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*** DRAFT 4 ***
Institute of Electrical and Electronics Engineers (IEEE)

BROADBAND WIRELESS ACCESS STANDARDS IN THE MOBILE SERVICE

This contribution was developed by IEEE Project 802, the Local and Metropolitan Area Network Standards Committee ("IEEE 802"), an international standards development committee organized under the IEEE and the IEEE Standards Association ("IEEE-SA").

The content herein was prepared by a group of technical experts in IEEE 802 and industry and was approved for submission by the IEEE 802.16 Working Group on Wireless Metropolitan Area Networks, the IEEE 802.18 Radio Regulatory Technical Advisory Group, and the IEEE 802 Executive Committee, in accordance with the IEEE 802 policies and procedures, and represents the view of IEEE 802.

IEEE thanks ITU-R for the liaison statement in Document IEEE L802.16-06/010 requesting input for the completion of the PDNR on "Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the Mobile Service operating below 6 GHz."

We note that Attachment 1 to IEEE L802.16-06/010 (Annex 17 to Document 8A/176) contains many standards and this contribution addresses only the parts covering the harmonized IEEE and ETSI standards for broadband wireless access in the mobile service.

IEEE 802.16 has also reviewed the technical details in the liaison contribution from ETSI BRAN in Attachments B and C to Doc. 8A/??? (Doc. IEEE L802.16-06/012) and confirms the accuracy of the information provided as it pertains to the IEEE 802.16 standard. This is shown in Attachment 1 including change marks to facilitate the update of the text, where editorial improvements have also been implemented. Attachment 2 confirms the technical information on the IEEE 802.16 standard for Annex 6 (to Annex 17 to Doc. 8A/376).

Regarding Annex 1 to Annex 17 to Doc. 8A/376, please refer to the updated information provided in Attachment 3. The values for the table in Annex 6 are provided in Attachment 2.

IEEE looks forward to continued cooperation with Working Party 8A on the development of future Recommendation(s) on broadband wireless access standards in the Mobile Service.

Attachment 1

Proposed Amendments to Annex 3
(to Annex 17 to Doc. 8A/376)

IEEE and ETSI harmonized radio interface standards, for broadband wireless access (BWA) systems including mobile and nomadic applications in the mobile service

1   Overview of the radio interface

The IEEE standard 802.16 (including the 802.16e-2005 amendment), and ETSI HiperMAN v.1.3.2 standards define harmonized radio interfaces for the OFDM and OFDMA modes Physical layers (PHY) and MAC/ (Media Access Control) / DLC features, including various hand-off types(Data Link Control) layer, however the ETSI BRAN HiperMAN targets only the nomadic applications, while the IEEE 802.16e standard is intended foralso targets full vehicular applications.

The use of frequency bands below 6 GHz provides for an access system to be built in accordance with this standardized radio interface to support a range of applications, including full mobility, enterprise applications, and residential applications in urban, suburban and rural areas nomadic and mobile applications. This. The interface is also optimized for dynamic mobile radio channels and provides support for optimized hand-offsoff methods and roaming.comprehensive set of power saving modes. The specification could easily support both generic internet-type data and real-time data, including applications such as voice and videoconferencing.

This type of system is referred to as a wireless metropolitan area network (WirelessMAN in IEEE and HiperMAN in ETSI BRAN). The word "metropolitan" refers not to the application but to the scale. The design is primarily oriented toward outdoor applications. The architecture for this type of system is primarily point-to-multipoint, with a base station serving subscribers in a cell that can range up to a few km. Users can access various kinds of terminals, e.g. handheld phones, smart phone, PDA, handheld PC and notebooks in a mobile environment. The radio interface supports a variety of channel widths and operating frequencies, such as 1.25, 3.5, 5, 7, 8.75, 10, 14, 15, 17.5, 28 and 20 MHz and for operating frequencies below 6 MGHz. The use of orthogonal frequency division multiplex (OFDM) and orthogonal frequency division multiplexing access (OFDMA) offers considerable improvement in bandwidth efficiency due to combined time/frequency scheduling and flexibility when managing different user devices with a variety of antenna types and form factors. It brings a reduction in interference for user devices with omni-directional antennas and improved NLOS capabilities that are essential when supporting mobile subscribers. Sub-channelization defines sub-channels that can be allocated to different subscribers depending on the channel conditions and their data requirements. This gives the operatorservice providers more flexibility in managing the bandwidth and transmit power, and leads to a more efficient use of resources, including spectrum resources.

