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Cut through the confusion of mobile WiMAX

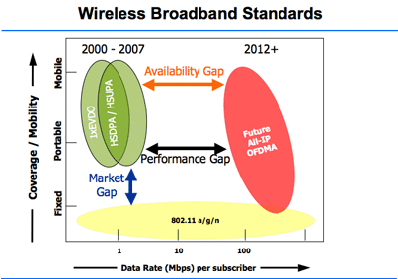
By David Patterson, Beceem Communications 06.04.2007 0

WiMAX is one of the most-anticipated telecom technologies of all time. However, that's not the same as saying it's over-hyped. In fact, dozens of service providers worldwide have deployed fixed WiMAX (IEEE 802.16d) networks, and dozens more are committed to launching mobile WiMAX (IEEE 802.16e) services over the next two years. There are crucial deployments in the U.S. this year by Sprint Nextel and Clearwire, on the heels of commercial launches last year by KT and SKT in Korea. There is also an imminent allocation of WiMAX spectrum in Japan, most likely to KDDI and NTT DoCoMo and also in the UK where BT is showing strong interest. These represent a remarkable shift in availability of spectrum for Mobile WiMAX and a clear roadmap to a global footprint of [WiMAX](#) networks.

By 2009, service providers worldwide will spend \$7.3 billion on WiMAX infrastructure, up from \$655 million in mid-2006, [See Trendsmidia Rethink Research](#). The firm also forecasts that based on operators' plans, the WiMAX share of spending on [broadband wireless](#) will grow from 22.5% to 63% over the same period.

This outlook highlights reasons why WiMAX is an opportunity that few [infrastructure](#) and device vendors can afford to ignore. However, not all WiMAX technologies are created equal. In fact, understanding the differences between the fixed and mobile versions, as well as the [WiBro](#) variant, is key to how the market will evolve over the next several years. Examples include:

- Although 802.16e is designed for use in a mobile environment, the technology can also be used to support fixed applications, such as broadband access to homes and offices, cell site backhaul and machine-to-machine communication. As a result, service providers and vendors can use [802.16e](#) to target a wider variety of applications and markets than with any other technology, a key difference over [3g](#) which is not suitable for broadband access and Fixed WiMAX (802.16d), which can not support mobility.



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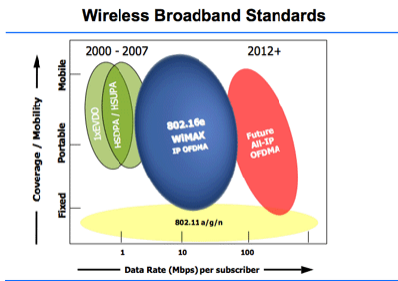
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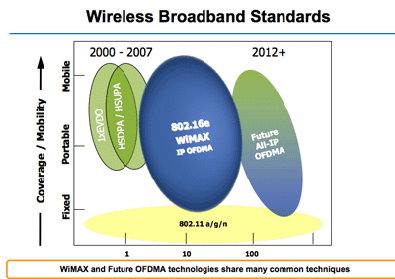
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- Mobile WiMAX creates opportunities for a wide variety of services and service providers, and it is key for a new technology to be able to address different market segments with a single network to maximize the marketing potential and minimize capital and operating expenditures. Mobile WiMAX not only allows a single operator to offer fixed, portable and mobile service but the technology also has the bandwidth and latency characteristics to simultaneously support voice, video and gaming services on top of basic data access. For example, DSL and cable providers can use 802.16e to deliver broadband, video and VoIP services to their customers when they're away from their home or office or cellular voice service providers can overlay their networks with Mobile WiMAX technology in order to be able to offer high-speed data services. These opportunities vary, depending on factors such as the availability of spectrum and business model, but the bottom line is that the pool of potential mobile WiMAX operators is larger than it might initially appear.
- Although 802.16d Fixed WiMAX networks have been commercially deployed for several years, many analysts and vendors believe that mobile WiMAX will quickly become a larger market. By 2010, 802.16d will have approximately 4.4 million customers worldwide, primarily in developing countries, according to a June 2005 report by NSR, an independent analyst firm. By comparison, a recent Maravedis study projects that there will be roughly 20 million Mobile WiMAX subscribers by 2010.
- Although most press coverage of WiMAX is focused on its use as a point-to-point access technology, 802.16d and 802.16e both can also be used for backhaul applications, such as linking remote enterprise offices and connecting cell sites. The WiMAX share of the worldwide cellular backhaul will grow from \$1.36 billion in 2007 to more than \$2 billion by 2010, according to a 2006 report by Pioneer Consulting, an independent analyst firm.

