CAN OFDM ENHANCEMENT DRIVE WiMAX MOBILITY FORWARD?

Today's operators require a smooth path to mobility; one that provides a future-proof solution, protects their investment and provides a sound business case. OFDM with subchannelization may be just the cost-effective solution they are after for their fixed to basic mobility business model. A solution that drives strong value differences in today's broadband mobility market.

By Vijay Dube

WiMAX covers a wide range of fixed and mobile applications. Analysts predict roughly 20 million subscribers for fixed services by 2009, while mobility figures vary between 15 and 40 million subscribers by the end of the decade (Figure 1).

The 802.16 WiMAX fixed protocol was officially adopted in October of 2004. Since that time, attention has turned to the development of the 802.16e WiMAX mobility protocol. This standard, which will include Orthogonal Frequency Division Modulation (OFDM) and OFDMA (also referred to as Multi-user OFDM), is expected to be completed in 2006. It will provide two primary areas of opportunity for the industry: basic, or urban mobility, which covers fixed to nomadic and portable applications; and full mobility which addresses the emerging broadband cellular market.

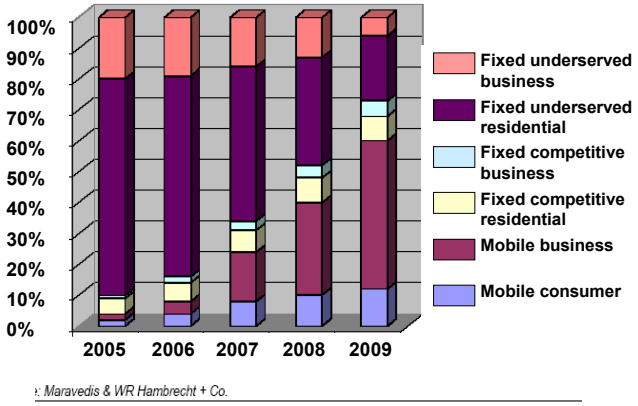

Figure 1: The higher cost of first generation WiMAX products (due to relatively limited production and potential interoperability adjustments) mandates that early WiMAX applications will favor high revenue generating applications, as well as underserved service areas such as backhauls and rural DSL extension.

For the purpose of this discussion, "fixed" is defined as a solution in which it is not possible to use the service from more than one location. "Mobility" covers different level of services including nomadicity (using a service in different locations), portability (basic mobility without soft handoff) and full mobility (high vehicular speed and seamless handoff between cells).

WiMAX basic mobility is the natural evolution of 802.16-2004 (OFDM256). It adds subchannelization to improve indoor performance and subscriber coverage flexibility in terms of throughput versus distance. OFDM256 basic mobility targets simple standard profiles and low-cost terminals. Fast time to market and backward compatibility with fixed applications are also retained as key values.

By comparison, WiMAX full mobility will follow a much more complex technical and challenging market path that may result in a larger market potential, but in the process puts it directly in the path of 3G. Based on scalable OFDMA (SOFDMA), WiMAX full mobility promises to deliver the performance and operational improvements required for cellular deployment, such as high-speed mobility and hand off, which would allow

in-vehicle users to switch from one base station to another seamlessly. These improvements however, come at the expense of a more complex PHY and MAC layer, an extensive inventory of profiles and lack of compatibility with existing OFDM256.

OFDMs PATH TO URBAN MOBILITY

In recent years, Intel's strong support of WiMAX and its characterization as a disruptive technology for low-cost broadband connectivity, earned the standard a high degree of visibility in the Telecommunications industry and contributed to its hype; even before anyone had an opportunity to experience a real WiMAX network implementation. A lot of pressure is now riding on WiMAX to deliver on that hype. But with the recent WiMAX shift to the OFDMA mobility standard, motivated by the large potential of the broadband mobility market, WiMAX's path to mobility may not be as smooth as the industry once expected.

Many industry players worry that shifting the focus of the WiMAX community singularly to scalable OFDMA, at this stage of the game, may induce severe penalties in terms of cost and implementation schedule. By the time the mobile version of SOFDMA user equipment is available in high volume and from a number of diverse suppliers, advanced 3G data networks using 1xEV-DO and WCDMA may well be already available from a well-established ecosystem.

Building on existing OFDM256 capacity to fulfill the fixed to basic mobility market space needs may be the best way to eliminate these concerns. It would provide the market window needed for WiMAX applications such as laptop connectivity and other portable devices, while highlighting the value difference between it and existing 3G technologies and WiFi serving the basic/urban mobility market.

