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## WiMAX: Demystifying 802.16d and 801.16e

It is the philosophy and development strategy of SOMA Networks to comply with the most modern and complete standards. Through this promise, SOMA Networks delivers service providers a system unparalleled in its ability to deploy quickly, provide the best business case, grow with unmatched scalability and interoperate with a multitude of network, operational and application level systems. This extends to WiMAX, the most advanced standard for broadband wireless access, while also delivering a state-of-the-art, fully converged all-IP multimedia application system.

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**White Paper**

### Executive Summary

As a principal member of the WiMAX Forum™, SOMA Networks believes that the IEEE 802.16 Standard shows great promise for the future of broadband wireless access. It is the most progressive, full-featured wireless standard available today, incorporating the latest radio, antenna and transport technologies that help yield the best business case for service providers. SOMA Networks delivers highly scalable and reliable standards-based Broadband Wireless Access (BWA) products with DSL-like performance and PSTN-like voice quality today. Applications and features include simultaneous transmission of toll-quality voice, video and data with unmatched efficiency through Quality of Service (QoS) and advanced bandwidth management software. In keeping with SOMA's currently available BWA portfolio, we believe that the 802.16e-2005 (802.16e) standard, with the ability to offer fixed, nomadic and mobile services, provides all of the essential elements for service providers wishing to offer broadband and high margin services that build market share and ensure customer retention.

With the 802.16e standard, the specification's inclusion of Scalable Orthogonal Frequency Division Multiplexing Access (SOFDMA), with 512 or 1024 sub-carrier channels offers the opportunity to utilize advanced antenna processing methods, as well as offer fixed, nomadic and fully mobile services. These features of 802.16e will ultimately allow mass market offerings of broadband services and the ability to offer applications such as voice, video and data simultaneously, similar to those offered today by DSL and cable networks. Products conforming to the 802.16e standard will be available in late 2006 and into early 2007.

Because of its inherent limitations with regard to nomadic and mobile applications, 802.16-2004 (802.16d) is not (nor will it ever be) suited for mass-market residential and small business broadband wireless service offerings. With reduced base station cell range, radius and capacity, supporting indoor, non-line of sight (NLOS) customer premise equipment (CPE) is challenging and may result in very inconsistent service. Advanced multi-antenna processing such as MIMO and AAS is not supported with 802.16d, which in turn limits opportunities to gain additional throughput and range with limited spectrum bandwidth. For these reasons, 802.16d compliant equipment is primarily suitable for fixed, line-of-sight or near-line-of-sight applications using outdoor CPE devices. One such application is cellular backhaul for operators looking to reduce leased facility costs. But it should be noted that the 802.16e standard may also be used for this application, with better performance and virtually no difference in cost.

### Introduction

The WiMAX Forum™ (the "Forum") has defined its charter as "committed to providing optimized solutions for fixed, nomadic, portable and mobile BWA." Since its inception in 2001, the mission of the Forum has been to promote worldwide operator adoption of IEEE Standard 802.16 compliant BWA equipment. As a result of the Forum's efforts, there is considerable momentum and market interest in WiMAX. As with any standard, evolution and improvements are expected and continuous. As such, 802.16 has evolved into two main variants: 802.16-2004 (802.16d) and 802.16e-2005 (802.16e). In late 2005, certification of 802.16d compliant equipment through the Forum was made available to equipment manufacturers.

Many equipment providers have devoted considerable financial, development, marketing and sales resources to making their 802.16d compliant equipment WiMAX certified and

commercially available. However, SOMA Networks believes that the 802.16e variant of the standard is more in keeping with many critical technical and market factors that will make BWA service offerings compelling, differentiated and truly competitive with wireline offerings such as DSL or cable. In keeping with this strategy, SOMA Networks is pursuing development using the 802.16e standard while continuing its strategic focus on delivering unmatched Quality of Service (QoS) capabilities required for broadband applications such as voice and video. The 802.16e preference for mass-market consumer applications is becoming increasingly clear as we have seen major operators in the largest industrialized nations announcing their support for Mobile WiMAX. In Japan, Softbank has announced Mobile WiMAX trials; in Korea, KT is rolling out WiBro which is a close cousin to Mobile WiMAX; in the U.S., Sprint has announced that they will use Mobile WiMAX for their next-generation consumer broadband services.

This paper will discuss each variant of the 802.16 Standard; the advantages of each, as well as what key differences make 802.16e the appropriate choice for broadband wireless access service offerings. It will also discuss how WiMAX is a stepping stone to differentiated and compelling broadband service offerings that can increase revenue per subscriber and build customer loyalty.

