Fixed, nomadic, portable and mobile applications for 802.16-2004 and 802.16e WiMAX networks

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Executive Summary

The WiMAX Forum is committed to providing optimized solutions for fixed, nomadic, portable and mobile broadband wireless access. Two versions of WiMAX address the demand for these different types of access:

- **802.16-2004 WiMAX.** This is based on the 802.16-2004 version of the IEEE 802.16 standard and on ETSI HiperMAN. It uses Orthogonal Frequency Division Multiplexing (OFDM) and supports fixed and nomadic access in Line of Sight (LOS) and Non Line of Sight (NLOS) environments. Vendors are developing indoor and outdoor Customer Premises Equipment (CPE) and laptop PCMCIA cards. The initial WiMAX Forum profiles are in the 3.5 GHz and 5.8 GHz frequency bands. The first certified products are expected by the end of 2005.
- **802.16e WiMAX.** Optimized for dynamic mobile radio channels, this version is based on the 802.16e amendment and provides support for handoffs and roaming. It uses Scalable Orthogonal Frequency Division Multiplexing Access (SOFDMA), a multi-carrier modulation technique that uses sub-channelization. Service providers that deploy 802.16e can also use the network to provide fixed service. The WiMAX Forum has not yet announced the frequency bands for the 802.16e profiles, but 2.3 GHz and 2.5 GHz are the most likely initial candidates. Certification is expected to start in the middle of 2006 when the certification labs open, with the first certified products available in the first quarter of 2007.

The two flavors of WiMAX will coexist and address a growing demand for wireless broadband access in the fixed and mobile markets. In addition to considering whether they want to build out a mobile or fixed network, when selecting a WiMAX solution operators need to evaluate additional factors such as the target market segments, the availability of spectrum, any regulatory constraints, and the timeline for deployment. 802.16-2004 products are less complex than those based on 802.16e, they can be used in a wider range of unlicensed bands, and they offer a faster time-to-market, and, in some cases, a higher throughput than 802.16e-based equipment. On the other hand, a better link margin, support for mobility, improved indoor coverage, flexible management of spectrum resources, and a wider range of terminal form factors are some of the advantages offered by 802.16e products.

Most operators will deploy only one WiMAX version in their networks. There are several migration options available to those operators that choose to move from a 802.16-2004 network to a 802.16e network. These include overlay networks, dual-mode user devices, software-upgradeable base stations and dual-mode base stations.

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Introduction

WiMAX is a broadband wireless technology that supports fixed, nomadic, portable and mobile access. To meet the requirements of different types of access, two versions of WiMAX have been defined. The first is based on IEEE 802.16-2004 and is optimized for fixed and nomadic access. The initial WiMAX Forum CERTIFIED products will be based on this version of WiMAX. The second version is designed to support portability and mobility, and will be based on the IEEE 802.16e amendment to the standard. Table 1 shows how WiMAX supports different types of access and their requirements (see the Annex for complete definitions).

Table 1. Types of access to a WiMAX network

Definition	Devices	Locations/ Speed	Handoffs	802.16-2004	802.16e
Fixed access	Outdoor and indoor CPEs	Single/ Stationary	No	Yes	Yes
Nomadic access	Indoor CPEs, PCMCIA cards	Multiple/ Stationary	No	Yes	Yes
Portability	Laptop PCMCIA or mini cards	Multiple/ Walking speed	Hard handoffs	No	Yes
Simple mobility	Laptop PCMCIA or mini cards, PDAs or smartphones	Multiple/ Low vehicular speed	Hard handoffs	No	Yes
Full mobility	Laptop PCMCIA or mini cards, PDAs or smartphones	Multiple/ High vehicular speed	Soft handoffs	No	Yes

The first WiMAX Forum CERTIFIED products will be available at the end of 2005 and will enable the first standards- and IP-based wireless broadband services that offer both

fixed and nomadic access for Point To Point (PTP) and Point To Multipoint (PMP) applications. Support for portability and mobility will be included subsequently in a separate certification program. The WiMAX Forum expects that the first certified products supporting mobility will be available in the first quarter of 2007, with the first networks deployed later that year.

This paper gives an overview of the two versions of WiMAX. It presents a comparison of the two technologies in terms of technology and capabilities, discusses the process and timeline for standardization and certification, and identifies the target markets and applications for 802.16-2004 and 802.16e WiMAX.

