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.

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