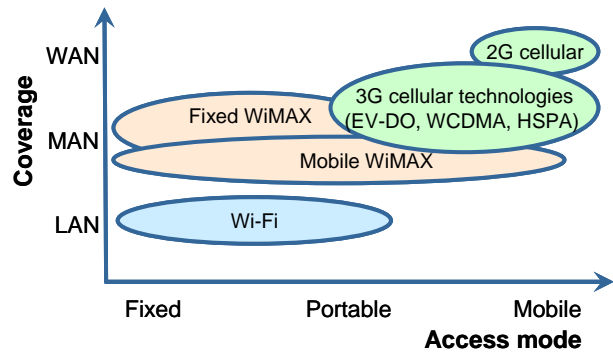


Figure 2. WiMAX and other wireless technologies. Source: Senza Fili Consulting

While the choice of technology depends mostly on the services selected and the operator’s focus and market, WiMAX is typically better suited to providing high capacity in areas with dense demand for either fixed or mobile access (e.g. urban areas) or to provide fixed access in more sparsely populated areas or where wired access technologies are not available. Mobile data coverage in areas with low density of demand is often better supported by cellular technologies. Conversely, within the home and the office, Wi-Fi is a more flexible and cost-effective solution.

WiMAX supports VoIP and we expect that VoIP services will become an important revenue stream for WiMAX operators, especially in emerging markets where the fixed and mobile phone charges are still very high. However, we do not expect that WiMAX will pose meaningful competition to cellular networks which are optimized for voice traffic and will retain more extensive coverage than WiMAX.

## The evolution of mobile broadband technologies

WiMAX is well equipped to compete not only with existing wireless technologies, but also with evolving wireless technologies like 3G. For even though 3GPP and 3GPP2, which are responsible for drafting 3G specifications, are now adopting an approach similar to that taken by WiMAX, the new equipment will not be commercially available for several years to come. This will result in an increase in time to market, with 3G

equipment supporting several key WiMAX capabilities two or three years later. Figure 3 shows the evolution of 3G technologies and WiMAX. IMS is already supported by both and will be crucial in facilitating the interworking of the two types of technology. 3G is also moving towards OFDMA multiplexing and an all-IP core, but Mobile WiMAX will already support both at the beginning of 2007. MIMO will be supported in WiMAX as early as 2007, while 3G technologies will have to wait at least until 2010.

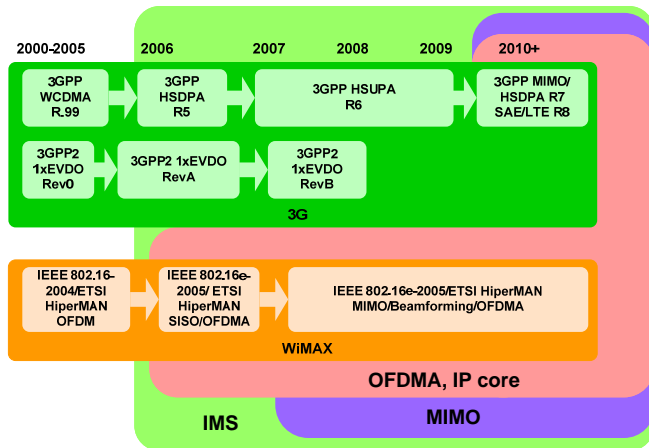


Figure 3. 3G and WiMAX evolution. Source: Senza Fili Consulting, WiMAX Forum

## Roadmap to product availability

WiMAX certification is the first step towards the commercialization of products. It has been introduced to ensure the interoperability of equipment from different vendors. During the WiMAX Forum certification testing, vendors have to show that their equipment can successfully operate within a network with equipment from multiple vendors.

The first certified products for Fixed WiMAX were announced in January 2006. Mobile WiMAX equipment will be certified starting in 2007. While all new certified products have to be backward compatible, new features are constantly added to the certification test cases, to ensure that WiMAX retains its technological edge and can support a rich set of applications and devices.

Figure 4 shows the timeline for certification of both fixed and mobile WiMAX and shows the additional tests that are to be added in time.

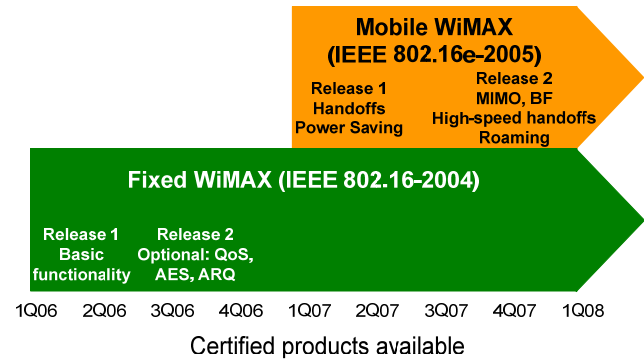


Figure 4. WiMAX certification timeline. Source: Senza Fili Consulting

The certification timeline indicates when the initial products will be available. Products like mobile phones, PDAs and CE devices are likely to be introduced in the market at a later stage.

