

Project	IEEE 802.16 Broadband Wireless Access Working Group < http://ieee802.org/16 >
Title	Draft Contribution to ITU-R WP 8F: Proposed Edits to ITU-R Rec. M.1457
Date Submitted	2006-11-05
Source(s)	Roger B. Marks NextWave Broadband, Inc. r.b.marks@ieee.org
Re:	IEEE I802.16-06/024 (“Call for Contributions: Proposed Contribution to ITU-R WP 8F Regarding IMT-2000 Proposal”)
Abstract	This contribution proposes the text of a contribution to ITU-R WP 8F. It suggests edits to ITU-R Rec. M.1547 to suitable for introducing IEEE Std 802.16 as an additional IMT-2000 radio interface.
Purpose	For consideration by the ITU-R Liaison Group and its correspondence group.
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Draft Contribution to ITU-R WP 8F: Proposed Edits to ITU-R Rec. M.1457

Roger Marks

NextWave Broadband, Inc.

1 Introduction *[no edits]*

2 Scope *[no edits]*

3 Related Recommendations

[add at the end:]

These existing Recommendations are not part of IMT-2000 but are relevant to this particular Recommendation:

Recommendation ITU-R F.1499: Radio transmission systems for fixed broadband wireless access based on cable modem standard

Recommendation ITU-R F.1763: Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz

Draft New Recommendation ITU-R M.[8A/BWA]: Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz

4 Considerations

4.1 Radio interfaces for IMT-2000

[edit as shown below:]

IMT-2000 consists of both terrestrial component and satellite component radio interfaces. All of the radio interfaces for IMT-2000 both terrestrial and satellite are fully encompassed by this Recommendation. In particular, the terrestrial radio interfaces are fully defined by information supplied within this Recommendation and by information incorporated by reference to external materials. The satellite radio interfaces are fully defined by information supplied with this Recommendation.

Recommendation ITU-R M.1455 lists the original key characteristics of all radio interface for the terrestrial component of IMT-2000. The organization of terrestrial radio interfaces within that Recommendation ~~continues~~ follows the philosophy that IMT-2000 should comprise a single terrestrial standard encompassing ~~two~~ three high-level groupings: code division multiple access (CDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), or a combination thereof. The CDMA grouping accommodates frequency division duplex (FDD) direct spread, FDD multi-carrier and time division duplex (TDD). The TDMA grouping accommodates FDD and TDD, single carrier and multi-carrier. The OFDMA grouping accommodates TDD. These groupings satisfy the needs expressed by the global community.

Recommendation ITU-R M.1455 also lists the key characteristics of six radio interfaces for the satellite component of IMT-2000. As highlighted in that Recommendation, due to the constraints on satellite system design and deployment, several satellite radio interfaces will be required for IMT-2000 (see Recommendation ITU-R M.1167 for further considerations).

A satellite system is severely resource limited (e.g. power and spectrum limited), its radio interfaces are therefore specified primarily based on a whole system optimization process, driven by the market needs and business objectives. It is generally not technically feasible or viable from a business point-of-view to have a radio interface common to satellite and terrestrial IMT-2000 components. Nevertheless, it is desirable to achieve as much commonality as possible with the terrestrial component when designing and developing an IMT-2000 satellite system.

The strong dependency between technical design and business objectives of an IMT-2000 satellite system requires a large scope of flexibility in the satellite radio interface specifications. Future modifications and updates of these specifications may nevertheless be needed in order to adapt to changes in market demands, business objectives, technology developments, and operational needs, as well as to maximize the commonality with terrestrial IMT-2000 systems as appropriate.

The radio interfaces for the terrestrial and satellite components are described in detail in § 5 and 6, respectively.

4.2 Incorporation of externally developed specification material *[no edits]*

4.2 Satellite component interfaces *[no edits]*

5 Recommendations (terrestrial component)

[edit as shown below:]

The Radiocommunication Assembly recommends that the radio interfaces given in § 5.1 to 5.5-6 should be those of the terrestrial component of IMT-2000.

The organization of terrestrial radio interfaces within this Recommendation ~~continues~~ follows the philosophy that IMT-2000 should comprise a single terrestrial standard encompassing ~~two~~ three high-level groupings: CDMA, TDMA, OFDMA, or a combination thereof. The CDMA grouping accommodates FDD direct spread, FDD multi-carrier and TDD. The TDMA grouping accommodates FDD and TDD, single carrier and multi-carrier. The OFDMA grouping accommodates TDD. These groupings satisfy the needs expressed by the global community.

The terrestrial radio interface sections are identified as:

- IMT-2000 CDMA Direct Spread
- IMT-2000 CDMA Multi-Carrier
- IMT-2000 CDMA TDD
- IMT-2000 TDMA Single-Carrier
- IMT-2000 FDMA/TDMA
- IMT-2000 BW-OFDMA.

An overview of each radio interface is provided in § 5.1.1, 5.2.1, 5.3.1, 5.4.1, ~~and 5.5.1,~~ and 5.6.1.