WiBro, Wave 1, Wave 2-The difference

There is substantial confusion in the industry with respect to Mobile WiMAX Wave 1 and Wave 2 and WiBro, and how the three different 'flavors' fit together. The short answer is that all three are essentially the same technology and are fully compatible, but differ with respect to the supported feature set and operating characteristics. Wave 2 is the most feature-rich and flexible variant of Mobile WiMAX, supporting such advanced Smart Antenna technologies as MIMO and beamforming as well as different frequency reuse and channel bandwidth deployments, something that the industry calls 'scalable OFDMA.' Wave 1 also supports different channel bandwidths and frequency bands but offers fewer features—in particular the support of MIMO and advanced beamforming are missing, making it less spectrally efficient. WiBro on the other hand has a feature set that is very similar to Wave 1 but it only supports one specific channel bandwidth and frequency combination (8.75 MHz channel bandwidth at 2.3 GHz frequency), and is only deployed in Korea.

So while WiBro is just a different name for Wave 1 deployments in Korea, Wave 1 itself is best considered as a stepping stone towards Wave 2. In this context it is important to understand that all three 'flavors' are fully compatible, allowing any Wave 1 device to work in the WiBro networks in Korea, and any Wave 2 device will be able to work in any Wave 1 or WiBro network and Wave 2 networks will be able to support Wave 1 and WiBro devices as well. Clearly this is important for service providers that now have the confidence to deploy Wave 1 Mobile WiMAX networks today and can upgrade to Wave 2 in the second half of 2007 or in 2008, without having to replace the terminals already activated.

Device Evolution

As stated, Mobile WiMAX supports fixed, portable and mobile services running data, voice, video or gaming applications. This provides tremendous opportunities for device makers to enter the market with differentiated products, unlike 3G cellular and Wi-Fi which are either focused on the handheld market (3G) or the home networking market (Wi-Fi). Mobile WiMAX on the other hand not only targets the mobile computing space while a wide variety of handheld and consumer electronics devices are simultaneously being designed.

This two-pronged approach poses a challenge for chipset providers that must either find a way to be successful building chipsets that are customized to meet the requirements of a certain niche market segment like gateways and access points, or they must be able to build chips that provide the lowest power consumption, footprint and price while incorporating the full Wave 2 feature set. It is here where the fortunes of the chipset providers will be decided and only those that can address the mobile and handheld market requirements will be successful. At a minimum, a Wave 2 chipset should have a footprint small enough to make it ideal even for handheld devices, and it should have low power consumption. Both are key in the eyes of service providers, who don't want to launch mobile WiMAX with devices that are bulky and have short battery lives. In fact, with so much press and analyst attention focused on 802.16e, no operator can risk botching its initial mobile WiMAX rollout by offering devices that users view as too big, too expensive, or too power-hungry.

An important lesson from the history of the cellular/WiFi chipset evolution lies in chipset integration: In cellular and WiFi, vendors have integrated baseband and RF functions into chipsets rather than leaving them separated. This approach benefits handset and device vendors because they don't have to waste time and resources on the integration issues that typically arise when using separate baseband and RF units. It also provides a solution with a smaller footprint and typically lower cost. This evolution is likely to occur in mobile WiMAX, too. As a result, makers of 802.16e smartphones and other user devices should look for chipsets that combine baseband and RF functions.

