Wireless Equipment & Components

WiMAX: The Next Generation of Broadband Wireless Access

By Allen Henley

The next generation of broadband wireless access (BWA) is almost upon us. IEEE 802.16 standard and the WiMAX Forum will enable interoperability and lower price-points that were previously unattainable with proprietary point-to-point (PTP) and point-to-multipoint (PMP) communication schemes. This article provides an overview of the 802.16 standard, the WiMAX forum, and key applications.

The IEEE 802.16 Standard

In July 1999, the first formal gathering took place for the IEEE 802.16 Working Group on BWA. The original 802.16 standard described a 10-66 GHz point-to-point system using a traditional single carrier modulated with QAM. Since then, two different task groups have been chartered to define an interface targeted at 2-11 GHz for fixed, non-line-of-sight (NLOS) applications. This interface uses 256 carrier OFDM modulation and has most recently been known as '802.16d'; however, it will be published as simply 802.16 - 2004. While the original 802.16 standard for 10-66 GHz operation had very little industry adoption, the 2-11 GHz standard is exactly the opposite. Many vendors are working to introduce solutions that will support the new 256 carrier OFDM interface standard and will operate in bands from 2-6 GHz.

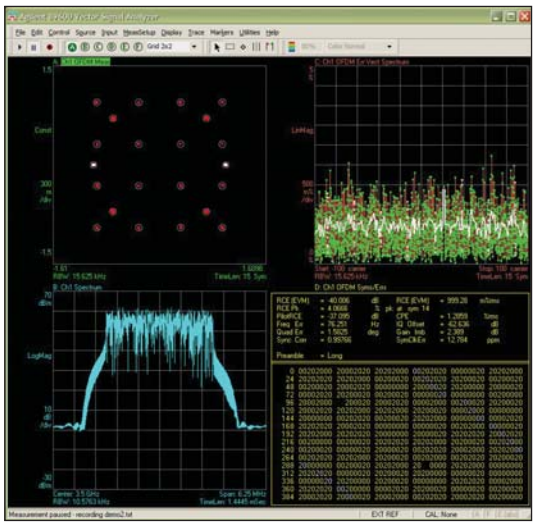

***Figure 1**. Typical OFDM spectrum with 200 carriers in use.*

By itself, the 802.16 standard is not sufficiently robust to guarantee good interoperability between devices from multiple vendors. Interoperability is seen as an enabler to help grow the market and reduce overall costs. To address these issues, a group of industry leaders including Intel and Nokia formed an organization called the WiMAX Forum. Although the WiMAX Forum is not formally connected with the IEEE, the purpose of the group is to help ensure interoperability, promote the 802.16 standard, and help grow the overall market acceptance for 802.16 as a BWA standard. The WiMAX Forum is growing rapidly and currently has over 100 members.

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One of the WiMAX Forums' first deliverables is to establish specific conformance procedures and testing labs to administer the testing. This process will result in 'WiMAX certified' products that have guaranteed interoperability with other WiMAX certified solutions. Initially, the first two WiMAX profiles are targeted at applications at 3.5 GHz and 5.8 GHz. WiMAX certification is expected to be in full swing by mid-2005.

Key Applications

WiMAX certified products are initially targeting applications such as wireless backhaul for telcos, high bandwidth/ high reliability remote connectivity, E1/T1 replacements for small and medium size businesses, and residential 'wireless DSL' for broadband Internet at home.

To address these diverse needs, vendors' solutions provide various level of price/performance. Premium devices provide carrier grade performance. These devices are engineered to provide guaranteed performance and reliability that is comparable to dedicated copper or fibre connections. An example application is a cellular service provider that needs backhaul for connecting remote cell towers or a remote oil platform that requires high bandwidth and guaranteed performance. The price/performance of these systems should be significantly better than existing proprietary solutions and will cause many existing copper or fibre links to convert to wireless.

Business Class is one of the largest segments of potential WiMAX applications. Typical applications will be connecting Wi-Fi hotspots to the Internet or replacing leased E1/T1 lines in commercial backhaul. Because 802.16 allows network operators to configure systems with different levels of bandwidth and quality of service, it is possible for operators to configure performance that matches an individual customer's needs. Some customers will require bandwidth and latency that is 'T1 equivalent' and may be willing to pay $500/month. Others need much less capability and expect to pay significantly less. WiMAX devices can be configured to meet both these needs with price/performance that is optimized for each customer.

A typical Consumer Class WiMAX device would be used for wireless DSL at home. 'Always On' connectivity and 1 to 2 Mbps transfer rate is sufficient for most home and small business needs. Because WiMAX is designed for NLOS and the base transceiver station (BTS) and consumer premise equipment (CPE) will be relatively inexpensive, wireless ISPs can deploy networks supporting individual neighborhoods that previously had very limited or no choices for broadband access. As volumes ramp up, expect CPE to cost $200-$300 for unlicensed band operation.

Air Interface

Although IEEE 802.16 defines multiple air interfaces, the WiMAX Forum and most vendors are currently focused on the 256 carrier orthogonal frequency division multiplexing (OFDM) air interface, which uses bandwidths between 1.25 and 20 MHz and is designed for NLOS frequencies <11 GHz. There is very little spectrum available above 5.8 GHz, so most vendors are targeting frequency bands from 2-6 GHz. Of the 256 carriers, only 200 are actually used, leaving unused carrier for guard bands and a null carrier at the channel center frequency. Used carriers include pilots and actual data.

Of these used carriers, subsets can be assigned to individual users or groups. This is known as sub-channelization and allows more granularity to dynamically allocate bandwidth and services. Figure 1 shows a typical OFDM spectrum with 200 carriers in use.

Framing is a traditional packet based structure that uses a preamble and header followed by data bursts. In the most simply configuration of a downlink frame, the BTS transmits a preamble, header, and multiple downlink bursts, with each burst assigned to a different user. In an uplink frame, each CPE transmits in TDM fashion, such that the burst from user 1 arrives at the BTS, followed by the burst from user 2, and so forth. Figure 2 shows typical downlink and uplink frames.

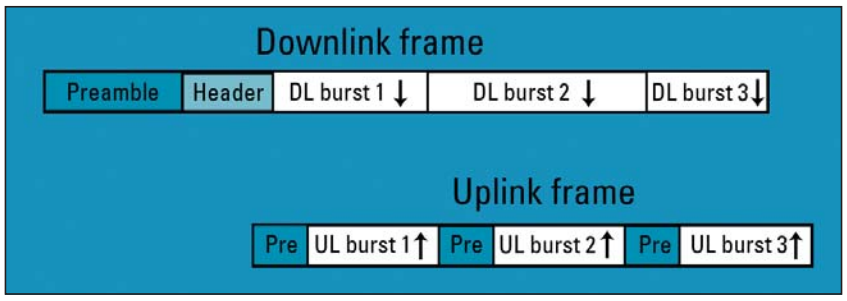

***Figure 2.** Typical downlink and uplink frames.*

These links can be configured as TDD, FDD, or half-duplex FDD. In TDD, the downlink and uplink transmission are on the same RF frequency, but not at the same time. In FDD, the downlink and uplinks are transmitted simultaneously, but on different RF frequencies.

Each preamble, header, and burst is made up of one or more OFDM symbols. Modulation on the OFDM carriers is BPSK, QPSK, 16 QAM, or 64 QAM. Signal conditions and bandwidth requirements will determine which modulation is selected for individual data bursts. Particularly interesting is the ability of the BTS to use different modulation formats on each data burst. Figure 3 shows a constellation diagram taken from an actual measured waveform. This constellation shows a frame control header with BPSK modulation, Downlink Burst 1 with QPSK modulation and Downlink Burst 2 with 16 QAM. Because of amplitude scaling, the BPSK, QPSK, and 16 QAM decision points do not fall on top of each other.

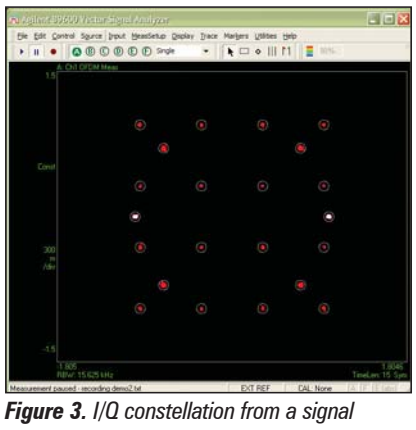

***Figure 3.** I/Q constellation from a signal downlink frame with BPSK, QPSK and 16 QAM modulation.*

Conclusion

WiMAX and the IEEE 802.16 standard will revolutionize the broadband wireless access industry and open many opportunities to deploy systems in applications that was previously cost prohibitive. WiMAX provides a viable competitive alternative to many applications currently serviced with copper, coax, and fibre connections. WiMAX is intended complement other wireless standards such as WLAN and cellular based data networks. Together these provide many options to meet customer needs and grow the overall opportunity for wireless systems.

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