The detailed information provided and/or referenced in § 5.1.2, 5.2.2, 5.3.2, 5.4.2, ~~and 5.5.2,~~ and 5.6.2 is recommended as the complete definition of the radio interfaces of the terrestrial component of IMT-2000.

5.6 IMT-2000 BW-OFDMA [new subclause]

5.6.1 Overview of the radio interface

5.6.1.1 Introduction

The IMT-2000 radio interface specification described in this subclause is designated as BW-OFDMA, for Broadband Wireless – Orthogonal Frequency Division Multiple Access. The core standards specifying BW-OFDMA are overseen and published by the IEEE Standards Association (IEEE-SA) of the global Institute of Electrical and Electronics Engineers (IEEE). The IEEE is a “recognized organization” per Note 1 of § 4.2 and is a Sector Member of ITU-R and ITU-T in the category CV231 (“Regional and other International Organizations.”) The relevant IEEE standard, designated as IEEE Std 802.16, is developed and maintained by the IEEE 802.16 Working Group on Broadband Wireless Access.

An earlier and more limited version of IEEE Standard 802.16, specified for fixed services only, is the basis of ITU-R Rec. F.1763 (“Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz”). The version as enhanced (by the amendment IEEE Std 802.16e) for the mobile service is referenced in ITU-R Draft New Recommendation M.[8A/BWA], which was approved by ITU-R SG 8 in September 2006. Both of these documents also reference the ETSI HiperMAN standards (ETSI TS 102 177 v1.3.2, ETSI TS 102 178 v1.3.2, and ETSI TS 102 210 v1.2.1:), which are fully harmonized with IEEE Standard 802.16.

The radio access network specified in IEEE Standard 802.16 is flexible, for use in a wide variety of applications, operating frequencies, and regulatory environments. IEEE 802.16 includes several physical layer specifications, one of which is known as WirelessMAN-OFDMA. The BW-OFDMA specification in this Recommendation is a special case of WirelessMAN-OFDMA specifying a particular interoperable radio interface.

The BW-OFDMA radio interface comprises the two lowest network layers – the physical layer (PHY) and the data link control layer (DLC). The lower element of the DLC is the medium access control layer (MAC); the higher element in the DLC is the logical link control layer (LLC). The PHY is based on orthogonal frequency division multiple access (OFDMA) suitable for use in a 10 MHz channel allocation. The MAC is based a connection-oriented protocol designed for use in a point-to-multipoint configuration. It is designed to carry a wide range of packet-switched (typically IP-based) services while permitting fine and instantaneous control of resource allocation to allow full carrier-class Quality of Service (QoS) differentiation. This allows for support of a differentiated services network simultaneously carrying multiple multimedia services, including multimedia broadcast and multicast services, with varying demands.

BW-OFDMA is specified and suitable for all IMT-2000 frequency bands. Although the WirelessMAN-OFDMA specification includes both TDD and FDD alternatives, BW-OFDMA as defined here operates only in TDD mode.

5.6.1.2 Radio access network architecture

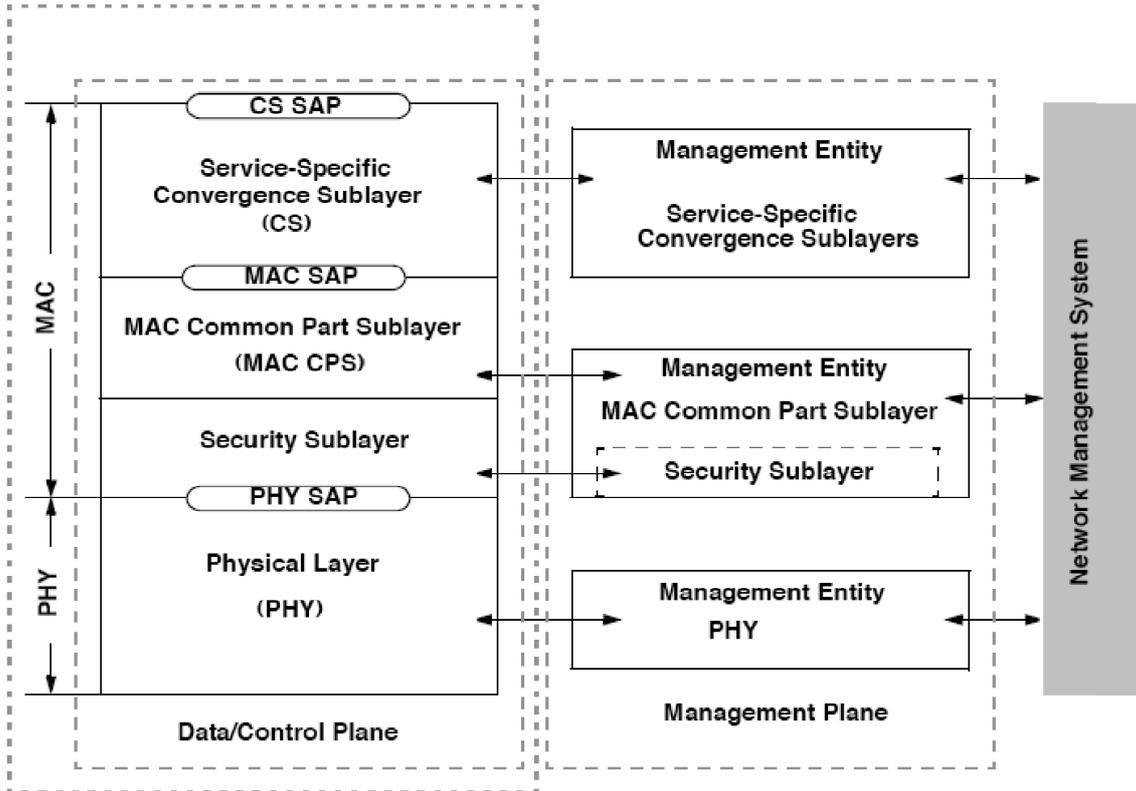
The BW-OFDMA radio interface is designed to carry packet-based traffic, including IP. It is flexible enough to support a variety of higher-layer network architectures for fixed, nomadic, or fully mobile use, with handover support. It can readily support functionality suitable for generic data as well as time-critical voice and multimedia services, broadcast and multicast services, and mandated regulatory services.