The radio interface supports a variety of channel widths and operating frequencies, providing a peak spectral efficiency of up to 43.5 bits/s/Hz.

The radio interface includes in a physical layer (PHY) as well as a medium-access control layer (MAC).single receive and transmit antenna (SISO) configuration.

The radio interface includes PHY as well as MAC/DLC. The MAC/DLC is based on demand-assigned multiple access in which transmissions are scheduled according to priority and availability. This design is driven by the need to support carrier-class access to public networks, ~~both internet protocol~~ through supporting various convergence sub-layers, such as Internet Protocol (IP) and ~~asynchronous transfer mode (ATM)~~ Ethernet, with full quality-of-service (QoS) ~~support~~.

~~The MAC supports several PHY specifications, depending on the frequency bands of interest and the operational requirements. In particular, the alternatives include, typically, below 6 GHz.~~

~~WirelessMAN-OFDM and HiperMAN, the OFDM PHY mode: this specification is based on orthogonal frequency-division multiplexing (OFDM).~~

~~ii)   WirelessMAN-OFDMA and HiperMAN, the OFDMA PHY mode: this specification is based on orthogonal frequency-division multiple access (OFDMA).~~

~~iii)   WirelessMAN-Sca: this specification uses single-carrier transmission.~~

~~All of the PHYs use the same MAC, harmonized between~~ The harmonized MAC/DLC supports the OFDM (orthogonal frequency-division multiplexing) and OFDMA (orthogonal frequency-division multiple access) PHY modes.

Figure 1 illustrates pictorially the harmonized interoperability specifications of the IEEE WirelessMAN and the ETSI HiperMAN standards, which include specifications for the OFDM and OFDMA physical layers as well as the entire MAC layer, including security.

FIGURE 1

BWA Standards harmonized for interoperability for frequencies below 6 GHz
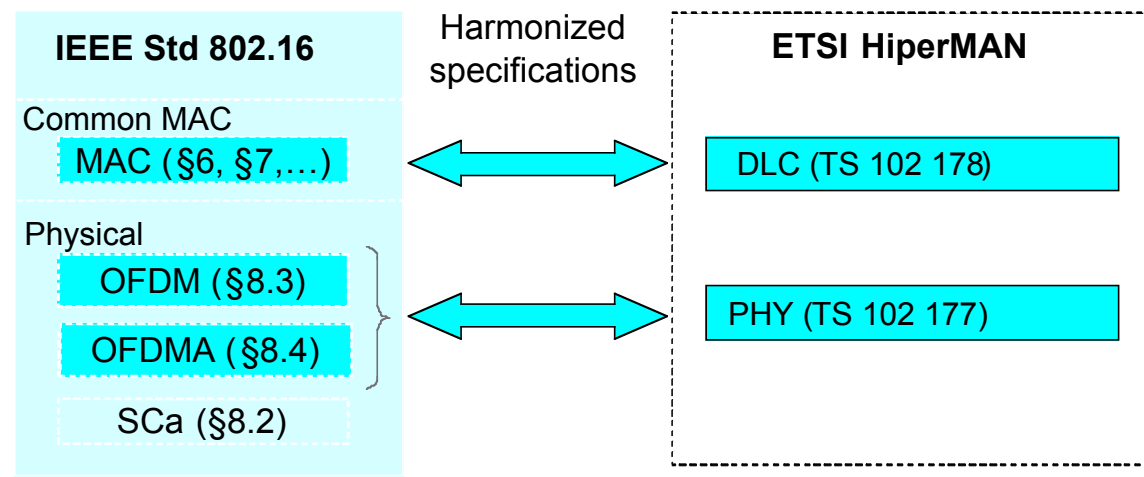
The WiMAX Forum, IEEE 802.16 and ETSI HiperMAN ~~(named DLC in HiperMAN).~~

~~The SDOs~~ define profiles for the recommended interoperability parameters[1]. IEEE 802.16 profiles are included in the main standards document, while HiperMAN profiles are included in a separate document. TTA defines profile for WiBro service which is referred to WiMAX Forum profiles.