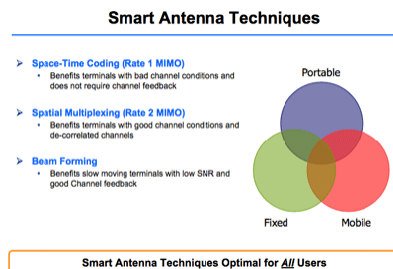
By purchasing a single-solution chipset, device vendors avoid integration issues and, in the process, reduce their development costs and time-to-market. This is a challenge that Mobile WiMAX chipset providers have to address, and if they can do it correctly it will vastly improve their competitive position in the market.

When to switch

For device manufacturers that plan to get into mobile WiMAX market, it is important to understand the nuances of 802.16e and how it differs from 802.16d and Wi-Fi when evaluating chipset providers. A prime example of those differences is multiple input, multiple output (MIMO) antenna technology. It is required in 802.16e Wave 2, so chipset vendors with an 802.16d background must learn MIMO's nuances. And since that takes time and resources it highlights the competitive strengths of a manufacturer that already has extensive MIMO experience.

Still, not all MIMO experiences are equally applicable to 802.16e, and although MIMO is increasingly used in Wi-Fi technologies such as 802.11n, it's a mistake to assume that experience with MIMO in a fixed, short-range environment such as Wi-Fi is applicable to mobile WiMAX. The reason is that the signal strength that is used to calculate the channel conditions change much more quickly in Mobile WiMAX than in Wi-Fi. Wi-Fi is designed for short-range transmission and used primarily for fixed indoor applications, and signal conditions typically do not change frequently in these environments.

Signal conditions in a mobile environment where a user moves in and out of buildings and travels through the network at high speeds however can change very suddenly. The resulting signal strength fluctuations are so frequent and can be so extreme that a channel estimation technique that works in a fixed environment will easily fail in a mobile environment because it is not able to measure, calculate and report the changing channel conditions in the required time, which is measured in milliseconds.



Not accurately assessing and reporting channel conditions will have a devastating impact on the network capacity. For example, if the user device reports good channel conditions while its signal is actually weak then the base station may shift to MIMO and send two simultaneous transmissions to the device that can create interference with each other that can completely wipe out the device connectivity. This is obviously unacceptable, but the other extreme of reporting a weak channel while the signal conditions are actually good are also inexcusable because the user receives data at

slower transmission speed than they could have. This wastes network resources and reduces spectral efficiency, which also means that the service provider can support fewer customers and has to invest more money into adding network capacity.

Experience counts

Being able to properly perform the sophisticated channel estimation process in a mobile environment is a key capability that will decide over the fate of participants in the entire supply chain. If a chipset vendor with a bad MIMO implementation were to find a customer, then this customer would invest resources into building devices that will not be performance competitive, potentially wasting a lot of precious resources. Even worse would be if the company would find an inexperienced operator to actually sell inferior devices, whereby the operator provides devices to subscribers that can not perform at design capacity and, in essence, builds a network with reduced capacity. A competing operator with a network that has higher capacity can offer similar services for a lower fee as they can support more subscribers for the same investment. In addition customers won't tolerate excuses about poor performance relative to their expectations and the products offered by the competition. Such problems can make or break a fledgling mobile WiMAX service: If substandard, word will spread, and the operator will have to spend more money to attract and retain customers, undermining its competitive position. Well-designed user devices are a key to a successful 802.16e launch, and why the right implementation of key features like MIMO and its performance are so crucial for the success of Mobile WiMAX equipment makers.