Since the higher network layers remain unspecified, the standard offers the advantage of flexibility and openness at the interface between Layers 2 and 3. This allows it to support a variety of network infrastructures. Common infrastructure design can provide economies of scale and opportunities for interoperator roaming. As a result, industry activities have arisen to develop norms in this area. In particular, the WiMAX Forum, a private non-profit industry organization, has developed the “Mobile WiMAX End-to-End System Architecture” to specify a network architecture design to make optimum use of IEEE Standard 802.16 and the BW-OFDMA radio interface.

The BW-OFDMA protocol layering is illustrated in Fig. 1. The core radio interface is defined in the data/control plane. Layer 1 comprises the PHY, which interfaces with the MAC at Layer 2 through the PHY service access point (SAP). The MAC includes three separate sublayers. The lowest of these is the security sublayer, which provides security mechanisms providing authentication, encryption, and key exchange for data privacy and to limit service to authorized use. Above the security sublayer is the core MAC functionality, known as the MAC Common Part Sublayer (MAC CPS). This interfaces, via the MAC SAP, with the Service-Specific Convergence Sublayer (CS), which provides an interface to the IP network via the CS SAP.

FIGURE 1

BW-OFDMA protocol layering, showing service access points (SAPs)



The BW-OFDMA MAC is connected-oriented. Each service, including inherently connectionless services, is mapped to a connection. Various mechanisms, known as scheduling services, are available for the SS to communicate to the BS the resource requirements of its connections. Each connection is assigned a specific scheduling service. The BS is required to manage a variety of simultaneous connections with disparate QoS requirements.

5.6.1.2.1 BS and SS Functionality

The BW-OFDMA system architecture consists of two logical entities, the base station (BS) and the subscriber station (SS). The basic architectural assumption of BW-OFDMA is of a base station (BS) communicating in point-to-multipoint fashion with a number of fixed or mobile subscriber stations (SSs). The BS is connected to an IP-based backhaul network. It controls and allocates the resources in spectrum and time. Transmissions on the downlink (BS to SS) are divided in both time and frequency (using the multiple subcarriers provide by OFDMA) for assigning communications to individual SSs. Transmissions on the uplink (from SS to BS) take place according to the schedule and in the subchannels assigned by the BS.

In brief, BS is responsible for:

- configuring and updating basic parameters
- performing bandwidth allocation for DL (per connection) and UL traffic (per SS) and performing centralized QoS scheduling, based on the QoS/service parameters and the active resource requests from the SS
- communicating to all SSs, through the maps, the schedule of each frame and supporting other data and management broadcast and multicast services
- Transmitting/receiving traffic data and control information as MAC protocol data units (PDUs)
- Performing connection admission control and other connection management functions
- Providing other SS support services such as ranging, clock synchronization, power control, and handoff.

The SS is responsible for:

- Identifying the BS, obtaining MAC parameters, and joining the network
- Establishing basic connectivity, setting up additional data and management connections, and negotiating any optional parameters as needed
- Generating resource requests for connections that require them, based on the connection profiles and traffic
- Receiving broadcast/multicast PDUs and unicast PDUs and forwarding them appropriately
- Making local scheduling decisions based on the current demand and history of resource requests/grants
- Transmitting only when instructed by the BS to do so or the SS has some information that qualifies for transmission in one of the allowed contention slots
- Unless in sleep mode, receiving all schedule and channel information broadcast by the BS and obeying all medium access rules
- Performing initial ranging, maintenance ranging, power control, and other housekeeping functions

Fig. 1 is limited to describing a system including a BS and the SSs with which it communicates. However, the BW-OFDMA radio interface also provides specifications to allow handover of an SS from one BS to another. Such handover would typically occur as a mobile devices moves toward and adjacent cell. However, it might also occur due to system-wide efforts at load balancing.