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[1] ~~[WiMAX and WiBro are profiles defined for the recommended interoperability parameters. The WiBro standard (TTAS.KO-06.0082/R1,2005) was developed by TTA and it uses WirelessMAN TDD/OFDMA which is one of the IEEE 802.16 alternatives.]~~

TTA maintains a standard TTAS.KO-06.0082/R1 for WiBro service, which is portable Internet service in Korea. The standard is a subset of IEEE Std 802.16 including the IEEE 802.16e-2005 amendment and the IEEE 802.16-2004/Cor1 corrigendum.

2 Detailed specification of the radio interface

2.1 IEEE 802.16e

IEEE Standard for local and metropolitan area networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems—Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands.

IEEE Std 802.16™ is an emerging suite of standardsair interface standard for broadband wireless access (BWA). IEEE Std 802.16e-2005, an amendment to the IEEE Std 802.16-2004 base specification,The base standard, IEEE Std 802.16-2004, address fixed and nomadic systems only. The amendment IEEE 802.16e-2005 enables combined fixed and mobile operation in licensed frequency bands under 6 GHz. This combination of IEEE Std 802.16-2004 andThe current IEEE 802.16 (including the IEEE Std 802.16e-2005 amendment) is designed as a high-throughput packet data radio network radio-capable of supporting several classes of IP applications and services based on different usage/, mobility, and business models. To allow such a diverse combination of usage, mobility, and deployment modelsdiversity, the IEEE Std 802.16-2004 and IEEE Std 802.16e-2005 air interface is designed with a high degree of flexibility and an extensive numberset of options.

Abstract: This amendment IEEE Std 802.16e-2005 updates and expands IEEE 802.16-2004 to allow for mobile stations.

Scope: This document provides enhancements to IEEE 802.16-2004 to support stations moving at vehicular speeds and thereby specifies a system for combined fixed and mobile broadband wireless access. Functions to support higher layer handover between base stations or sectors are specified. Operation is limited to licensed bands suitable for mobility below 6 GHz. The fixed subscriber capabilities given in IEEE Std 802.16-2004 are not compromised.

The mobile broadband wireless technology, based on IEEE-802.16 standard offers scalability in air interface and network architecture thus enables flexible network deployment and service offerings. Some relevant key standard features are described below:

High Throughput, Spectral Efficiency and Coverage

Advanced multiple antenna techniques work with OFDMA signaling very well to maximize system capacity and coverage. OFDM signaling converts a frequency selective fading wideband channel into multiple flat fading narrow band sub-carriers and therefore smart antenna operations can be performed on vector flat sub-carriers. From receiver design perspective, this significantly simplifies the equalizer design otherwise required to compensate frequency selective fading impairment. Major multiple antenna technique features are listed here.

- 2nd, 3rd and 4th order Multiple Input Multiple Output (MIMO) and Spatial Multiplexing (SM) in Uplink and Downlink

- Adaptive MIMO switching between Spatial Multiplexing/Space Time Block Coding to maximize spectral efficiency with no reduction in coverage area

- UL Collaborative Spatial Multiplexing for single transmit antenna devices

- Advanced Beamforming and Null Steering.

QPSK, 16QAM and 64QAM modulation orders are supported both in up-link and downlink. Advanced coding schemes including Convolution Encoding, CTC, BTC and LDPC along with Chase Combining and Incremental Redundancy Hybrid ARQ and Adaptive Modulation and Coding mechanism enables the technology to support a high performance robust air link. Support of HARQ in particular is crucial to improve the robustness of data transmission over the fading wireless channel through fast retransmission.