The IEEE 802.16 standard

WiMAX is based on the IEEE 802.16 standard and on ETSI HiperMAN. The latest version of IEEE 802.16, 802.16-2004 (previously known as Revision D, or 802.16d), was ratified in July 2004. 802.16-2004 is a wide-ranging standard, that includes previous versions (802.16-2001, 802.16c in 2002, and 802.16a in 2003) and covers both LOS and NLOS applications in the 2-66 GHz frequencies. As is customary with IEEE standards, it specifies only the Physical (PHY) and Media Access Control (MAC) layers.

The changes introduced in 802.16-2004 were focused on fixed and nomadic applications in the 2-11 GHz frequencies. Two multi-carrier modulation techniques are supported in 802.16-2004: OFDM with 256 carriers and OFDMA with 2048 carriers. The first WiMAX Forum certification profiles are based on OFDM as defined in this version of the standard.

In December 2002, Task Group e was created to improve support for combined fixed and mobile operation in frequencies below 6 GHz. Work on the 802.16e amendment is approaching completion and its ratification is expected by the end of 2005. The new version of the standard introduces support for SOFDMA (a variation on OFDMA) which allows for a variable number of carriers, in addition to the previously-defined OFDM and OFDMA modes. The carrier allocation in OFDMA modes is designed to minimize the effect of the interference on user devices with omnidirectional antennae. Furthermore, IEEE 802.16e offers improved support for Multiple Input Multiple Output (MIMO) and Adaptive Antenna Systems (AAS), as well as hard and soft handoffs. It also has improved power-saving capabilities for mobile devices and more extensive security features. Both OFDM- and OFDMA-based products can take advantage of the newly-added capabilities.

As with 802.16-2004, 802.16e will incorporate previous versions of the standard and add support for fixed and mobile access. However, 802.16e is often used to refer to the

changes introduced to support mobility and, in particular, SOFDMA. In the rest of the paper, we refer to 802.16e WiMAX profiles as most likely to adopt SOFDMA, and to 802.16-2004 profiles as using OFDM with 256 carriers.

The new version of the 802.16 standard is backwards-compatible, so new specifications of the OFDM mode are compatible with previous versions. However, OFDM and SOFDMA modes are not compatible as they are based on two distinct modulation techniques. As a result, a single-mode OFDM CPE will not work within a SOFDMA network and, conversely, an SOFDMA CPE will not work within an OFDM network.

WiMAX Forum Profiles

WiMAX is a set of profiles based on IEEE 802.16 developed by the WiMAX Forum and its members. While 802.16 supports a wide range of frequencies (up to 66 GHz), channel sizes (1.25 MHz to 20 MHz) and applications (LOS and NLOS; PTP and PMT), the WiMAX profiles narrow the scope of 802.16 to focus on specific configurations.

The selection of a limited number of profiles is essential to ensure interoperability across vendors and to generate the economies of scale that lead to lower prices and a more appealing technology.

The choice of profiles is driven by market demand, spectrum availability, regulatory constraints, the services to be offered, and vendor interest. For instance, the availability of spectrum for broadband wireless access services in several countries motivated the creation of initial profiles in the 3.5 GHz band. The availability of license-exempt spectrum and the demand for fixed services determined the creation of a profile in the 5.8 GHz band. Demand for mobile services and spectrum availability make the 2.3 GHz and 2.5 GHz bands likely targets for future 802.16e profiles.

WiMAX Forum profiles are defined by the following parameters:

- **Spectrum band.**
- **Duplexing.** Two options are available: Time Division Duplex (TDD) for operators with unpaired or license-exempt spectrum, and Frequency Division Duplex (FDD). FDD requires two channels, one for uplink and the other for downlink traffic. In a TDD network traffic occupies a single channel, with uplink and downlink traffic assigned to different time slots.