5.6.1.3 Layer 1: Physical Layer (PHY)

The BW-OFDMA radio interface is a special case of the WirelessMAN-OFDMA air interface specified in § 8.4 of IEEE Standard 802.16. It uses orthogonal frequency-division multiple access (OFMDA), which is an extension of orthogonal frequency-division multiplexing (OFDM).

5.6.1.3.1 OFDMA Concept

OFDM divides the channel by frequency into orthogonal subcarriers. Data to be transmitted is divided into parallel streams of reduced data rate (and therefore longer symbol duration) and each stream is modulated and transmitted on a separate subcarrier. The lengthened symbol duration improves the robustness of OFDM

to delay spread. Furthermore, the introduction of a cyclic prefix (CP) eliminates intersymbol interference if the CP duration is longer than the channel delay spread.

In a typical OFDM implementation, all of the transmitter's subcarriers are, at any given time, addressed to a single receiver; multiple access is provided solely by TDMA time slotting. OFDMA, however, divides the subcarrier set into subsets, known as subchannels. Each subchannel can address a different receiver at any given time. In the downlink, each subchannel may be intended for a different receiver or group of receivers. In the uplink, multiple SUs may transmit simultaneously as long as they are assigned different subchannels.

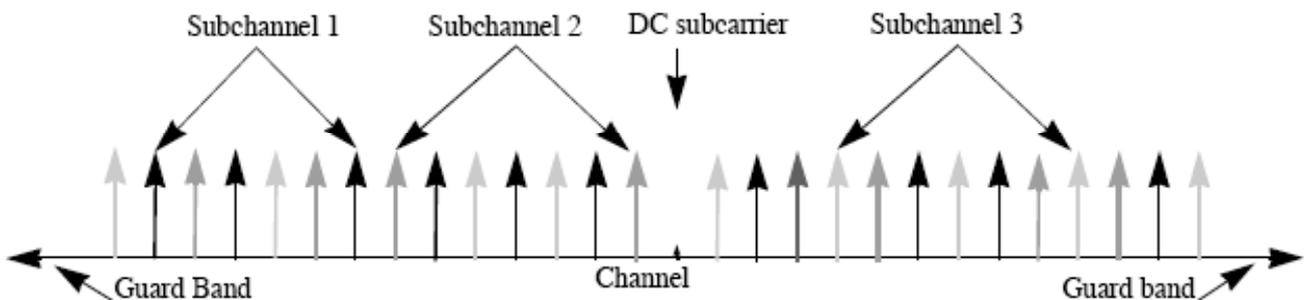
Subcarriers are used for three purposes:

- Data transmission
- Pilot transmission, for various estimation purposes
- Null transmission, for guard bands and at DC

The concept is illustrated in Fig. 2. As indicated, the subcarriers forming one subchannel need not be adjacent.

FIGURE 2

OFDMA frequency description, schematically showing three subchannels



Subchannelization is a multiple access technique. It provides OFDMA systems increased scheduling flexibility and a number of performance advantages, including enhanced scalability and advanced antenna array processing capabilities.

5.6.1.3.2 OFDMA Details

The BW-OFDMA PHY utilizes OFDMA with 1024 subcarriers in a 10 MHz channel. The primitive PHY parameters are listed in Table 1.

TABLE 1

BW-OFDMA Primitive PHY Parameters

FFT Size (N_{FFT})	1024
System Channel Bandwidth (BW)	10 MHz
Sampling Frequency (F_s)	11.2 MHz

Subcarrier Frequency Spacing ($\Delta f = F_s / N_{\text{FFT}}$)	10.9375 kHz
Useful Symbol Time ($T_b = 1 / \Delta f$)	$\sim 91.43 \mu\text{s}$
Guard (CP) Time ($T_g = T_b / 8$)	$\sim 11.43 \mu\text{s}$
OFDMA Symbol Duration ($T_s = T_b + T_g$)	$\sim 102.9 \mu\text{s}$
Frame Duration	5 ms
OFDMA Symbols per frame	48