In particular, Mobile WiMAX will initially only support limited mobility. Full mobility will be introduced by WiMAX vendors only towards the end of 2007. While initially there will be mobile devices targeting early adopted, mass-market products at attractive price levels will appear in 2008–2009.

## The market opportunity

The technological and market advantages of WiMAX translate into an attractive opportunity for service providers to offer advanced services like personal broadband, along with fixed and mobile access.

To new entrants and fixed operators, WiMAX offers the opportunity to enter the mobile broadband market, which to date is controlled by mobile operators which have not been very successful or aggressive at promoting high-bandwidth applications. To mobile operators, WiMAX brings more capacity, lower latency, and lower costs which enable them to provide mobile broadband

services in a more cost-effective way and to support more effectively real-time, high bandwidth applications.

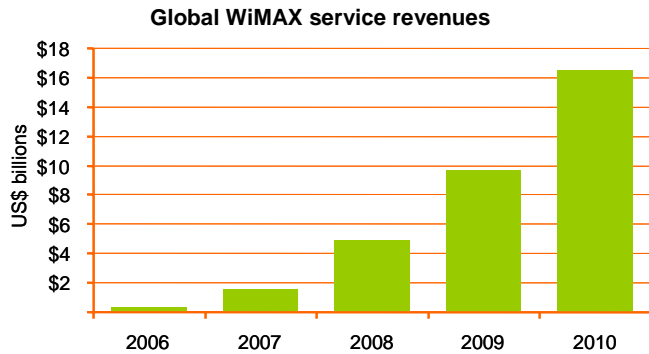


Figure 5. Global WiMAX service revenues. Source: Senza Fili Consulting

We have conducted an extensive demand-driven forecast of WiMAX adoption worldwide over the next five years that illustrates the market potential of WiMAX.

We expect that there will be 15.4 million subscribers by 2010 (Figure 6), contributing to service revenues in excess of US\$16 billion (Figure 5). The forecast includes both Fixed and Mobile WiMAX, with Mobile WiMAX including both fixed and mobile access. In practice, the distinction between fixed and mobile subscribers will become increasingly tenuous, as mobile and fixed access will be combined in personal broadband service offerings.

The growth trend shows an early dominance of Fixed WiMAX, which benefits from its early market introduction. In subsequent years, Fixed WiMAX will continue to grow in niche markets, but by 2010 Mobile WiMAX will have grown to outpace Fixed WiMAX and to capture 57% of subscribers.

The introduction of Mobile WiMAX equipment in the market in 2007 is followed by initial trials of the technology in 2007 and early 2008. As with every new wireless technology, a multi-year cycle is needed to complete technology and commercial trials and to initiate the commercial rollout. For Mobile WiMAX, this cycle will take place in the next five years. Wider commercial rollouts from 2010 onwards will lead to even stronger growth from that point.

The Asia Pacific region will be the largest WiMAX market with over 41% of worldwide subscribers (Figure 7, Figure 8). WiMAX will be successful in those countries with a