Table 2. WiMAX Forum certification profiles			
Frequency (MHz)	**Duplexing**	**Channels (MHz)**	**IEEE standard**
3400-3600	TDD	3.5	802.16-2004
3400-3600	FDD	3.5	802.16-2004
3400-3600	TDD	7	802.16-2004
3400-3600	FDD	7	802.16-2004
5725-5850	TDD	10	802.16-2004

- **Channel bandwidth.** The channel bandwidth is highly dependent on the spectrum allocated by regulators. Initial profiles are limited to 3.5 MHz and 7 MHz in the licensed spectrum as these are the prevalent spectrum channels allocated in the 3.5 GHz band. As wider channels are made available to operators, so the WiMAX Forum members will add certification profiles with wider channel bandwidths.
- **IEEE standard.** 802.16-2004 profiles use OFDM with 256 carriers. 802.16e profiles are most likely based on SOFDMA. Only the latter support mobility.

All the certification profiles based on 802.16-2004 are based on a common system profile. This includes WiMAX specifications that remain the same whatever the frequency, channel size and method of duplexing. A new system profile is currently being developed for 802.16e certification profiles. If there is sufficient interest from the vendor community, a third system profile may be introduced for 802.16-2004 products to support portability and limited mobility. The initial profiles defined by the WiMAX Forum (Table 2) support fixed and nomadic access in the 3.5 GHz and 5.8 GHz bands.

The WiMAX Forum has defined certification releases as shown in Figure 1. The timetable for product certification is driven by product availability since three products are needed to test interoperability across vendors. The certification process includes interoperability testing with products from other vendors, and compliance testing for conformance against the WiMAX system profile.

The first certification release for 802.16-2004 is currently under way and includes products submitted within the two 3.5 GHz profiles with a channel bandwidth of 3.5 MHz. The scope of the certification and the list of tests will be extended during subsequent releases. The first release will focus on certification of the air protocol. The second release will add functionality needed to support outdoor services (QoS and security, for instance). The third release will include support for indoor user devices.

The profiles for 802.16e have not yet been announced, as the 802.16e amendment to the standard has not yet been finalized. The most likely bands for the first mobile profiles are 2.3 GHz and 2.5 GHz. Better indoor coverage and support for mobile or portable devices make bands below 3 GHz the best targets. However, additional profiles in higher frequencies (3.3 GHz, 3.5 GHz or even 5.8 GHz) may be added if there is sufficient demand for 802.16e-based products for fixed or nomadic access.

The WiMAX Forum plans to announce new profiles supporting mobility in the coming months and to open certification labs in the third quarter of 2006. The first 802.16e WiMAX Forum CERTIFIED products are expected by the first quarter of 2007.

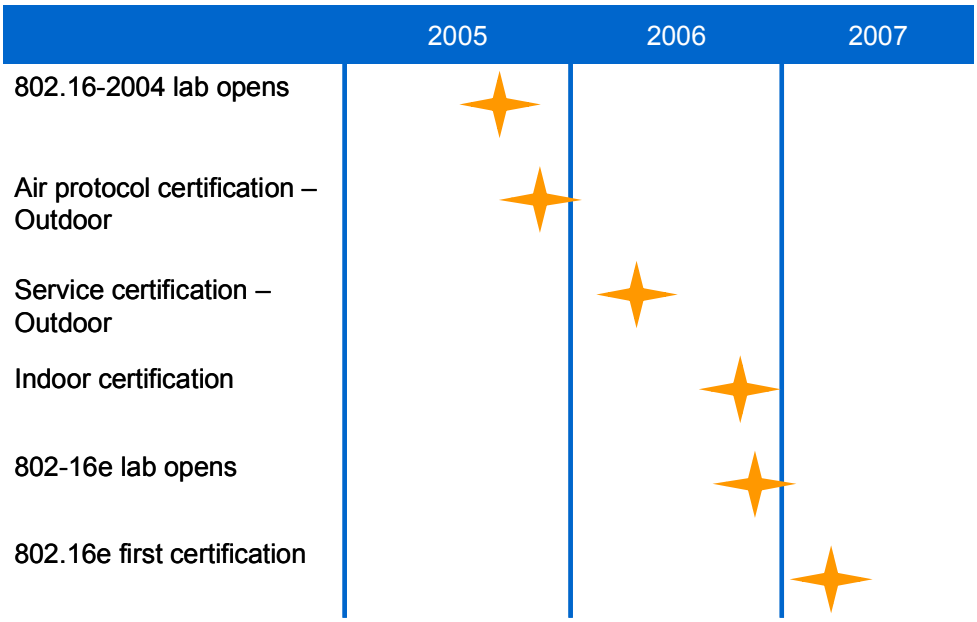

Figure 1. WiMAX Forum timeline for product certification

A comparison between 802.16-2004 and 802.16e profiles

The two versions of WiMAX reflect the demand for products that are either optimized for fixed or for mobile access. The requirements for the two types of access vary and different solutions are required to meet them.

