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Purpose	To provide a summary of the Working Group for purposes of public relations.
Notice	
Release	
Patent Policy and Procedures	

Consensus IEEE 802.16 Standard Marks Maturation of Broadband Wireless Access Industry[1]

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Abstract
With the completion of the IEEE Standard 802.16® WirelessMAN™ air interface, broadband wireless access (BWA) is reaching maturity as a serious alternative for broadband access deployment. Once the 802.16a amendment is complete, the standard will specify interoperable wireless metropolitan area network (wireless MAN) air interfaces from 2-66 GHz, including licensed and license-exempt operation, under a single umbrella with a common medium access control layer (MAC). The standard represents future-looking technology designed specifically for the unique problem of the wireless metropolitan area network (MAN) environment and will offer tremendous advantages over proprietary interfaces or those based on wireless local area network (LAN) or mobile telephone technology.

Fixed broadband wireless access (BWA) has, for several years, been expected to serve as one of the three primary technologies supporting ubiquitous broadband access. While digital subscriber line (DSL) and cable-modem networks have experienced deployment problems, their use has nevertheless grown rapidly . Industry analysts who have waited for fixed wireless to take its place as a serious alternative for broadband access have, so far, been disappointed. Yet expectations for wireless remain high. The January report "A National Imperative: Universal Availability of Broadband by 2010" issued by the industry group TechNet continued to emphasize the role of fixed wireless as the third leg in broadband access. Furthermore, the report's call for 100 Mbit/s service to 100 million American homes and small businesses by 2010 implicitly places further emphasis on fixed wireless, since these data rates are beyond the capabilities of the current DSL and cable infrastructures.

Those who expected rapid deployment of BWA may have failed to consider the relative immaturity of the technology and the absence of standardized equipment. Large-scale deployments of cable and DSL modems were founded upon multiyear efforts to develop stable and broadly supported technical standards. Finally, in 2002, broadband wireless access is reaching maturity, marked by the completion and acceptance of IEEE Standard 802.16-2001, and important enhancements, defining the IEEE Standard 802.16® WirelessMAN™ air interface. Once the enhancements are complete this fall, the standard will specify interoperable wireless metropolitan area network (wireless MAN) air interfaces from 2to 66

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GHz, including licensed and license-exempt operation, under a single umbrella with a common medium access control layer (MAC). The standard represents future-looking technology designed specifically to solve the unique problem of the wireless metropolitan area network (MAN) environment. It will offer tremendous advantages over proprietary interfaces or those based on wireless local area network (LAN) or mobile telephone technology. It was patiently developed, with intense scrutiny, over the course of three years by a broad, worldwide, consensus team that persisted in spite of industry fluctuations and in the face of private efforts to shortcut the process. The work was conducted by the 130 members, 128 former members, and hundreds of other individual participants (from 19 countries) of the IEEE 802.16 Working Group on Broadband Wireless Access <http://WirelessMAN.org>.

The core function of a fixed (that is, stationary) BWA system is to provide network access to buildings. In a home or small business, BWA will compete with cable or DSL networks. In a midsize commercial building, BWA can support high-data-rate connections that might otherwise be available only with a fiber-optic line. In spite of the wide deployment of fiber in network backbones, it remains rare in network access due to the high construction and right-of-way costs.

IEEE Standard 802.16 supports a point-to-multipoint topology in which each base station, normally connected to a public network, communicates with perhaps hundreds of stationary subscriber stations, each of which is typically mounted on a rooftop. Through the WirelessMAN™ MAC, each base station allocates uplink and downlink bandwidth to satisfy, almost instantaneously, the prioritized bandwidth requirements of the subscribers. The air interface is designed to carry any data or multimedia traffic with full Quality of Service (QoS) support. The MAC supports burst frequency-division duplex (FDD) and time-division duplex (TDD) in a consistent framework. It also supports real-time adaptive modulation and coding so that, in each burst, communication in the link to each subscriber station is optimized at that instant.