IEEE 802.16 supports peak sector data rates up to 50 Mbps in a 10 MHz channel with MIMO (2x2). Higher throughputs are achieved by using higher order multiple antenna techniques.

Support for Mobility

The standard supports BS and MS initiated Optimized Hard Handoff for bandwidth-efficient handoff with reduced delay achieving a handoff delay less than 50 msec. The standard also supports Fast Base Station Switch (FBSS) and Marco Diversity Handover (MDHO) as options to further reduce the handoff delay.

Also is supported a comprehensive set of power saving modes including multiple power saving class types sleep mode and Idle mode.

Service Offering and Classes of Services

A set of QoS options such as UGS, Real-Time Variable Rate, Non-Real-Time Variable Rate, Best Effort and Extended Real-Time Variable Rate with silence suppression (primarily for VoIP) to enable support for guaranteed service levels including committed and peak information rates, minimum reserved rate, maximum sustained rate, maximum latency tolerance, jitter tolerance, traffic priority for varied types of internet and real time applications such as VoIP.

Variable UL and DL subframe allocation supports inherently asymmetric UL/DL data traffic.

Multiple OFDMA adjacent and diversified subcarrier allocation modes enable the technology to trade off mobility with capacity within the network and from user to user. OFDMA with adjacent sub-carrier permutation makes it possible to allocate a subset of sub-carriers to mobile users based on relative signal strength. By allocating a subset of sub-carriers to each MS for which the MS enjoys the strongest path gains, this multi-user diversity technique can achieve significant capacity gains. Adaptive beamforming techniques effectively work with frequency selective scheduling on adjacent sub-carrier permutation.

Subchannelization and MAP-based signaling schemes provide a flexible mechanism for optimal scheduling of space, frequency and time resources for simultaneous control and data allocations (multicast, broadcast and unicast) over the air interface on a frame-by-frame basis.

MS and BS initiated Service Flow creation and Multicast and Broadcast Services with customized security support enables flexible service offering.

Scalability

The IEEE-802.16 standard is designed to be able to scale to work in different channel bandwidth sizes from 1.25 to 20 MHz to comply with varied worldwide requirements as efforts proceed to achieve spectrum harmonization in the longer term.

Scalable Physical layer based on concept of Scalable OFDMA enables the technology to optimize the performance in a multipath fading mobile environment, characterized with delay spread and

Doppler shift, with minimal overhead over a wide range of channel bandwidth sizes. The scalability is achieved by adjusting the FFT size to the channel bandwidth while fixing the sub-carrier frequency spacing. By fixing sub-carrier spacing to an optimal value of around 10 KHz, the performance is maximized with respect to multipath tolerance and mobility irrespective of channel bandwidth. More specifically, while large channel sizes and small sub-carrier spacing decreases the overhead required to mitigate degradation due to multipath delay spread, mobility link performance typically degrades due to Doppler shift. Scalable FFT sizes keeps subcarrier spacing fixed and as a result system performance in a mobile environment is maintained.

Flexible and Ease of Reuse Planning

IEEE 802.16 OFDMA PHY supports various subcarrier allocation modes and frame structures such as Partially Used Sub-Channelization (PUSC), Fully Used Sub-Channelization (FUSC) and Advance Modulation and Coding (AMC). These options enable service providers to flexibly perform wireless network reuse planning for spectrally efficient reuse factor 1, interference robust reuse factor 3 or optimal fractional reuse deployment scenarios.

In the case of reuse factor 1, although system capacity can typically increase, users at the cell edge may suffer low connection quality due to heavy interference. Since in OFDMA, users operate on sub-channels, which only occupy a small fraction of the channel bandwidth, the cell edge interference problem can be easily addressed by reconfiguration of the sub-channel usage and reuse factor within frames (and therefore the notion of fractional reuse) without resorting to traditional frequency planning. In other words, the sub-channel reuse pattern can be configured so that in each frame users close to the base station operate on the zone with all sub channels available. While for the edge users, each cell/sector operates on the zone with a fraction of all sub-channels available. In this configuration, the full load frequency reuse factor 1 is maintained for center users with better link connection to maximize spectral efficiency while fractional frequency reuse is achieved for edge users to improve edge user connection quality and throughput. The sub-channel reuse planning can be adaptively optimized across sectors or cells based on network load, distribution of various user types (stationary and mobile) and interference conditions on a per frame basis. All the cells/sectors can operate on the same RF frequency channel and no conventional frequency planning is required.