Several optional features that are supported in both 802-16.2004 and 802.16e profiles are more likely to be implemented in 802.16e products simply because mobile services stand to gain more from the added functionality. Among these, improved support for MIMO and AAS will bring a substantial increase in throughput and NLOS capabilities.

OFDM and SOFDMA

A key difference between 802.16-2004 and 802.16e profiles is the multiplexing technique: the first uses OFDM and the second will most likely use OFDMA.

WiMAX profiles based on 802.16-2004 are better suited to fixed applications that use directional antennae because OFDM is inherently less complex than SOFDMA. As a result, 802.16-2004 networks may be deployed faster and at a lower cost. In addition, 802.16-2004 WiMAX Forum CERTIFIED products will be available earlier and will be adopted by service providers that plan to deploy a network in the near future.

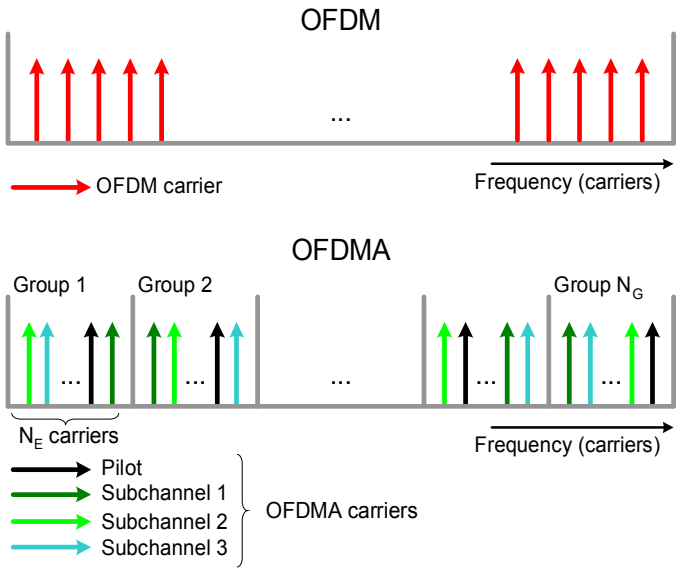

Figure 2. OFDM and OFDMA
In OFDM, all carriers are transmitted in parallel with the same amplitude. OFDMA divides the carrier space into N_G groups, each of which has N_E carriers, and into N_E sub-channels, each with one carrier per group. In OFDMA with 2048 carriers, for instance, this translates in N_E=32 and N_G= 48 in the downlink, and N_E=32 and N_G= 53 in the uplink, with the remaining carriers used for guard bands and pilots. Coding, modulation and amplitude are set separately for each sub-channel based on channel conditions to optimize the use of network resources.

OFDMA gives 802.16e profiles more flexibility when managing different user devices with a variety of antenna types and form factors. It brings a reduction in interference for user devices with omnidirectional antennas and improved NLOS capabilities that are essential when supporting mobile subscribers. Sub-channelization defines sub-channels that can be allocated to different subscribers depending on the channel conditions and their data requirements (Figure 2). This gives the operator more flexibility in managing the bandwidth and transmit power, and leads to a more efficient use of resources.

For instance, within the same time slot more transmit power can be allocated to a user with less favorable channel conditions, while lowering the power for users in better locations. Improved in-building coverage can be achieved by allocating higher power to sub-channels assigned to indoor user devices.

Sub-channelization in the uplink brings additional performance improvement, as transmit power from the user device is severely limited. In OFDM, user devices transmit using the entire carrier space at once (Figure 3). OFDMA supports multiple access, which allows user devices to transmit only through the sub-channel(s) allocated to them. In OFDMA with 2048 carriers and 32 sub-channels, if only one sub-channel is allocated to a device, all the transmit power will be concentrated in 1/32 of the spectrum available and may bring a 15 dB gain over OFDM. Multiple access is particularly advantageous when wide channels are used.