The advantages of using OFDM256 to address the fixed to basic mobility market are numerous. In fact, many of the same OFDMA strengths are present in OFDM256. Both OFDM and OFDMA, for example, share the same basic advantages over other single-carrier mobile technologies in that they are highly suitable for NLOS environments. Here, the symbol period for each subcarrier is much greater than the maximum delay spread which simplifies equalization and optimizes FEC correction to tolerate the deep fades caused by multipath on multiple subcarriers.

Other important features included in OFDMA can also be supported in OFDM256 with less complexity in the physical (PHY) and the media-access control (MAC) layers. Some of the advantages and limitations of OFDM are:

- Scalable FFT

OFDM does not support scalable FFT, but rather a fixed 256 FFT structure. However, 256 FFT can offer as much granularity (carrier spacing) for most applications, as 2.5-MHz system bandwidth is a popular scenario in a typical 1:3 re-use pattern in a multi-sector cell design. On the other hand, OFDMA offers more flexibility in system design and scalability while keeping the same performance and the fixed equipment subcarriers spacing.

- OFDMA boasts theoretically superior system gain performance, but remains unproven in real implementation.

OFDMA offers high system gain performance by introducing up and downlink subchannelization. OFDM256 optionally supports uplink and downlink subchannelization which allows link budget improvement by concentrating the transmit power on a subset of the total OFDM subcarriers, which translates into coverage (indoor penetration), capacity and power consumption benefits. In OFDMA this feature, referred to as AMC (Advanced Modulation and Coding) is aiming at additional diversity gain through adaptive subcarrier allocation.

With regard to subcarrier permutation scheme, OFDM uses a less complex pattern of permutations. Its subchannels are distributed over frequency as with OFDMA but they are fixed in time for any given allocation. Consequently, if the OFDM subchannel falls on bad channel conditions (at least until the BS allocates a new subchannel), the advantage goes to OFDMA.

The bottom line is that OFDMA is well suited for full mobile applications, while more simple subcarrier permutations, fixed in time for a given subchannel allocation, are well suited for fixed, portable, or low mobility environments.

- Potentially better frequency re-use in favor of OFDMA.

OFDMA's more complex subcarrier permutation is aimed at better frequency reuse and easier cell planning (minimizing the probability of hits between adjacent sectors/cells by reusing subcarriers). OFDM offers a similar feature in the scheduler (MAC), although it is less systematic.

- Similar space diversity features for downlink.

The OFDMA Space-Time Code (STC) mode and AAS are supported as options for OFDM in the downlink segment.

WHY OFDM?

While OFDMA has the potential to offer more performance and scalability than OFDM for urban mobility, from an operational perspective it is not the ideal solution.

From a market strategy perspective alone, use of OFDM for covering both fixed as well as simple mobility applications provides a way to put WiMAX on the map substantially faster than waiting for OFDMA. Its value in the market is already known. Plus it gives WiMAX supporters a way to take advantage of the transition from fixed to basic mobility now, as it happens, while the window of opportunity to branch into wireless laptop, handheld devices and related applications still exists.

Furthering strengthening OFDM's position as the solution for urban mobility is that it features low-cost CPE, profile and engineering simplicity, market availability and upgradeability as well as backwards compatibility (a single path from fixed to basic mobility). These features are essential for building fast traction in an emerging WiMAX market, as well as for growing low-cost CPE volume shipments to reach the market commodity phase. Some of OFDM's most notable strengths are:

- Standards and profile simplicity.

OFDM supports 256 FFT which simplifies profiles with sufficient granularity for most allocated spectrum; assuming the usual cell frequency reuse pattern is employed. To date, WiMAX certification has faced delays so far due to equipment availability even in the limited profiles. Adding a myriad of profiles, as expected in scalable OFDMA, will only serve to make the certification much more complex and time consuming.

- Fast time to market.

The 802.16-2004 WiMAX protocol has already been published and 802.16e for OFDM is near completion. Minimal work needs to be done to cover the basic mobility requirements. Fast time to market is extremely important for an emerging market where addressing the window of opportunity with a low-cost product can make all the difference. Given the current market opportunity, WiMAX would provide the best product fit for wireless laptop and handheld devices; a segment in which 3G lacks cost-effective throughput and reliability and where WiFi offers limited coverage, a lack of security features and no carrier grade MAC.

- Low cost, proven technology.

OFDM, as defined in 802.16e, is far less complex than scalable OFDMA. It guarantees low-cost terminals and infrastructure to fit the emerging WiMAX markets in term of scalability and application flexibility. Such low-cost terminals can open a wider range of applications which in turn accelerates market traction and the ability to quickly reach mass production.