When evaluating Wave 2 chipsets, mobile WiMAX device vendors should choose one that is designed for the rigors of a mobile environment and designed by a company that has the technical excellence required to properly develop and implement the complex algorithms required for the many advanced Mobile WiMAX features. One reliable quality indicator is when a vendor and its Mobile WiMAX chipset have been through extensive field trials. This experience advantage has helped refine algorithms to the point that they're sophisticated enough to estimate channel conditions accurately, even when users are moving at a fast pace, with frequent hand-offs. That ability creates a competitive advantage for 802.16e device vendors since they can market their products to operators knowing that they are built on industry leading experience and give operators the confidence that they won't negatively impact the network capacity.

Direct to Market

Wave 2 chipsets should also be designed to support multiple bands and channel bandwidths with a single, simple design. If not, it's much more difficult for the device vendor to tap the largest possible segment of the mobile WiMAX market.

To support this flexibility, Wave 2 chipsets must feature a direct conversion radio (DCR), which eliminates the need for surface acoustic wave (SAW) filters. This design allows vendors to develop a single 802.16e product SKU that can be sold into multiple markets, each of which has different mobile WiMAX spectrum bands. With the ideal Wave 2 chipset, device vendors can program in all four of the primary mobile WiMAX bands—2.3 GHz, 2.5 GHz, 3.3 GHz and 3.5 GHz—and the different channel bandwidths that can range from 5 MHz to 10 MHz.

Band Class	Frequency (GHz)	Bandwidth (MHz)
1A	2.3 – 2.4	8.75
1B	2.3 – 2.4	5 / 10
2A	2.305 – 2.320 2.345 – 2.360	3.5
2B	2.305 – 2.320 2.345 – 2.360	5
2C	2.305 – 2.320 2.345 – 2.360	10
3A	2.496 – 2.60	5 / 10
4A	3.3 – 3.4	5
4B	3.3 – 3.4	7
4C	3.3 – 3.4	10
5A	3.4 – 3.8	5
5AL	3.4 – 3.6	5
5B	3.4 – 3.6	7
5BL	3.4 – 3.8	7
5C	3.4 – 3.8	10
5CL	3.4 – 3.8	10

Figure 5. Frequency Band Classes

Eliminating SAW filters that are still used in many traditional designs gives device vendors more flexibility. SAW filters for different bands and bandwidths generally have different footprints. If a device vendor wants to switch to a different type of SAW filter to support a customer with different spectrum and channel bandwidth requirements, then it has to redesign its device to accommodate the new footprint. That change hurts the device vendor's competitive position by increasing its overhead costs and time-to-market. Consequently a Wave 2 chipset that doesn't use SAW filters is more competitive from a cost standpoint, by requiring fewer product design and also by reducing the chipset's component count and thus its bill of materials (BoM). Those savings improve the device vendor's ability to price its products at a point that is affordable to the widest possible market.

A DCR design also enables global roaming, which is key for mobile WiMAX services that target multinational enterprises and international business travelers. Considering that those users will be mobile WiMAX's early adopters and the most coveted, lucrative customers over the long term, 802.16e devices that can accommodate their global roaming needs will be particularly attractive in the eyes of service providers. Global roaming also is key for competing with cellular technologies such as CDMA2000 and UMTS, which are already available in many countries around the world.

In summary Mobile WiMAX—based on the IEEE 802.16e standard—is a major, long-term opportunity for service providers, device makers and chipset providers. To capitalize on that opportunity, both service providers and device makers should pay close attention to not only the Wave 2 chipset features, but also to the qualifications and experience of the vendors producing those chipsets.

About the Author

David Patterson is vice president of marketing for Beceem Communications, where he is responsible for a range of marketing initiatives relating to baseband and radio frequency chipsets. He joined Beceem with more than 11 years of executive management, product development and marketing experience in the wireless industry. Patterson served as the senior director of product management for Qualcomm, responsible for Global WCDMA operator relationships, business development, and WCDMA product management. He has also held positions with LSI Logic, Ericsson, and Lockheed Martin. Patterson received his Bachelor's degree in Physics and Mathematics from the University of Missouri and a Master's degree in Physics from the University of Missouri. He can be reached at: dpatterson@beceem.com.

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