SOFDMA brings an additional advantage over OFDMA. It scales the size of the Fast Fourier Transform (FFT) to the channel bandwidth in order to keep the carrier spacing constant across different channel bandwidths. Constant carrier spacing results in a higher spectrum efficiency in wide channels, and a cost reduction in narrow channels.

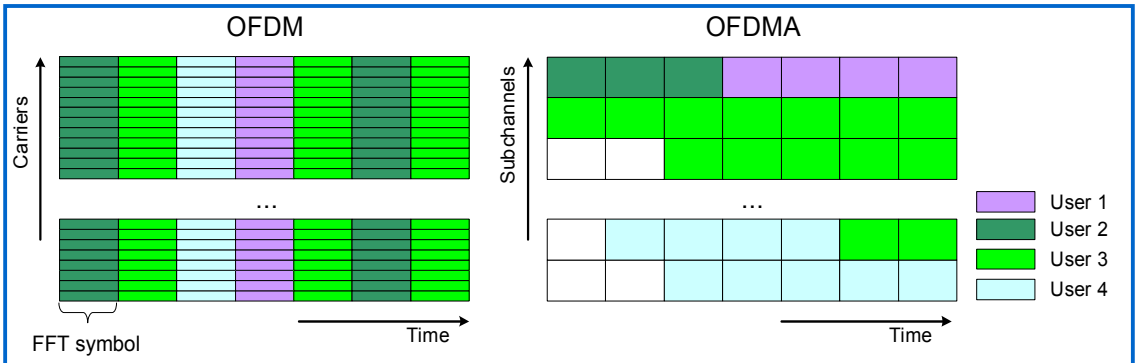

Figure 3. Uplink in OFDM and OFDMA
In OFDM, user devices are assigned time slots for transmission, but only one user device can transmit during a single time slot. In OFDMA, sub-channelization enables several user devices to transmit at the same time over the sub-channel(s) allocated to them.

Handoffs and roaming

Support for handoffs is another crucial addition in the 802.16e amendment for mobile access. The ability to maintain a connection while moving across cell borders is a prerequisite for mobility and will be included as a requirement in the 802.16e system profile. While the 802.16-2004 standard offers optional handoff capabilities, support for handoffs is not required by the 802.16-2004 system profile.

802.16e WiMAX will support different types of handoff, ranging from hard to soft and it is up to the operator to choose among them. Hard handoffs use a break-before-make approach – the user device is connected to only one base station at any given time – which is less complex than soft-handoffs but has a high latency. Soft handoffs are

comparable to those used in some cellular networks and allow the user device to retain the connection to a base station until it is associated with a new one (make-before-break approach), thus reducing latency. While applications like mobile Voice over Internet Protocol (VoIP) or gaming greatly benefit from low-latency soft handoffs, hard handoffs typically suffice for data services. QoS and Service Level Agreements (SLAs) are maintained during handoffs.

Roaming capabilities across service providers can be implemented in both 802.16-2004 and 802.16e WiMAX, but they are especially valuable for portable and mobile access. The WiMAX Forum does not expect to include roaming requirements in the 802.16e system profile, as roaming is a higher level capability that goes beyond the scope of the certification program, which focuses on the PHY and MAC layers. The Service Providers Working Group and the Network Working Group within the WiMAX Forum are working towards identifying the functional requirements for roaming and establishing a roaming platform.

Roadmap for 802.16-2004 and 802.16e WiMAX

The first WiMAX Forum CERTIFIED products are expected to be commercially available shortly after the first round of certification has been completed at the end of 2005. From then on, we expect to see a gradual increase in functionality, a wider selection of form factors for user devices, and a steady decrease in prices as volumes increase.

While the commercial availability of products cannot be predicted with absolute certainty, a roadmap for 802.16-2004 and 802.16e products can be drawn from the feedback received from member vendors (Figure 4). 802.16-2004 WiMAX Forum CERTIFIED products will be available approximately a year before