### **The “d” Standard (IEEE 802.16-2004)**

While there are many features and profiles for 802.16d, it is primarily optimized for fixed transmission utilizing directional antennas. The standard does not, nor will it ever, support full mobility. Furthermore, while some vendors supporting 802.16d have developed indoor CPEs with improved range by adding non-standard features, these vendors cannot assure interoperability between their custom CPEs and standards compliant base stations. This ultimately dictates that standards compliant indoor CPEs must be located within a short range of the base station in order to account for the additional power required to transmit through physical barriers. Deployment of systems with non-standard features restricts the operator's equipment choice to that of a single equipment vendor thereby defeating a primary purpose of standardization.

What does this do for the business case in broadband wireless access, and where would 802.16d equipment be useful? Because of the limitations posed by 802.16d as noted above, the financial feasibility to achieve a large scale, mass market broadband access offering is not attractive. And even though many equipment providers market the availability of lower cost base stations, the physical plant and initial deployment, as well as the ongoing operational costs would render a large scale, consumer and SOHO offering cost prohibitive.

Many of the 802.16d equipment providers have targeted their offerings directly at the enterprise, or service providers focusing on this market. In these applications, generally fewer CPEs are needed, and outdoor CPE installation is acceptable. Generally, 802.16d deployments have been used for fixed, line-of-site or near-line-of-sight applications where future plans do not call for mass-market consumer and small business services. Cellular backhaul transport is an additional application that can be applied to 802.16d compliant solutions, which could deliver a more favorable business case when compared to leased-line transport. It should be noted, however, that these applications are also suitable for 802.16e compliant solutions, since the standard specifies fixed, nomadic as well as mobile services at virtually the same initial and eventually lower, cost.

### The “e” Standard (IEEE-802.16e-2005)

Ratified in late 2005, 802.16e was created to support full mobility using Scalable Orthogonal Frequency Division Multiplexing Access (SOFDMA) with 512 or 1024 sub-carrier channels for operation below 6 GHz. In comparison to OFDM and 802.16d, this affords 802.16e and SOFDMA more efficient use of the full spectrum bandwidth and transmission power, as well as improved NLOS capabilities essential for mass market (fixed, nomadic and mobile) broadband service offerings. In addition, 802.16e allows for multiple antenna schemes, such as Adaptive Antenna Systems (AAS) or Multiple Input, Multiple Output (MIMO) Systems, thus adding the opportunity to increase throughput and power efficiency. By doing this, 802.16e creates the foundation for a scalable service offering with far greater flexibility for service providers.

With SOFDMA, multiple antennas per CPE and/or base-station and lower overall power utilization, equipment that supports the 802.16e standard has far more flexibility, including: location (indoor or outdoor), NLOS, fixed or mobile, as well as markets and applications that can be served. This flexibility also means greater scalability, better cell coverage and radius and fewer base stations. While it is true that more sophisticated chipsets, modems and other components of 802.16e compliant equipment will be more costly initially, the mass-market volumes for these components will drive the prices down rapidly. Furthermore, because 802.16e base stations can quadruple coverage and offer an order-of-magnitude greater capacity than 802.16d, the higher equipment cost is quickly recovered in reduced up-front capital and reduced site rental costs and operational expenses associated with base station deployment. As a result, a far more favorable economic deployment model may be realized. This makes 802.16e compliant systems suitable for mass market deployments of broadband services and associated applications. And as continued investment and market growth continue into the future, the commoditization of pure 802.16e solutions will drive down hardware prices below those of 802.16d equipment.

There are several significant advantages for service providers as a result of these technical feature improvements over 802.16d:

- Dramatically reduced on-site installation and maintenance (i.e., truck-rolls). Uplink sub-channelization in SOFDMA is a key enabler of the self install CPE. Subscriber self-install CPE removes the service provider burden of costly truck rolls and simplifies maintenance. In addition, there is a greatly reduced need to install and/or reach outdoor BWA CPE.
- Flexible Frequency Configurations. With 802.16e, service providers have far greater flexibility to support multiple bandwidth offerings allowing for multiple pricing schemes and application bundles.
- Greater coverage with lower power cells. By making use of advanced antenna technologies such as MIMO and AAS, signal strength can be increased with the same power consumption (or less), which increases the cell radius.
- Varied Service Offerings. Because 802.16e defines profiles for fixed, nomadic and mobile implementations, it is possible to offer CPEs, service rates, and bundled applications with multiple pricing schemes.
- Full mobility provides the ultimate differentiator against wired services, such as DSL or Cable. Investments in mobile consumer devices supporting 802.16e have been announced and development is underway. Figure 1 summarizes the key differences between the 802.16d and 801.16e standards.