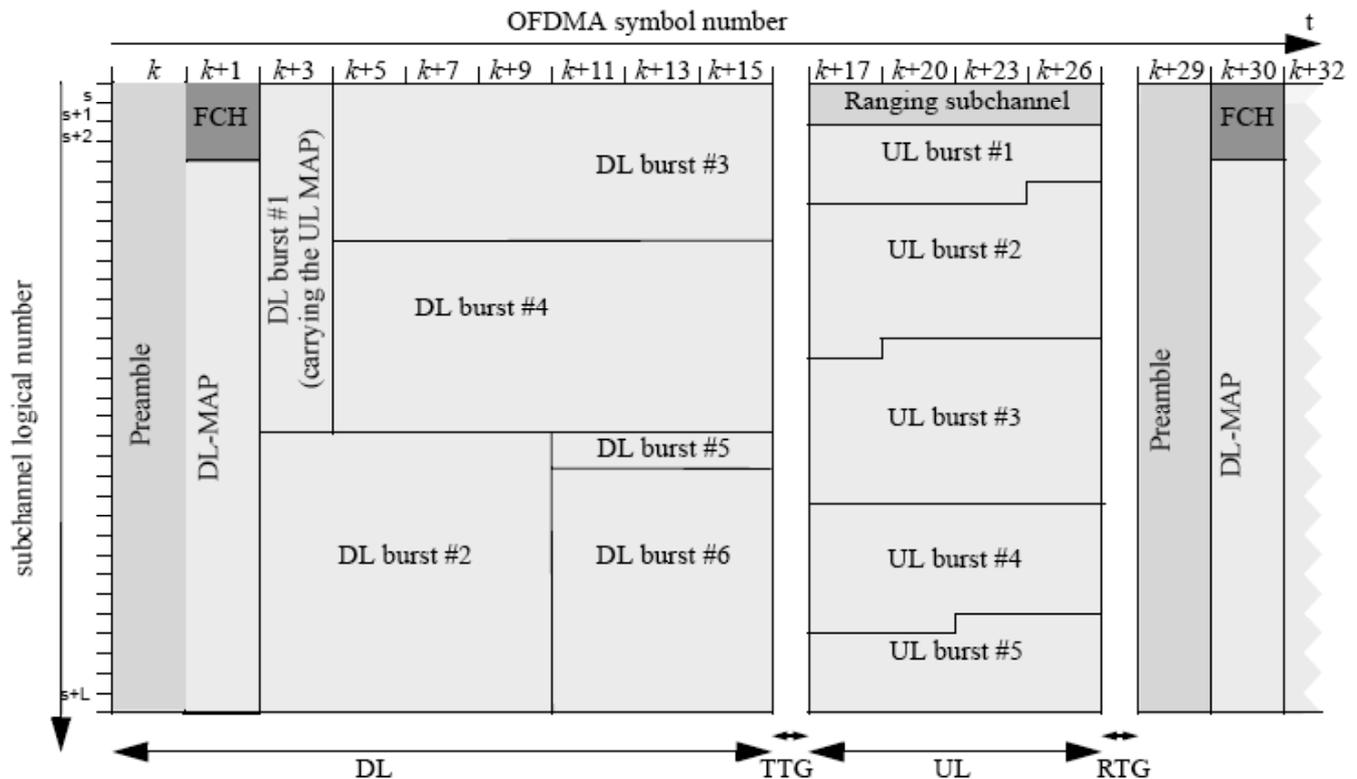
5.6.1.3.3 Framing and Subchannelization

BW-OFDMA utilizes a framed TDD PHY. The 5 ms frame includes first downlink and then uplink subframes, divided by a time gaps to allow the transceivers to switch between receive and transmit. The two gaps (TTG and RTG) are both included in the 5 ms duration. The asymmetry between the uplink and downlink subframe durations is configurable on a systemwide basis.

The frame structure is illustrated schematically in Fig. 3.

FIGURE 3

Schematic illustration of frame structure



The frame is shown in two dimensions. The horizontal dimension is of time, which maps directly into the OFDM symbol sequence. The vertical dimension represents the list of available logical subchannels. This maps into frequency, although only indirectly, since the subcarriers in a given logical channel are not arranged in sequential order.

The frame begins with a preamble for synchronization. In following OFDM symbol contains the frame control header (FCH) and the downlink map (DL_MAP), transmitted simultaneously on different subchannels. The FCH include frame configuration data. The DL-MAP indicates the use of the use of the DL subframe, in time and subchannel allocation. The UL-MAP that follows provides similar information for the uplink, though the allocation is relevant not to the current frame but to a subsequent one, in order to allow the SS time to prepare an appropriate transmitter in accordance with the UL-MAP.

The construction of the subchannel from individual subcarriers is called the permutation. BW-OFDMA provides a number of possible permutations. The optimal choice depends on the deployment scenario and instantaneous circumstances; therefore, the permutation may differ from one OFDM symbol to the next. The specification supports a sequence of permutation zones in the frame, so that different subscriber stations can be served with different permutations.

5.6.1.3.4 Adaptive Modulation and Coding

BW-OFDMA supports a variety of modulation and coding alternatives. The control is adaptive and dynamic, so that the BS may select different options for communicating with different SSS and may order the SS to alter the choices in order to optimize the tradeoff of robustness versus capacity.

The BS selects the modulation from among QPSK, 16QAM, and 64QAM. For forward error correction, Convolutional Coding and Convolutional Turbo Coding with variable code rate and repetition coding are specified. Block Turbo Code and Low Density Parity Check Code (LDPC) are supported as optional features.

Data randomization is specified in order to reduce the peak-to-average power ratio. Interleaving is specified to increase frequency diversity.

5.6.1.3.5 Fast feedback and Hybrid ARQ

BW-OFDMA specifies an uplink fast-feedback channel to provide time-critical PHY parameter data to the BS. Parameters include signal-to-noise ratio, MIMO coefficients, and MIMO configuration parameters.

Additional UL acknowledgment channels may be allocated by the BS to support hybrid automatic repeat request (HARQ).