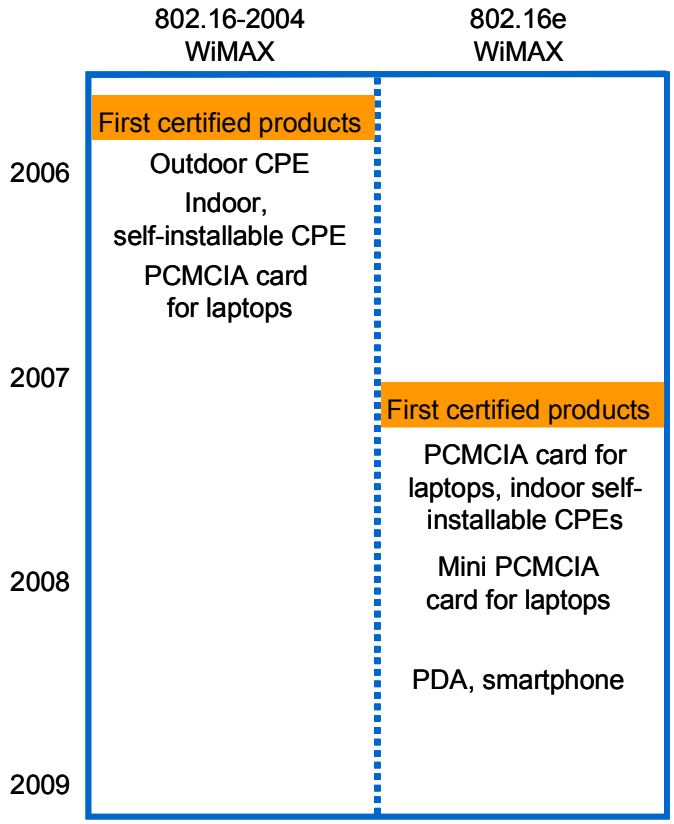

Figure 4. Expected commercial availability of WiMAX user device equipment

802.16e certified products. Outdoor CPEs that require a professionally installed outdoor antenna will be available first, shortly followed by self-installable indoor CPEs. The first PCMCIA cards that support nomadic access may be introduced in the market as early as the second half of 2006.

The WiMAX Forum expects that the initial 802.16e certified user devices will include both PCMCIA cards for laptops and indoor self-installable units, and these will support any type of access, from fixed to mobile. Towards the end of the year, mini PCMCIA cards should become available for laptops with built-in WiMAX functionality. Personal Digital Assistants (PDAs) and smartphones will be introduced to the market at a later stage.

802.16e functionality will increase with time in parallel with the widening selection of different form factors for user devices. The WiMAX Forum expects that initial products will support only simple mobility, which uses hard handoffs and does not support real-time applications. As demand for more advanced forms of mobility is fueled by the introduction of PDAs and smartphones, certified products will include support for soft handoffs, mobile VoIP, and real-time applications.

802.16-2004 or 802.16e WiMAX?

Fixed and mobile deployments have very different requirements and target substantially different market segments, with different usage patterns and locations, throughput needs, user device form factors, and SLAs. The two flavors of WiMAX were defined to meet the distinct demands of these two market segments and the varying requirements of different applications.

In a fixed deployment with basic functionality, 802.16-2004 and 802.126e offer similar performance. Single sector maximum throughput for both versions of WiMAX is about 15 Mbps for a 5 MHz channel, or 35 Mbps for a 10 MHz channel. Base station range in densely populated areas can go up to a few kilometers depending on attributes such as CPE type, frequency band, mobility, morphology and so on. In networks that are capacity constrained, the number of base stations installed depends on throughput demand, rather than range.

However, the performance of the two versions of WiMAX can change substantially for specific applications, because 802.16-2004 is optimized for fixed access and 802.16e for mobile access, although it can also be used for fixed access.

Fixed networks can benefit from the many advantages offered by 802.16-2004 WiMAX Forum CERTIFIED products:

- **Less complex modulation.** OFDM is a simpler modulation technique that is better suited to deployments that do not require support for mobility.
- **License-exempt bands.** Mobile services require licensed spectrum to provide coverage in wide areas. Fixed deployments, however, have often successfully used license-exempt bands in areas where interference levels are acceptable. For this reason, most profiles targeting license-exempt bands are likely to be based on 802.16-2004.
- **Higher throughput.** Higher spectrum bands selected for the 802.16-2004 profiles result in higher throughput. This is a clear advantage, especially when targeting enterprise users with higher traffic levels and with CPEs with outdoor antennas.
- **Better time to market.** Earlier commercial availability of 802.16-2004 products enables operators to meet the pent-up demand for broadband connectivity in underserved areas, and to start gaining market share ahead of competitors.