Definition	Devices	Locations / Speeds	Handoffs	802.16d	802.16e
Fixed Access	Indoor & Outdoor CPEs	Single / Stationary	No	Yes	Yes
Nomadic Access	Indoor CPEs, PCMCIA Cards	Multiple / Stationary	No	Limited	Yes
Portability	Laptop PCMCIA or mini cards, PDAs or Smartphones	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

**Figure 1: WiMAX Standard Variants**  
Source: WiMAX Forum

However, while 802.16 has been ratified for compliance and ultimate interoperability, not all profiles stated in either 802.16d or 802.16e are required. And standards compliance alone is not a panacea for offering all BWA services with wireline quality. It is SOMA’s philosophy to bring broadband applications and wireless technology together by developing products that match DSL offerings in scale and quality of service with full standards conformance. Distinguishing features of the SoftAir™ Wireless Multimedia Application System include: intelligent CPE (including a SIP user agent, in service software upgrades, self installation and integrated voice and data ports for simultaneous use) and base-stations with integrated softswitch/voice server gateway and Quality of Service (QoS) management. These features are not specified in the 802.16e standard but nonetheless are required for successful multimedia (such as a “Quad Play”) service offerings.

### Upgrading 802.16d Compliant Products

There is work underway within the WiMAX Forum through the Evolutionary Task Group (ETG) to provide a nomadic version of the 802.16d standard with an associated upgrade path. This “extended d” standard will provide sub-carrier channels to support a better link budget and nomadic services, as well as support for indoor non-line of site CPE. Many vendors supporting the 802.16d standard claim that equipment can be easily upgraded to this variation of the standard. However, the WiMAX Forum has stated that single-mode OFDM CPE and CPE based on SOFDMA are not compatible because they are based on two entirely different modulation techniques, which require chipset encoding. The claim by some equipment providers that their equipment will be software upgradeable may be true, but only to the extended version of the 802.16d standard. These somewhat ambiguous and deceptive claims have created confusion in the marketplace. Currently, there is no work taking place within the WiMAX Forum to achieve full compatibility between the 802.16d and 802.16e standards, and therefore, they will not be able to operate within the same wireless infrastructure. Figure 2 illustrates the key compatibility differences between 802.16d (OFDM) and 802.16e (sOFDMA). Certainly, at some point in the future it is possible for a vendor of 802.16d WiMAX equipment to offer “dual mode” equipment, supporting 802.16d and 802.16e. However, technical considerations, time-to-market and cost are currently unknown.

WiMAX	802.16d	802.16e
<b>OFDM</b> 256 Sub-carrier channels	“Fixed WiMAX” “16d” Fixed Services Not Compatible	“Nomadic WiMAX” “16d+” Compatible
<b>sOFDMA</b> 512 or 1024 Sub-carrier channels	N/A	“Mobile WiMAX” “16e” Fixed, Nomadic, Portable, Mobile Services

**Figure 2: WiMAX Standard Compatibility**

### Business Cases are more than Standards-based Technology

While the 802.16e standard provides the foundation for technology and ultimately cost advantages, other factors are required in order to make BWA offerings successful. Competition through service differentiation, rather than simply broadband access is necessary. This can only be accomplished through a system that has been developed from the ground up to coordinate all layers of the system – the physical, MAC, IP, and application layers. This includes full, carrier-grade capabilities for provisioning, billing, management and customer support. In addition, it is a system which must include the ability to manage traffic and bandwidth to account for the fact that most IP-based broadband applications were not developed with wireless infrastructures in mind.

### Conclusion

The WiMAX Forum has made significant strides in creating profiles for 802.16d and 802.16e and has built a high level of market awareness for this broadband wireless standard. It is clear, as the 802.16e profiles have been defined and ratified, that 802.16d will serve a limited set of applications to a limited set of service providers’ customers. The 802.16e standard will ultimately allow service providers to deliver services with a much more favorable business case because of many factors, including: a development ecosystem, better overall performance, integrated quality of service, scalable bandwidth as well as the ability to offer fixed, nomadic and fully mobile broadband applications.

Many equipment providers are claiming there is a transition from 802.16d to 802.16e, and while SOMA Networks can not comment directly on other equipment providers’ product roadmaps, there are several technical reasons that support these claims as misrepresentations. The WiMAX Forum states that OFDM and sOFDMA are not compatible since they are based on two distinct modulation techniques. It is possible to offer “dual-mode” equipment, supporting 802.16d and 802.16e, however availability and cost are unknown.

## WiMAX: Demystifying 802.16d and 802.16e

SOMA Networks recently announced the FlexMAX™ Mobile WiMAX System, which fully supports IEEE 802.16e-2005. Working in concert with the software-based SoftAir™ Wireless Multimedia Application System, FlexMAX includes base stations and multiple CPEs, supporting advanced antenna processing, integrated, toll-quality VoIP capabilities and more. The SoftAir System is the wireless industry's only all-IP multimedia application platform optimized for wireless access, part of a core software system that has been designed to deliver IP applications with QoS guarantees over a wireless interface. By making the most of the 802.16e standard, and combining advanced standards-based middleware to maximize use of bandwidth, prioritize traffic, and deliver voice, data and video applications simultaneously, with SOMA's solutions service providers have the opportunity to deploy quickly and effectively with differentiated, higher margin applications.

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