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# IEEE 802.16 Backgrounder (DRAFT)

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## Broadband Wireless Access: An Introduction to the Technology Behind the IEEE 802.16 WirelessMAN™ Standard

Broadband wireless access (BWA) has become the best way to meet escalating business demand for rapid Internet connection and integrated data, voice and video services. BWA can extend fiber optic networks and provide more capacity than cable networks or digital subscriber lines (DSL). One of the most compelling aspects of BWA technology is that networks can be created in just weeks by deploying a small number of base stations on buildings or poles to create high-capacity, point-to-multipoint (PMP) systems.

BWA has had limited reach so far, in part because of the unmet need for a universal standard. While providing such a standard is important for developed countries, it is even more important for the developing world where wired infrastructures are limited.

## The IEEE 802.16 WirelessMAN™ Standard

The Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) sought to make BWA more widely available by developing IEEE Standard 802.16, which specifies the WirelessMAN Air Interface for wireless metropolitan area networks. The standard, which was published on 8 April 2002, was created in a two-year, open-consensus process by hundreds of engineers from the world's leading operators and vendors.

IEEE 802.16 addresses the "first-mile/last-mile" connection in wireless metropolitan area networks. It focuses on the efficient use of bandwidth between 10 and 66 GHz (the 2 to 11 GHz region with PMP and optional Mesh topologies by the end of 2002) and defines a medium access control (MAC) layer that supports multiple physical layer specifications customized for the frequency band of use.

The 10 to 66 GHz standard supports continuously varying traffic levels at many licensed frequencies (e.g., 10.5, 25, 26, 31, 38 and 39 GHz) for two-way communications. It enables interoperability among devices, so carriers can use products from multiple vendors and warrants the availability of lower cost equipment. The draft amendment for the 2 to 11 GHz region will support both unlicensed and licensed bands.

## Telecommunications Choices

Business-based telecommunications encompasses many options. Major businesses often access large-capacity, high-speed fiber optic networks for broadband, converged services. Less than five percent of commercial structures worldwide are served by fiber networks, however, and extending these networks with cable is costly and time consuming.

Today, small businesses and residential customers typically use wired networks such as cable modem networks and DSL. Cable systems are based on residential cable TV infrastructure, so they are often not available in serving business subscribers. DSL is a copper-based method that typically offers 128 kbps to 1.5 Mbps data services, however service is not available to every subscriber because of distance limitations from the central office.

DSL, cable and older wireless systems tend to have low upstream bandwidth. The same is true of another option, two-way satellite transmission, which is still early in its life cycle. While invaluable in some rural areas, it has limited application in more populous locales due to limited spectrum availability and high latency.

IEEE Standard 802.16 BWA systems offer true differentiated broadband services at minimal cost. They let thousands of users share capacity for data, voice and video. They also are scalable: carriers can expand them as subscriber demand for bandwidth grows by adding channels or cells.

## Quality of Service (QoS) in Broadband Wireless

BWA transmission is via free space, and is subject to attenuation and distortion by various matter such as vegetation, buildings, precipitation and vehicles, which move and change unpredictably. IEEE Standard 802.16 recognizes this and includes mechanisms to make robust links for PMP BWA systems with line-of-sight. Obstructed line-of-sight and non line-of-sight transmission are considered in the 2-11 GHz draft amendment.

Mechanisms in the WirelessMAN MAC provide for differentiated QoS to support the different needs of different applications. For instance, voice and video require low latency but tolerate some error rate. By contrast, generic data applications cannot tolerate error, but latency is not critical. The standard accommodates voice, video, and other data transmissions by using appropriate features in the MAC layer, which is more efficient than doing so in layers of control overlaid on the MAC.

Many systems in the past decade have involved fixed modulation. Higher-order modulation in such systems offers higher data rates but requires optimal links, while lower orders of modulation are more robust but support lower data rates. The new standard supports adaptive modulation, effectively balancing different data rates and link quality. The modulation method may be adjusted almost instantaneously for optimum data transfer. Adaptive modulation allows efficient use of bandwidth and a broader customer base.

The standard also supports both frequency and time division duplexing (FDD and TDD). Frequency division duplexing (FDD), the legacy duplexing method, has been widely deployed in cellular telephony. It requires two channel pairs, one for transmission and one for reception, with some frequency separation between them to mitigate self-interference.

In regulatory environments where structured channel pairs do not exist, TDD provides a highly flexible duplexing scheme where a single channel is used for both upstream and downstream transmissions. A TDD system can dynamically allocate upstream and downstream bandwidth depending on traffic requirements.

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# More on the IEEE 802.16 Working Group

Since July 1999, the IEEE 802.16 Working Group on Broadband Wireless Access has been openly developing voluntary consensus standards for Wireless Metropolitan Area Networks with global applicability. Addressing the demand for broadband access to buildings, IEEE 802.16 provides solutions that, in many cases, are more economical than wireline alternatives. The standards set the stage for a revolution in reliable, high-speed network access in the first mile (also known as the "last mile") by homes and enterprises.

The Working Group has completed, and is currently enhancing, two IEEE Standards:

- The IEEE 802.16 WirelessMAN™ Standard ("Air Interface for Fixed Broadband Wireless Access Systems") addresses Wireless Metropolitan Area Networks. Following a two-year effort, the initial standard, covering systems between 10 and 66 GHz, was approved, in December 2001, for publication. IEEE Standard 802.16 was published on 8 April 2002. The Working Group is currently development Amendment 802.16a to expand the scope to licensed and license-exempt bands from 2 to 11 GHz. Amendment 802.16c is in progress, developing 10-66 GHz system profiles to aid interoperability specifications.
- IEEE Standard 802.16.2 is a Recommended Practice on "Coexistence of Fixed Broadband Wireless Access Systems" covering 10-66 GHz. IEEE Standard 802.16.2 was published on 10 September 2001 and is now available for download without charge. In developing Amendment 802.16.2a, the Working Group is expanding the scope include to licensed bands from 2 to 11 GHz as well as enhancing the recommendations regarding point-to-point systems.

Other projects are also being formulated. The Mobile Broadband Wireless Access (MBWA) Study Group was formed in March 2002.

The Working Group operates in an open, accredited process under the rules of the IEEE 802 LAN/MAN Standards Committee. Meeting bimonthly, it has a record of rapidly reaching technical consensus. As of May 2002, 130 people were Members of the Working Group. Over 700 individuals have attended a session.

The IEEE 802.16 Working Group maintains close relationships with other standardization groups, including ITU, ETSI and well as the IEEE 802.11 (Wireless LAN) and 802.15 (Wireless PAN) Working Groups.

For more information, see the WirelessMAN web site (http://WirelessMAN.org) or contact the Chair, Dr. Roger B. Marks).

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