On the other hand, some operators may decide to wait for 802.16e profiles for several reasons:

- **Support for mobility.** 802.16e products are optimized for mobility and will support handoffs at up to 120 kph. Support for power-saving and sleep modes will extend the battery life of mobile user devices.
- **Better indoor coverage.** The better indoor coverage achieved through sub-channelization and the AAS option benefits both fixed and mobile applications, because users are often indoors or not within line of sight. However, while outdoor antennas can compensate for limited indoor coverage in fixed deployments, this is clearly not an option for mobile users with a laptop or a PDA.
- **Greater flexibility in managing spectrum resources.** Sub-channelization also brings the ability to use network intelligence to allocate resources to user devices as needed. Effectively this results in a more efficient use of spectrum, leading to higher throughput and better indoor coverage, and, in some cases, to lower deployment costs. This is particularly valuable to operators with limited spectrum.
- **Wider range of form factors for user devices.** While outdoor and indoor CPEs, and laptop PCMCIA cards are expected to dominate the 802.16-2004 market, laptop PCMCIA cards, mini cards, indoor modems, PDAs, and phones will be available among 802.16e user devices. This variety allows operators to extend their services to new market segments and to give more freedom to their subscribers. Despite the later introduction of 802.16e products, it is likely that their CPE prices will quickly fall below those for 802.16-2004 CPEs, as 802.16e products are targeted at a larger addressable market. With CPE costs typically being the most important variable in

any operator's business plan, the availability of cheap CPEs will be one of the guiding factors in deciding which version of WiMAX to adopt.

The choice between 802.16-2004 and 802.16e products largely depends on the type of services provided and the business model of the operator. In some cases the choice will be obvious. A mobile operator building an overlay network to complement a 3G network will head straight for 802.16e. A Wireless Internet Service Provider (WISP) providing wireless access to a rural community will typically choose the less complex, OFDM-based, 802.16-2004 WiMAX products.

In addition, operators need to take into account several other factors that may affect the choice between 802.16-2004 and 802.16e products:

- **Target market.** If the operator targets business users and residential users in a mostly LOS environment, CPEs with an outdoor antenna that have better throughput and LOS performance may be more suitable. This may drive the operator towards a 802.16-2004 deployment. If instead the operator addresses a mostly mobile market, low-cost 802.16e CPEs may be required for a viable business plan.
- **Spectrum.** While the WiMAX Forum will continue to add new profiles in response to market demand, it is likely that there will only be either 802.16-2004 or 802.16e profiles in some bands. In most cases the operator will have little choice over the spectrum bands that are available, and the choice of WiMAX flavor may depend on product availability. It is possible that 802.16e profiles will be added in bands typically reserved for fixed and nomadic applications, because 802.16e is less prone to multi-path interference.
- **Regulation.** Some regulators mandate specific types of services that can be offered in a spectrum band. For instance, some regulators in Europe limit 3.5 GHz spectrum to fixed and nomadic services, which may preclude the adoption of 802.16e, as it supports mobile services, even though the spectrum licenses do not typically mandate the use of a particular technology.
- **Timeline.** The earlier availability of 802.16-2004 products in the 3.5 GHz band will be an important factor for service providers that want to deploy a WiMAX network quickly.

Migration paths to 802.16e

The WiMAX Forum is committed to supporting migration paths to networks that support portable and mobile services. Operators that want to move smoothly and in a cost-effective way from a 802.16-2004 to a 802.16e network will have several options available to them:

- **Overlay network.** In areas where an operator wants to add portable and mobile access, an 802.16e overlay network that operates in parallel with the 802.16-2004 network can be deployed if sufficient spectrum resources are available. This allows the operator to offer both fixed and mobile access in the same area, but requires subscribers to have two CPEs if they want to access both networks.
- **Dual-mode CPEs.** Operators that want to switch over to 802.16e can deploy dual-mode CPEs that support both 802.16-2004 and 802.16e. Initially the operator will deploy 802.16-2004 base stations and CPEs, but once 802.16e products become available, it will start introducing dual-mode CPEs. When all subscribers have a dual-mode CPEs, the operator will swap 802.16-2004 with 802.16e base stations and the CPEs will automatically switch over to the 802.16e mode.
- **Software-upgradeable base stations.** This solution can be used in conjunction with the dual-mode CPE. In this case, instead of replacing the base station, the operator may perform a software upgrade to the 802.16e mode.
- **Dual-mode base stations.** If CPEs support only a single mode and the operator plans a gradual move to 802.16e, dual-mode base stations can be installed. Where an overlay networks proves not to be cost-effective or the operator lacks the required spectrum, dual-mode stations provide a way to support both modes and eventually switch entirely to 802.16e when all the CPEs have been upgraded. Some vendors plan to offer dual-mode base stations that split the available channel between the two modes, while others plan to support both modes within the same channel, by alternating 802.16-2004 and 802.16e frames.