5.6.1.4 Layer 2: Medium Access Control Layer (MAC)

The medium access control layer (MAC) functionality controls access to the medium, which in this case is the radio spectrum. The MAC is also responsible for basic functions such as data encapsulation, fragmentation, radio resource control, radio link control, error detection and retransmission, QoS, security, sleep mode, and handover.

Elements of the core MAC design, particularly those related to QoS management, are based on standards for cable modem networks, which likewise serve a point-to-multipoint topology. This application of cable modem standards to fixed broadband wireless networks is described in ITU-R F.1499 (“Radio transmission systems for fixed broadband wireless access based on cable modem standard”). In its details, the BW-OFDMA MAC is vastly different from that of the cable modem standards.

Although the BW-OFDMA radio interface is designed primarily to support a connectionless network layer, such as IP, the BW-OFDMA MAC is connection-oriented. All services, including inherently connectionless services, are mapped to a connection. The connection provides a mechanism for requesting resource allocation, associating QoS and traffic parameters, transporting and routing data, and all other actions associated with the terms of the service. A 16-bit connection identifier (CID) is assigned to designate each connection. The MAC uses the CID to identify all information exchanged between BS and SS, including management and broadcast data. The CID provides a simple and direct way to differentiate traffic. All

MAC-level QoS functions, such as the classifier and QoS scheduler, use the CID to identify and differentiate traffic in order to maintain the service level and fairness among connections.

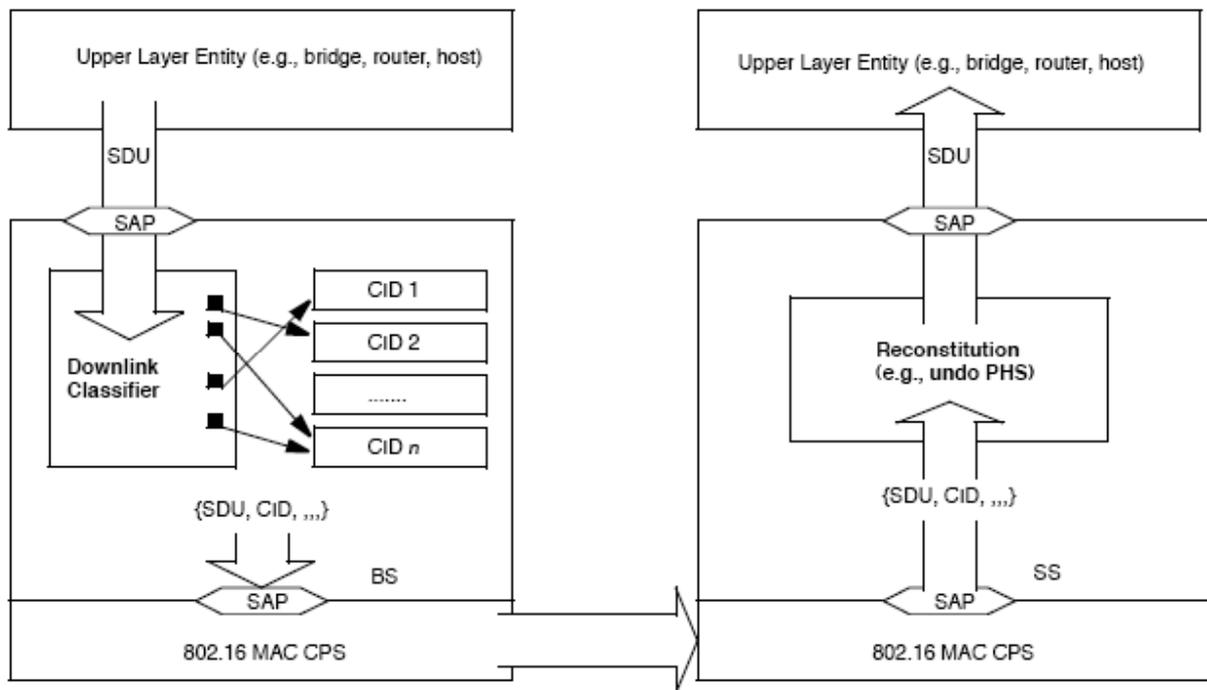
5.6.1.4.1 Convergence Sublayer (CS)

At the transmitter side, the Convergence Sublayer is responsible for transforming packet-based protocol data units from the higher layer protocol into MAC service data unit (SDUs), possibly using payload header suppression (PHS) to suppress some of the packet headers and reduce the burden of carrying them over the air. The CS then classifies each MAC SDU, assigning it to a particular connection, and passes it to the MAC CPS. At the receiver side, the CS is responsible for the inverse operations, including reassembly of packets into their original format with complete headers.

The CS contains a classification function that determines on which connection a particular packet shall be carried and which PHS rule applies for that packet. The operation is illustrated in Figure 4, which shows the downlink case. Classifier parameters are configured during dynamic service signaling.