IEEE Standard 802.16-2001 (completed in October 2001 and ready for March 2002 publication) defines the WirelessMAN-SC air interface, a single-carrier (SC) modulation scheme for 10-66 GHz operation. At these frequencies, propagation is strictly line-of-sight, but tremendous spectral allocations (such as 1.3 GHz of spectrum in the U.S. Local Multipoint Distribution Service (LMDS) allocation) are available. The standard takes full advantage of the allocations, specifying bit rates of up to 120 Mbit/s on each reusable 25 MHz channel. The primary markets will include commercial, industrial, and multi-tenant residential buildings. The opportunities for the success of such operations has not been demonstrated, but the availability of standard equipment is sure to reinvigorate the risk-averse capital markets funding them. In further support of this industry, the 802.16 Working Group has completed IEEE Standard 802.16.2-2001, a Recommended Practice on Coexistence, and is currently developing, in Project 802.16c, system profiles for use in compliance and interoperability testing.

While the WirelessMAN MAC in IEEE Standard 802.16 provides the foundation for a wireless MAN industry, the physical layer (PHY) is not suitable for lower-frequency applications, where the available spectrum allocations are narrower and non-line-of-sight operation is required. For this reason, most of the effort in the 802.16 Working Group has gone toward the development and completion of IEEE 802.16a, an amendment to address 2-

11 GHz operation. Successive versions of the 802.16a draft have been in ballot since November 2001, and the details are nearing completion. The amendment includes both licensed and 5-6 GHz license-exempt bands. In the licensed bands, the current draft provides for compliance using any of three physical layer modes: single-carrier modulation, orthogonal frequency division multiplex (OFDM), or orthogonal frequency division multiple access (OFDMA), with advanced antenna options supported. Given the variety of regulatory environments and deployment scenarios worldwide, these options provide licensed operators with the opportunity to customize their solution. On the other hand, the license-exempt spectrum is generally more chaotic and more in need of direction from the standards body. In the case of 802.16a, the current draft specifies the OFDM mode in license-exempt spectrum.

In license-exempt operation, wireless MANs are susceptible to interference with other wireless MANs as well as with other devices such as wireless LANs. As one solution to this problem, the 802.16a draft specifies a dynamic frequency selection method for license-exempt bands similar to the one being standardized in IEEE Project 802.11h. The draft also supports the use of a mesh architecture in which some subscriber stations communicate with other data-forwarding subscriber stations rather than directly with the base station. This allows extending the cells and reaching customers not directly reachable from the base station. The defined scheduling algorithms provide for collision-free transmissions in mesh deployment. The protocols also eliminate the hidden-terminal problem typical of wireless LANs.

IEEE 802.16 Working Group has become the focal point of the world's broadband wireless access industry. The only other active standardization activities are within the Broadband Radio Access Networks (BRAN) of the European Telecommunications Standards Institute (ETSI). However, the 802.16 group works closely with BRAN, and BRAN's 2-11 GHz HIPERMAN project has essentially followed 802.16's lead. Industry consortia that sprung up to short-circuit 802.16's efforts have also yielded to 802.16's lead, or fallen by the wayside. One important new player is the Worldwide Interoperability for Microwave Access (WiMAX) Forum, whose mission includes promoting IEEE Standard 802.16 to achieve global acceptance as well as developing and implementing test procedures to ensure interoperability.

As the 802.16a amendment reaches its conclusion, the Working Group's members are entitled to look forward to a little time away from the continued rigor of standards development. However, they may not get a break. The next great hurdle is to bring a level of portability or mobility into the standard. Many of the participants recognize that limited mobility is a feasible near-team goal. However, following the lead of a new group of participants who are anxious to push even harder in the direction of mobility, the Working Group on March 15 initiated the IEEE 802.16 Study Group on Mobile Broadband Wireless Access, whose scope includes "mobile broadband wireless access networks operating in licensed frequency bands and supporting mobility at vehicular speeds." This Study Group will meet along with the Working Group's Session #19 (Calgary on 20-24 May 2002).

As the many applications and extensions of the IEEE 802.16 standard unfold, the core that unites all of these remains the WirelessMAN MAC. This forward-looking and flexible design holds the promise of future multitiered wireless metropolitan area networks that support fixed and mobile devices with data-centered multimedia services. It's no wonder that independent observers are increasingly viewing IEEE 802.16 as the foundation of the Fourth Generation

of wireless communications. If called to do so, the standard will serve well in that role. The IEEE 802.16 WirelessMAN standard was forged with time and heat and built to last. The history of the effort bodes well for its widespread and effective deployment worldwide.