Since the OFDM standard is based on a number of proven solutions that have been successfully implemented in many wired and wireless applications, it is highly probable that it will achieve its targeted performance. Scalable OFDMA, on the other hand, tries to incorporate a wide variety of proposed technologies, some more proven than others. Since there has been only modest justification of proposed features on the basis of performance data, and since the final composition of these technologies is not yet completely determined, it is difficult to know whether a given feature will enhance performance.

- Upgradeability and backward compatibility.

Upgradeability is mandatory to protect customer investment as the WiMAX market evolves in terms of applications, operator diversity (including ISP, WISP, green field and infrastructure based, new and incumbents) and business case profiling. Without a path to mobility and the security of upgradeability and backward compatibility, many industry players, especially Tier 1 companies, will adopt a standstill position toward WiMAX. While Tier 1 players are notoriously slow movers in an emerging market, their presence is absolutely essential to reach volume shipments.

As shown in Figure 2, there is a technology overlap covering basic mobility. The technology of choice depends on the application, the carrier (a fixed carrier interested in basic mobility only), the size of the network (such as a low-density network in poorly deserved areas or a small specialized carrier for vertical applications), and the best cost efficiency for the application..

A strong polarization toward full mobility at this stage of WiMAX development may not be the best tactic or positioning to face direct competition from 3G. Many believe that WiMAX' sweet spot starts with the fixed to basic mobility market where current wireless technologies are not offering the throughput, affordable cost for high data-rate usage, security or reliability customers demand.

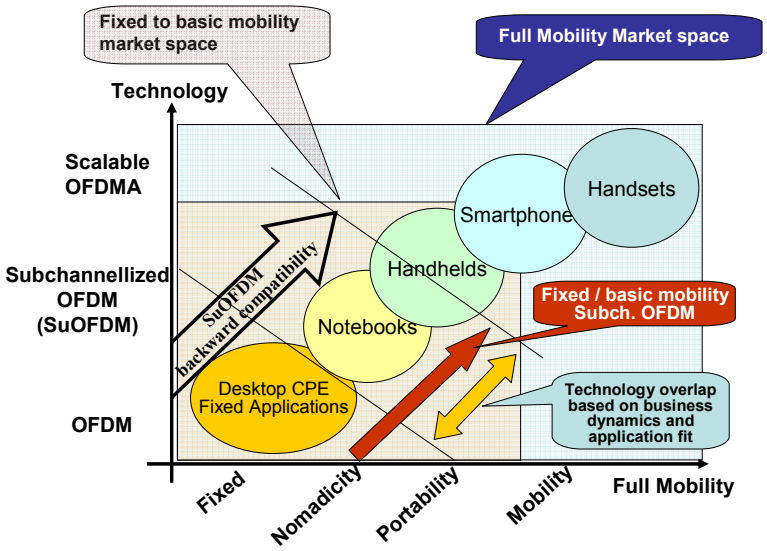

Figure 2: WiMAX basic mobility is covered by a range of overlapping technologies.

Once the first market steps for the transition from fixed to basic mobility have been successfully completed and the WiMAX ecosystem is backed by customer confidence, OFDMA will be in a prime position to help forge the path for WiMAX full mobility. Backed by a completed standard and certification, and building on the successes of OFDM256, OFDMA will be well equipped to face the full mobility challenge where entrenched leaders have already made tremendous progress in technology development and network deployments.

Conclusion

In contrast to OFDMA, OFDM has already gone through the definition stage and is now heading to full implementation. Today, a growing number of chip manufacturers, as well as Original Design Manufacturers (ODMs) and equipment makers, are developing their solutions based on OFDM256 WiMAX technology. This technology is field proven making it a safe choice for current and future deployments. By the end of 2005, many manufacturers will benefit from low-cost CPE packaging, such as miniPCI and other high-volume manufacturing formats, providing broadband service providers access to cost-effective solutions.

OFDM 802.16e highlights the operator's need for a smooth path to mobility; one that provides a future-proof solution, protects their investment and provides a sound business case. For the operator who is deploying fixed wireless access solutions today, and who wants to offer nomadic or mobile services in the future, OFDM256 is the only choice.

ABOUT THE AUTHOR

Vijay Dube is Vice President Marketing & Business Development at Wavesat. He is a seasoned executive with nearly 25 years of extensive experience in the global semiconductor industry. Before Wavesat, Vijay worked with leading Canadian semiconductor manufacturers such as Atsana Semiconductor Corporation and Dipix Systems Limited.