FIGURE 4

Classification and CID mapping (downlink)



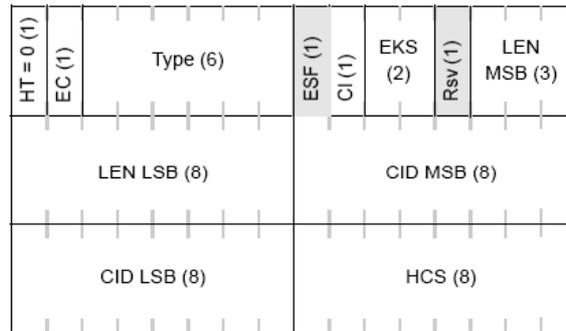
5.6.1.4.2 MAC common part sublayer (CPS)

The MAC CPS is responsible for performing the core MAC functions. It receives MAC service data units (SDUs) from the CS and encapsulates them in its native MAC PDU format for transmission over the PHY. The MAC CPS also manages the transport connections and QoS, controlling access to the radio spectrum by the SSs.

Encapsulation may be as simple as adding necessary information to the SDU. However, the MAC CPS also has the possibility of dividing a single SDU into multiple fragments before transmission, for reassembly at the receiving MAC CPS. Fragmentation allows more efficient support of higher layer protocols with variable-size SDUs, given that the underlying PHY used a fixed frame size. The MAC CPS also has the complementary option to pack multiple higher layer payloads into a single PDU. Since MAC encapsulation introduces some fixed overhead per PDU, this can improve the efficiency of carrying small SDUs.

A MAC PDU consists of a six-byte MAC header, a variable-length payload, and an optional cyclic redundancy check. Four header formats, distinguished by the HT field, are defined. The generic header is shown in Fig. 5.

FIGURE 5
Generic MAC header format



MAC PDUs generally contain either MAC management messages or convergence sublayer data. However, one header type is reserved for uplink PDUs that contain no payload, conveying their information (such as a resource request) in the content of the header itself. Additional subheaders are also defined. For example, the SS can use the grant management subheader to convey bandwidth management needs to the BS. The fragmentation subheader contains information indicates the presence and orientation in the payload of any fragments of SDUs. The packing subheader is used to indicate the packing of multiple SDUs into a single PDU. The grant management and fragmentation subheaders may be inserted in MAC PDUs immediately following the generic header if so indicated by the Type field. The packing subheader may be inserted before each MAC SDU if so indicated by the Type field.

5.6.1.4.2.1 Uplink scheduling services

The scheduling algorithm is not specified in the standard but is critical to efficient multimedia delivery when the BS support a variety of disparate connections. The BS is presumed capable of scheduling its own downlink transmissions based on QoS information developed in the CS. Uplink scheduling is more complicated because, while resource allocation is under the control of the BS, only the SSs know in real time their immediate transmission demands.

In order to allow efficient QoS-based scheduling, a number of uplink scheduling services are defined, with a specific service assigned to each connection. The alternatives summarized in Table 2.

TABLE 2
BW-OFDMA Uplink scheduling services

QoS Category	Typical Applications	QoS Specifications
UGS Unsolicited Grant Service	VoIP	<ul style="list-style-type: none"> • Maximum Sustained Rate • Maximum Latency Tolerance • Jitter Tolerance
rtPS Real-Time Packet Service	Streaming Audio or Video	<ul style="list-style-type: none"> • Minimum Reserved Rate • Maximum Sustained Rate • Maximum Latency Tolerance • Traffic Priority

QoS Category	Typical Applications	QoS Specifications
ErtPS Extended Real-Time Packet Service	Voice with Activity Detection (VoIP)	<ul style="list-style-type: none"> • Minimum Reserved Rate • Maximum Sustained Rate • Maximum Latency Tolerance • Jitter Tolerance • Traffic Priority
nrtPS Non-Real-Time Packet Service	File Transfer Protocol (FTP)	<ul style="list-style-type: none"> • Minimum Reserved Rate • Maximum Sustained Rate • Traffic Priority
BE Best-Effort Service	Data Transfer, Web Browsing, etc.	<ul style="list-style-type: none"> • Maximum Sustained Rate • Traffic Priority

Resource requests, for transmission slots, are initiated by a specific connection at the SS. However, grants are allocated not to the connection but to the supporting SS. The SS is required to manage the slots allocated to it, assigning them to the multiple connections it supports. By distributing the management problem and assigning authority to local control, over-the-air negotiation is minimized and rescheduling decisions are made more quickly and effectively.

5.6.1.4.2.2 Radio Link Control

As noted in 5.6.1.3.2, BW-OFDMA supports adaptive modulation and coding. The MAC CPS is responsible for radio link control, managing the modulation and coding selection at the SS through interactive message exchange based on monitoring the ratio of carrier signal to noise and interference.

5.6.1.4.2.3 Energy conservation in the mobile SS

The BW-OFDMA MAC CPS controls two energy-saving modes – Sleep Mode and Idle Mode – to conserve energy in the mobile SS. During Sleep Mode, the SS observes pre-negotiated periods without transmission. Idle Mode is intended as a mechanism to allow the SS to become periodically available for DL broadcast messaging without registration at a specific BS as the SS traverses an air link environment populated by multiple BSs, typically over a large geographic area.