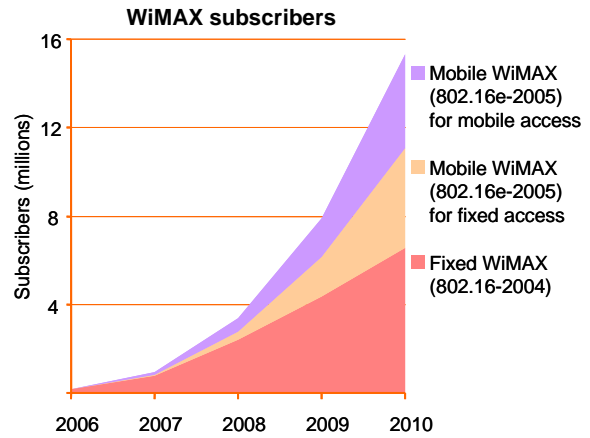


Figure 6. WiMAX subscribers worldwide. Source: Senza Fili Consulting

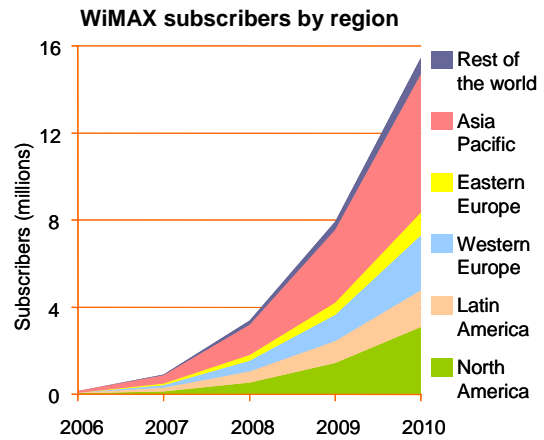


Figure 7. WiMAX subscribers worldwide. Source: Senza Fili Consulting

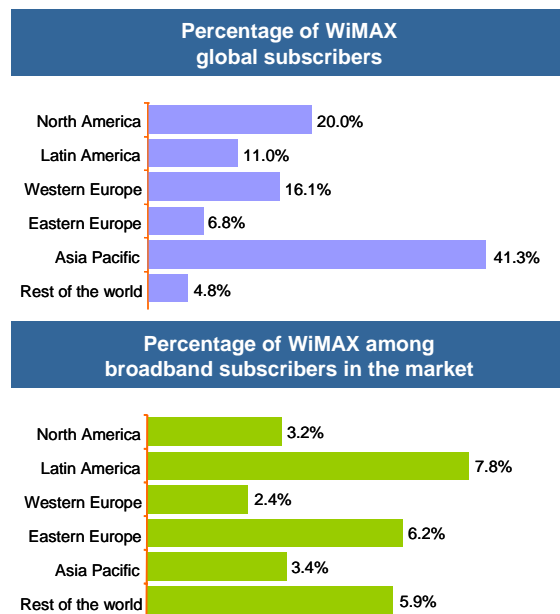


Figure 8. The impact of WiMAX in different regions. Source: Senza Fili Consulting

strong interest in mobile services (e.g. Korean and Japan). Huge developing market like India and China will also drive uptake partly due to the sheer size of the addressable market, though operators in these countries will initially focus on fixed services.

To get a better understanding of the role that WiMAX plays in different regions, it is useful to compare these data to the WiMAX market share among broadband subscribers (Figure 8, bottom). The data shows that Latin America and Eastern Europe are the markets where WiMAX will have the strongest impact. However, since these countries don't have large populations or a high broadband penetration, their contribution to the global estimate of subscribers is limited.

The data suggests that, especially in the early stages, when both Fixed and Mobile WiMAX will mostly support fixed services, emerging markets are the most attractive and rapidly growing market for the technology. In these countries, the lack of an existing wired infrastructure, and the high cost of building one, make WiMAX an ideal solution to provide connectivity quickly and at a reasonable price. In the long run, developed countries will become more influential as Mobile WiMAX is rolled out to support mobile services.

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## Conclusions

Technological and market advantages make WiMAX the most credible contender for innovative fixed and mobile services like personal broadband. WiMAX will move from being a niche technology to gaining much wider acceptance both in the enterprise and in the consumer market.

Growth in adoption will gradually evolve from a prevalence of fixed access in developing or underserved areas to a more varied landscape, where fixed and mobile access will coexist in both developed and developing countries, and where Mobile WiMAX will increasingly take a dominant position.

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## Acronyms

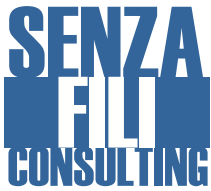
2G	Second Generation
3G	Third Generation
3GPP	The Third Generation Partnership Project
3GPP2	The Third Generation Partnership Project Two
AES	Advanced Encryption Standard
ARQ	Automatic Repeat Request
BF	BeamForming
CE	Consumer Electronics
CPE	Customer Premises Equipment
ETSI	European Telecommunications Standards Institute
EV-DO	CDMA EVolution Data Optimized
FDD	Frequency Division Duplex
HiperMAN	High Performance Radio Metropolitan Area Network
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
IEEE	Institute of Electrical and Electronics Engineers
IMS	IP Multimedia Subsystem
IP	Internet Protocol

LAN	Local Area Network
LTE	Long Term Evolution
MAN	Metropolitan Area Network
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Multiplex
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
SAE	System Architecture Evolution

SISO	Single Input Single Output
SOFDMA	Scalable Orthogonal Frequency Division Multiple Access
TDD	Time Division Duplex
VoIP	Voice over Internet Protocol
WAN	Wide Area Network
WCDMA	Wideband CDMA
WiMAX	Worldwide Interoperability for Microwave Access

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Senza Fili Consulting provides advisory support on wireless data technologies and services. Our expertise extends to cellular communications, WiMAX, Wi-Fi, and other fixed and mobile Broadband Wireless Access (BWA) technologies. We assist vendors in gaining a better understanding of the service provider and end-user markets. We work alongside service providers in developing a wireless data strategy and in assessing the demand for wireless services. Independent advice, a strong quantitative backing, and an international perspective are the hallmarks of our work.

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