Security sublayer

IEEE 802.16 supports Privacy and Key Management - PKMv1 RSA, HMAC, AES-CCM and PKMv2 – EAP, CMAC, AES-CTR, MBS Security

Standard

The IEEE Standard is available in electronic form at the following address:

Base Standard: http://standards.ieee.org/getieee802/download/802.16-2004.pdf

Amendment 802.16e: http://standards.ieee.org/getieee802/download/802.16e-2005.pdf

[Editor's Note: A copy of the ~~current draft~~standard has been provided to the BR (SG 8 counsellor) so that it can be made available to members for review purposes as needed. The document will be attached electronically to the document to be submitted to SG 8 for adoption.]

2.2   ETSI standards

The specifications contained in this section include the following standards for BWA, the last available versions being:

–   ETSI TS 102 177 v1.3.2: Broadband Radio Access Networks (BRAN); HiperMAN; Physical (PHY) Layer.

–   ETSI TS 102 178 v1.3.2: Broadband Radio Access Networks (BRAN); HiperMAN; Data Link Control (DLC) Layer.

–   ETSI TS 102 210 v1.2.1: Broadband Radio Access Networks (BRAN); HiperMAN; System Profiles.

Abstract: The HiperMAN standards addresses interoperability for BWA systems below 11 GHz frequencies, to provide high cell sizes in non-line of sight (NLoS) operation. The standard provides for FDD and TDD support, high spectral efficiency and data rates, adaptive modulation, high cell radius, support for advanced antenna systems, high security encryption algorithms. Its existing profiles are targeting the 1.75 MHz, 3.5 MHz and 7 MHz channel spacing, suitable for the 3.5 GHz band.

The main characteristics of ~~HIPERMAN~~HiperMAN standards, ~~v. 1.3.2,~~ which ~~is~~ are fully harmonized with IEEE 802.16 ~~2004 and the IEEE 802.16e-2005 amendment, with the exception of the single-carrier PHY mode, include~~, are:

•   ~~a~~All the PHY improvements related to OFDM and OFDMA modes, including MIMO for the OFDMA mode;

•   ~~f~~Flexible channelization, including the 3.5 MHz, the 7 MHz and 10 MHz raster (up to 28 MHz);

•   ~~s~~Scalable OFDMA, including FFT sizes of 512, 1 024 and 2 048 points, to be used in function of the channel width, such that the subcarrier spacing remains constant;

•   ~~u~~Uplink and downlink OFDMA (sub-channelization) for both OFDM and OFDMA modes;

•   ~~a~~Adaptive antenna support for both OFDM and OFDMA modes;

•   ~~MIMO support for OFDMA mode.~~

Standards: All the ETSI standards are available in electronic form at: http://pda.etsi.org/pda/queryform.asp, by specifying in the search box the standard number.

Attachment 2

Proposed Amendments to Annex 6
(to Annex 17 to Doc. 8A/376)