5.6.1.4.2.4 Handover

The BW-OFDMA MAC CPS supports three handover methods – Hard Handover (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO).

5.6.1.4.3 Security sublayer

The security sublayer, which operates between the PHY and the MAC CPS, is responsible for providing strong encryption, decryption, mutual authentication, and secure key exchange. Security is maintained as a separate sublayer so that it may be upgraded as necessary. Also, the key functionality internal to the sublayer is also modular, to provide easy maintenance upgrade. For example, the protocol provides a means of identifying the one from a set supported cryptographic suites, each of which specifies data encryption and authentication algorithms, and the rules for applying those algorithms to a MAC PDU payload.

The BW-OFDMA security sublayer defines the concept of the security association (SA), which is a set of information shared between the transmitter and receiver. Each SA contains information on the cryptographic suite used for that SA and may also contain keys, such as the traffic encryption keys (TEKs), along with the key lifetimes and other associated state information. Prior to transmission, the MAC PDUs are mapped to an SA. The receiver uses the CID to determine the correct SA and applies the corresponding processing to the received PDU.

Device and user authentication use the IETF EAP protocol. BW-OFDMA encrypts user data using the AES-CCM cryptographic suite, with the Advanced Encryption Standard (AES) algorithm in the counter with CBC-MAC (CCM) mode, with 128-bit keys. The keys are generated using EAP authentication and managed by a Traffic Encryption Key (TEK) state machine. MAC management messages are AES encrypted and authenticated. A three-way handshake scheme is supported to optimize re-authentication during handover.

5.6.1.5 Smart antennas

BW-OFDMA specifies the use of smart antenna technologies, including beamforming, space-time coding, and spatial multiplexing.

5.6.2 Detailed specification of the radio interface

The standards contained in this section are derived from IEEE Standard 802.16. The global core specifications for IMT-2000 BW-OFDMA are contained at <http://ties.itu.int/u/itu-r/ede/rsg8/wp8f/wp8f-tech/GCSrev5/5-6/>.

5.6.2.1 IEEE Standard 802.16

IEEE Standard 802.16 describes the BW-OFDMA radio interface.

SDO	Document No.	Status	Issued date	Location
IEEE	802.16-2004	Published	01/10/2004	http://standards.ieee.org/getieee802/802.16.html
IEEE	802.16e-2005 & Cor1	Published	28/02/2006	http://standards.ieee.org/getieee802/802.16.html
IEEE	802.16f-2005	Published	01/12/2005	http://standards.ieee.org/getieee802/802.16.html

6 Recommendations (satellite component) *[no edits]*

7 Recommendations on unwanted emission limits *[no edits]*

REFERENCES

Carl Eklund, Roger B. Marks, Kenneth L. Stanwood, and Stanley Wang, "IEEE Standard 802.16: A Technical Overview of the WirelessMAN Air Interface for Broadband Wireless Access," *IEEE Communications Magazine*, June 2002, pp. 98-107.

Carl Eklund, Roger B. Marks, Subbu Ponnuswamy, Kenneth L. Stanwood, and Nico J.M. van Waes, *WirelessMAN: Inside the IEEE 802.16 Standard for Wireless Metropolitan Area Networks*. IEEE Press, New York, May 2006 [ISBN 0-7381-4842-3].

Cover Sheet for Submission of proposed radio transmission technologies for IMT-2000 to ITU

[ATTACHMENT 2 of Circular-letter 8/LCCE/47]

The information listed below will be used for cataloguing radio transmission technologies for IMT-2000 by the ITU and will be posted electronically.

This cover sheet (and additional information, if applicable) should be attached when an evaluation group submits a proposal on radio transmission technologies for IMT-2000.

1. Proponent

- a) Name of proponent: IEEE 802.16 Working Group on Broadband Wireless Access
- b) Proponent category:
- ITU-R membership: Yes x No ___
- Regional/National standards body: Yes x (Name: IEEE) No ___
- Industry group: Yes ___ (Name: _____) No x
- Other: (Name: _____) No x

c) Contact point

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 Tel: +1 303 725 4626
 Fax: none
 Email: r.b.marks@ieee.org

2. Proposal identification

- a) Name of the proposed RTT BW-OFDMA
- b) Status of proposal:
- Revision ___ (former proposed RTTs name: _____)
- New proposal x

3. Proposed RTT(s) service environment (check as many as appropriate)

Indoor x Outdoor to indoor pedestrian x
 Vehicular x Satellite ___

4. Attachments

Technology template for each test environment ___

Requirements and objectives template ___

IPR statement ___

Other
 (any additional inputs which the proponent may consider relevant to the evaluation) ___

5. Has the proposal already been submitted to an evaluation group registered with ITU?

Yes ___
 (Name of evaluation group: _____, Date of submission: _____)

No x

6. Other information

Name of person submitting form: Michael Lynch
 Date: 24 November 2006