While a transition path is valuable to those who plan to move to 802.16e, the WiMAX Forum expects that most operators will elect to retain their 802.16-2004 network. Operators for whom mobility is a requirement are likely to deploy 802.16e from the beginning. Operators with a focus on fixed services do not stand to gain much from switching to 802.16e, unless they plan to extend their service portfolio by including portability and mobility.

Conclusions

Demand for wireless broadband access is growing fast and embracing an ever-widening range of applications that encompass fixed, nomadic, portable and mobile data access as well as fixed and mobile voice services, and content streaming. The WiMAX Forum is committed to meeting the requirements of all these applications.

Two system profiles, one based on the 802.16-2004 revision of the IEEE 802.16 standard and the other based on the 802.16e amendment, define two versions of WiMAX. The first targets the requirements of the fixed and nomadic market, and will be the first to be commercially available. The 802.16e version has been designed with portable and mobile access in mind, but it will also support fixed and nomadic access.

The WiMAX Forum expects that each version of WiMAX will have its role in the marketplace, as each addresses demand from distinct market segments. Operators will need to assess the differences in performance and functionality that 802.16-2004 and 802.16e WiMAX present in different types of deployments and in target markets. In many cases, spectrum availability, regulatory requirements and the timeline for deployment will also be key factors for consideration. Having a choice between two options guarantees that operators will find a solution that is right for them.

Acronyms

AAS	Adaptive Antenna System *or* Advanced Antenna System
CPE	Customer Premises Equipment
FDD	Frequency Division Duplex
FFT	Fast Fourier Transform
ETSI	European Telecommunications Standards Institute
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
LOS	Line Of Sight
MIMO	Multiple Input Multiple Output
NLOS	Non Line Of Sight
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiplexing Access
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal Digital Assistant
PMT	Point to Multi Point
PTP	Point To Point
QoS	Quality of Service
SLA	Service Level Agreement
SOFDMA	Scalable OFDMA
TDD	Time Division Duplex
VoIP	Voice over Internet Protocol
WiMAX	World Interoperability for Microwave Access
WISP	Wireless Internet Service Provider

Annex. WiMAX Forum definitions of fixed, nomadic, portable and mobile access

Fixed Access. The user device is assumed to be fixed in a single geographic location for the duration of the network subscription. The user device can connect and disconnect from the network. It may be able to select the "best" base station at the time of network entry. The user device will typically be associated with the same base station sector or cell, and any re-association with another sector or cell will be controlled by the network, for instance, for failure mode or macro-diversity.

Nomadic Access. The user device is assumed to be fixed in a geographic location at least as long as the network data service session is in operation. If the user device is moved to a different location in the same wireless network (e.g. cell or sector change), the user device subscription is recognized and a new data service session may be established. The user device may be able to select the "best" base station at the time of network entry. During a data service session, the user device will typically be associated with the same base station sector or cell, and any re-association with another sector or cell will be controlled by the network, for instance, for failure mode or macro-diversity.

Portable Access. The user device will maintain an operating network data service session as it moves at pedestrian speeds within a limited network coverage area. Limited handover capabilities are provided during an operating network data service session while the user device moves into a different cell or sector area within the same cell.

Simple Mobility Access. The user device will maintain an operating network data service session for non real-time applications as it moves at vehicular speeds within the network coverage area. Handover between sectors and base stations provide this service continuity for all non real-time applications.

Full Mobility Access. The user device will maintain an operating network data service session as it moves at high vehicular speeds within the network coverage area. Guaranteed handover performance between sectors and base stations provide this service continuity for all applications.