System	Nominal RF channel bandwidth	Modulation/coding rate[2] – upstream – downstream	Coding support	Peak channel transmission rate per 5 MHz channel	Beam-forming support (yes/no)	Support for MIMO (yes/no)	Duplex method	Multiple access method	Frame duration	Mobility capabilities (nomadic/mobile)
IEEE 802.16 WirelessMAN/ ETSI HiperMAN	Flexible from 1.25 MHz and above. Typical sizes are: – 3.5, – 5, – 7, – 8.75, – 10 and – 20 MHz	Up: – QPSK-1/2, 3/4 – 16QAM-1/2, 3/4 – 64QAM-1/2, 2/3, 3/4, 5/6 Down: – QPSK-1/2, 3/4 – 16QAM-1/2, 3/4 – 64QAM-1/2, 2/3, 3/4, 5/6	CC/CTC Other options: BTC/LDPC	Up to 35 Mbit/s with (2x2) MIMO	Yes	Yes	TDD/FDD/HFDD	OFDMA TDMA	5 msec Other options: 2, 2.5, 4, 8, 10, 12.5 and 20 msec	Mobile
IEEE 802.11-1999 (R2003) (802.11b)	22 MHz	Symmetric up and down: DQPSK CCK BPSK PBCC – 1/2 QPSK PBCC – 1/2	Uncoded/ CC	2.5 Mbit/s	No	No	TDD	CSMA/CA, SSMA	Variable frame duration	Nomadic
IEEE 802.11-1999 (R2003) (802.11a)	20 MHz	Symmetric up and down: 64 QAM OFDM 2/3, 3/4 16 QAM OFDM -1/2, 3/4 QPSK OFDM -1/2, 3/4 BPSK OFDM -1/2, 3/4	CC	13.5 Mbit/s	No	No	TDD	CSMA/CA	Variable frame duration	Nomadic
IEEE 802.11-1999 (R2003) (802.11g)	20 MHz	Symmetric up and down: 64 QAM OFDM 2/3, 3/4 16 QAM OFDM -1/2, 3/4 QPSK OFDM -1/2, 3/4	CC	13.5 Mbit/s	No	No	TDD	CSMA/CA	Variable frame duration	Nomadic

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[2] Including all applicable modes, or at least the maximum and the minimum.

		BPSK OFDM -1/2, 3/4								
		8PSK PBCC – 2/3								
		64 QAM DSSS-OFDM – 2/3, 3/4								
		16 QAM DSSS-OFDM – 1/2, 3/4								
		QPSK DSSS-OFDM – 1/2, 3/4								
		BPSK DSSS-OFDM – 1/2, 3/4								

Attachment 3

Proposed Amendments to Annex 1
(to Annex 17 to Doc. 8A/376)

Broadband radio local area networks

RLANs offer an extension to wired LANs utilizing radio as the connective media. They have applications in commercial environments where there may be considerable savings in both cost and time to install a network; in domestic environments where they provide cheap, flexible, connectivity to multiple computers used in the home; and in campus and public environments where the increasing use of portable computers, for both business and personal use, while travelling and due to the increase in flexible working practices, e.g. nomadic workers using laptop personal computers not just in the office and at home, but in hotels, conference centres, airports, trains, planes and automobiles. In summary, they are intended mainly for nomadic wireless access applications, with respect to the access point (i.e. when the user is in a moving vehicle, the access point is also in the vehicle).

Recommendation ITU-R M.1450 recommends standards for broadband radio local area networks, which can be grouped as follows:

- IEEE ~~Project~~ 802.11
- ETSI BRAN HIPERLAN
- Japan MAC HSWA HiSWAN a

IEEE ~~Project~~ 802.11 has developed a set of standards for RLANs, 802.11-1999 (R2003), which have been harmonized with IEC/ISO[3]. The medium access control (MAC) and physical characteristics for wireless local area networks (LANs) are specified in ISO/IEC 8802-11:2005, which is part of a series of standards for local and metropolitan area networks. The medium access control unit in ISO/IEC 8802-11:2005 is designed to support physical layer units as they may be adopted dependent on the availability of spectrum. ISO/IEC 8802-11:2005 contains five physical layer units: four radio units, operating in the 2 400-2 500 MHz band and in the bands comprising 5.15-5.25 GHz, 5.25-5.35 GHz, 5. 47-5 725 GHz, and 5.725-5.825 GHz, and one baseband infrared (IR) unit. One radio unit employs the frequency-hopping spread spectrum (FHSS) technique, two employ the direct sequence spread spectrum (DSSS) technique, and another employs the orthogonal frequency division multiplexing (OFDM) technique.

ETSI BRAN HIPERLAN

[To be completed.]

Japan MAC HSWA HiSWAN a

[To be completed.]

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[3] ISO/IEC 8802-11:2005, Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications.