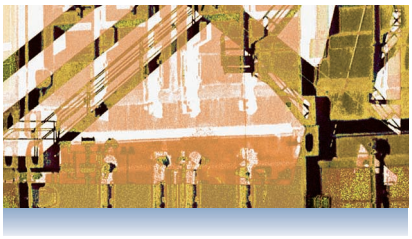
Achieving Wireless Broadband with WiMax

Steven J. Vaughan-Nichols

When users want broadband Internet service today, they're generally restricted to a T1, DSL, or cable-modem-based connection. However, these wireline infrastructures can be considerably more expensive and time consuming to deploy than a wireless one.

In addition, rural areas and developing countries frequently lack optical fiber or copper-wire infrastructures for broadband services, and providers are unwilling to install the necessary equipment for regions with little profit potential. Many residents thus must do without broadband service.



Wireless approaches could address this problem. Therefore, proponents are advocating WiMax (worldwide interoperability for microwave access), a technology based on an evolving standard for point-to-multipoint wireless networking. Carriers can use WiMax to provide wireless Internet service via transceivers to users' antennas.

Craig Mathias, principal analyst for the FarPoint Group, a technology and market analysis firm, said WiMax is the commercialization of the maturing IEEE 802.16 standard, which specifies the radio-frequency technology for wireless metropolitan area networks.

In addition to IEEE 802.16, WiMax addresses the European Telecommunications Standards Institute's (ETSI) similar high-performance radio metropolitan area network (HiperMAN) broadband standard, explained Dean Chang, director of product management for Aperto Networks, a vendor of broadband wireless access systems, and also a board member of the WiMax Forum. The forum is a wireless industry consortium supporting WiMax technology and promoting its commercial use. The "Promoting the Technology: The WiMax Forum" sidebar provides additional information about the consortium.

DRIVING FORCES BEHIND WIMAX

Point-to-multipoint microwave networks from companies such as Alcatel and Siemens have existed for years, but they have relied on proprietary technology. WiMax, on the other hand, offers a standardized technology.

WiMax's open approach could let manufacturers achieve economies of scale by building large quantities of products and components to one standard. It would also let equipment makers buy lower-cost, standards-compliant components from competing suppliers, explained Edward Rerisi, director of research for Allied Business Intelligence, a market research firm.

Promoting the Technology: The WiMax Forum

The WiMax Forum (www.wimaxforum.org)—a wireless industry consortium with about 100 members including such major vendors as AT&T, Fujitsu, Intel, and Siemens Mobile—is supporting WiMax technology and promoting its commercial use. As WiMax has gained traction, major companies such as British Telecommunications, France Telecom, and Qwest Communications have joined the forum.

The forum is preparing profiles for systems that comply with WiMax specifications and creating interoperability tests to make sure different vendors' implementations work together.

Eventually, vendors will be able to advertise that they are selling forum-certified, WiMax-compliant equipment. The forum plans to begin certifying products by the end of this year, according to board member Dean Chang, who is also director of product management for Aperto Networks, a vendor of broadband wireless access systems.

Although WiMax will support traffic based on various data-transport technologies such as asynchronous transfer mode, Ethernet, and the Internet Protocol, the forum will certify compliance only for the IP-related aspects of IEEE 802.16 products, explained Margaret LaBrecque, director of Intel's Industry Program for Broadband Wireless Division.

The focus is on the Internet Protocol because so many networking operations are IP based, noted Chang.

This would help existing wireless service providers. In addition, carriers without a mobile network could start a WiMax system at relatively low cost.

WiMax would also enable interoperability between systems, Mathias noted.

Rerisi anticipates that WiMax will provide high-speed network connections and thereby serve as a backbone for IEEE 802.11 wireless LAN hot spots, where roaming mobile users can access carriers' WiFi services. WiMax could thus offer a less expensive, easier to build infrastructure than the wireline WiFi backbones that DSL, cable, or T1 systems currently provide.

These factors, along with public demand for broadband services, will cause the WiMax and wireless-broadband markets to grow, predicted Rerisi.

Nonetheless, the technology faces several stiff challenges before it can become widely popular.

INSIDE WIMAX

Because WiMax is based on IEEE 802.16 and HiperMAN, the IEEE and ETSI have each adapted its standard to include many of the other's important features.

IEEE 802.16 divides its media-access-control layer into sublayers that support different transport technologies, including IPv4, IPv6, Ethernet, and asynchronous transfer mode. This lets vendors use WiMax no matter which transport technology they support.

WiMax has a long transmission range—up to 31 miles—because regulations allow WiMax systems to transmit at high power rates and because the approach's use of directional antennas produces focused signals.

To keep from serving too many customers and thereby greatly reducing each user's bandwidth, Rerisi said, providers will want to serve no more than 500 subscribers per 802.16 base station. Thus, he noted, each station will probably serve an area within a 10-mile radius.

WiFi, on the other hand, has a range of only several hundred feet, and third-generation cellular technology has a range of several thousand feet.

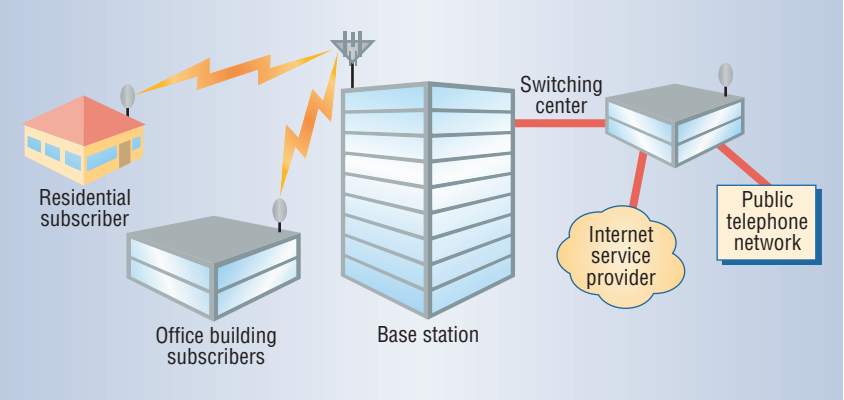


Figure 1. Initial plans are to use WiMax—a point-to-multipoint, broadband wireless-networking technology—for Internet access. Carriers would set up rooftop transceivers as base stations connected to the Internet. Each base station would use WiMax technology to communicate with fixed, externally mounted subscriber antennas.

As Figure 1 shows, WiMax proponents' initial vision is that carriers will set up rooftop transceivers as base stations connected to the Internet. Each base station would use WiMax technology to send and receive data to and from fixed subscriber antennas, mounted on rooftops or external walls.

WiMax vendors are currently working to upgrade the technology so that customers could use interior antennas.

Basic IEEE 802.16

Unlike other wireless standards, which address transmissions over a single frequency range, WiMax allows data transport over multiple broad frequency ranges.

Being able to work in multiple ranges maximizes the technology's ability to transmit over the frequencies that will avoid interfering with other wireless applications.

In addition, Aperto Networks' Chang explained, WiMax's transmission range and data rate vary significantly depending on the frequency bands an implementation uses. This flexibility lets providers use different frequencies depending on the range and speed required for a specific transmission.

The technology achieves high data rates in part via orthogonal frequency division multiplexing. OFDM increases bandwidth and data capacity by splitting broad channels into multiple narrowband channels—each using a different frequency—that can then carry different parts of a message simultaneously.

The channels are spaced very close together but avoid interference because neighboring channels are orthogonal to one another and thus have no overlap, explained Professor Douglas Jones of the University of Illinois, Urbana-Champaign.

The initial 802.16 standard operates in the 10 to 66 GHz range. At these higher frequencies, IEEE 802.16 requires a direct line of sight between senders and receivers. This reduces multipath distortion, which occurs when broadcast signals not following a line of sight bounce off of large objects and end up out of synch, thereby scrambling the received transmission and decreasing bandwidth.

Reducing multipath distortion, therefore, increases bandwidth. Theoretically IEEE 802.16 can provide single-channel data rates up to 75 Mbits per second on both the uplink and downlink.

Providers could use multiple IEEE 802.16 channels for a single transmission to provide bandwidths of up to 350 Mbps.

The popular IEEE 802.11b WiFi

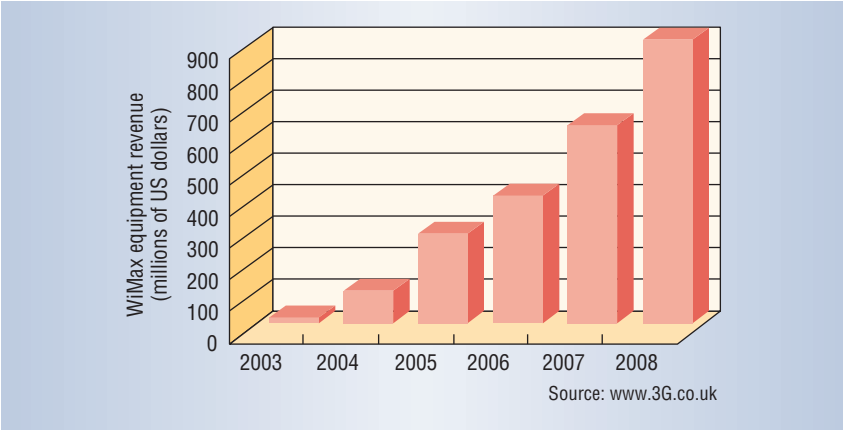


Figure 2. As WiMax technology becomes more popular, equipment sales are expected to grow significantly.

wireless LAN technology's maximum data rate is only 11 Mbps per channel, while the newer 802.11a and 802.11g theoretically provide up to 54 Mbps, although all deliver less in practice. Third-generation cellular technologies will offer up to 115 Kbps.

For security, WiMax uses public-key-infrastructure authentication, in which trusted authorities identify parties to a transmission via digital certificates. The system encrypts data via 56-bit Data Encryption Standard keys.

Meanwhile, WiMax is highly scalable because it is easy to add transmission channels to provide more bandwidth as necessary.

IEEE 802.16 extensions

The IEEE's 802.16 Working Group has adopted several extensions to the technology's basic standard, noted Working Group chair Roger B. Marks, a scientist with the US National Institute of Standards and Technology.

IEEE 802.16a. The IEEE has developed 802.16a for use in licensed and license-exempt frequencies from 2 to 11 GHz. Most commercial interest in IEEE 802.16 is in these lower frequency ranges.

At the lower ranges, the signals can penetrate barriers and thus do not require a line of sight between transceiver and antenna. This enables more flexible WiMax implementations while maintaining the technology's data rate and transmission range.

IEEE 802.16a supports mesh deployment, in which transceivers can pass a single communication on to other transceivers, thereby extending basic 802.16's transmission range.

IEEE 802.16b. This extension increases the spectrum the technology can use in the 5 and 6 GHz frequency bands and provides quality of service. WiMax provides QoS to ensure priority transmission for real-time voice and video and to offer differentiated service levels for different traffic types, Chang explained.

IEEE 802.16c. According to Marks, IEEE 802.16c represents a 10 to 66 GHz system profile that standardizes more details of the technology. This encourages more consistent implementation and, therefore, interoperability.

IEEE 802.16d. According to Chang, IEEE 802.16d includes minor improvements and fixes to 802.16a. This extension also creates system profiles for compliance testing of 802.16a devices.

IEEE 802.16e. This technology will standardize networking between carriers' fixed base stations and mobile devices, rather than just between base stations and fixed recipients. IEEE 802.16e would enable the high-speed signal handoffs necessary for communications with users moving at vehicular speeds.

Referring to this extension, Margaret LaBrecque, director of Intel's Industry Program for Broadband Wireless Division, said, "It's three to five years from deployment."

WiMax chipsets

Various vendors plan to release WiMax chipsets. For example, Wavesat, in partnership with Atmel, hopes to produce them this year. Fujitsu is also working on WiMax chipsets. Intel plans to sell chipsets that will include both the 802.11 and 802.16 technologies. The products include both networking circuitry and a radio. The antenna is located off the chipset. The chipsets initially will be implemented in transceivers and later in computers themselves.

A challenge in implementing WiMax on chipsets, Chang explained, is that the powerful radio section can cause heat problems and also interfere with the networking component's operations.

FACING CHALLENGES

Some critics argue that much of the radio spectrum needed to deploy WiMax has already either been distributed by governments or dedicated for other purposes by carriers.

Also, the cost of deploying wireless technology is considerably more when the service is offered at higher radio frequencies because the line-of-sight requirements necessitate the installation of additional antennas to cover the same service area. The frequencies available for new technologies such as WiMax are frequently the higher ones because many of the more desirable lower spectrum ranges have been licensed for other uses.

However, Allied Business Intelligence's Rerisi said, "There's still lots of unlicensed spectrum available in the 2.5 to 3.5 GHz range, and companies like Sprint and Nextel already have a ton of spectrum they're not using."

WiMax, particularly the mobile version, may face serious competition from IEEE 802.20 mobile broadband technology, which targets high-speed,

wireless, IP-based connectivity to devices such as cellular phones, PDAs, and laptops. The technology will operate in the 500 MHz to 3.5 GHz range.

While the two standards are not designed to do exactly the same things, Rerisi said, "They both aim to serve similar [mobile] users."

Many analysts say WiMax will become successful and popular, in part because of strong support from Intel, which has considerable resources, marketing muscle, and influence.

The www.3G.co.uk news service, which focuses on third-generation wireless technology, estimates that revenue from WiMax equipment sales will increase rapidly at least through 2008, as Figure 2 shows.

However, because not all aspects of the technology have been finalized, the FarPoint Group's Mathias said, "Mass deployment is a couple of years away." The WiMax Forum, Chang explained, won't even release WiMax certification tests until late this year.

WiMax will have to compete with the proprietary broadband wireless technologies that are already established in the marketplace, Rerisi noted.

Nonetheless, he said, if WiMax companies don't give up, they may well begin to gain on proprietary approaches by the end of this decade because of the interoperability and lower prices that the standardized technology will offer.

Mathias said he doesn't see WiMax overtaking DSL and cable as a popular broadband Internet-access technology because they're so well established.

The real key for WiMax in the marketplace, he said, will be how IEEE 802.16e functions as a mobile approach, because this is where future market demand for the technology will be the greatest. ■

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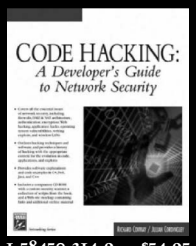

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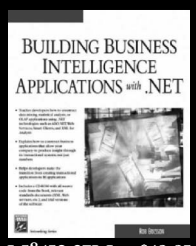

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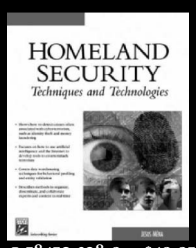

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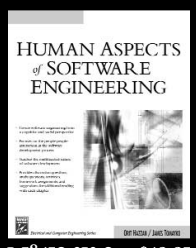

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