The Draft IEEE 802.16m System Description Document

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1 Scope

The 802.16m amendment shall be developed in accordance with the P802.16 project authorization request (PAR), as approved on 6 December 2006 [1], and with the Five Criteria Statement in IEEE 802.16-06/055r3 [2]. According to the PAR, the standard shall be developed as an amendment to IEEE Std 802.16 [3][4]. The resulting standard shall fit within the following scope:

> *This standard amends the IEEE 802.16 WirelessMAN-OFDMA specification to provide an advanced air interface for operation in licensed bands. It meets the cellular layer requirements of IMT-Advanced next generation mobile networks. This amendment provides continuing support for legacy WirelessMAN-OFDMA equipment.*

And the standard will address the following purpose:

> *The purpose of this standard is to provide performance improvements necessary to support future advanced services and applications, such as those described by the ITU in Report ITU-R M.2072.*

The standard is intended to be a candidate for consideration in the IMT-Advanced evaluation process being conducted by the International Telecommunications Union– Radio Communications Sector (ITU-R) [5][6][7]. This document represents the system description document for the 802.16m amendment. It describes the system level description of the 802.l16m system based on the SRD developed by the IEEE 802.16 TGm[8]. All content included in any draft of the 802.16m amendment shall be in accordance with the system level description in this document as well as in compliance with the requirements in the SRD. This document, however, shall be maintained and may evolve. The system described herein is defined to ensure competitiveness of the evolved air interface with respect to other mobile broadband radio access technologies as well as to ensure support and satisfactory performance for emerging services and applications.

2 References

[1] IEEE 802.16m PAR, December 2006, http://standards.ieee.org/board/nes/projects/802-16m.pdf

[2] IEEE 802.16 WG, “Five Criteria Statement for P802.16m PAR Proposal,” IEEE 802.16-06/55r3, November 2006, http://ieee802.org/16/docs/06/80216-06_055r3.pdf

[3] IEEE Std 802.16-2004: Part 16: IEEE Standard for Local and metropolitan area networks: Air Interface for Fixed Broadband Wireless Access Systems, June 2004

[4] IEEE Std. 802.16e-2005, IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, and IEEE Std. 802.16-2004/Cor1-2005, Corrigendum 1, December 2005

[5] Recommendation ITU-R M.1645: Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000, January 2003

[6] ITU-R Document 8F/TEMP/568: Guidelines for evaluation of radio interface technologies for IMT-Advanced, May 2007

[7] ITU-R Document 8F/TEMP/574: Requirements related to technical system performance for IMT-Advanced radio interface(s) [IMT.TECH] , May 2007

[8] IEEE 802.16m System Requirements, IEEE 802.16m-07/002r4

[9] The WiMAX Forum Network Architecture Stage 2 - 3: Release 1, Version 1.2 http://www.wimaxforum.org/technology/documents/WiMAX_End-to-End_Network_Systems_Architecture_Stage_2-3_Release_1.1.2.zip

3 Definition, Symbols, Abbreviation

4 Overall Network Architecture

<Editor's Note: This section will describe the overall network architecture applicable to 802.16m.>

The Network Reference Model (NRM) is a logical representation of the network architecture. The NRM identifies functional entities and reference points over which interoperability is achieved between functional entities. The following Figure 1 illustrates the NRM, consisting of the following functional entities: Mobile Station (MS), Access Service Network (ASN), and Connectivity Service Network (CSN). The existing network reference model is defined in WiMAX Network Architecture [9].

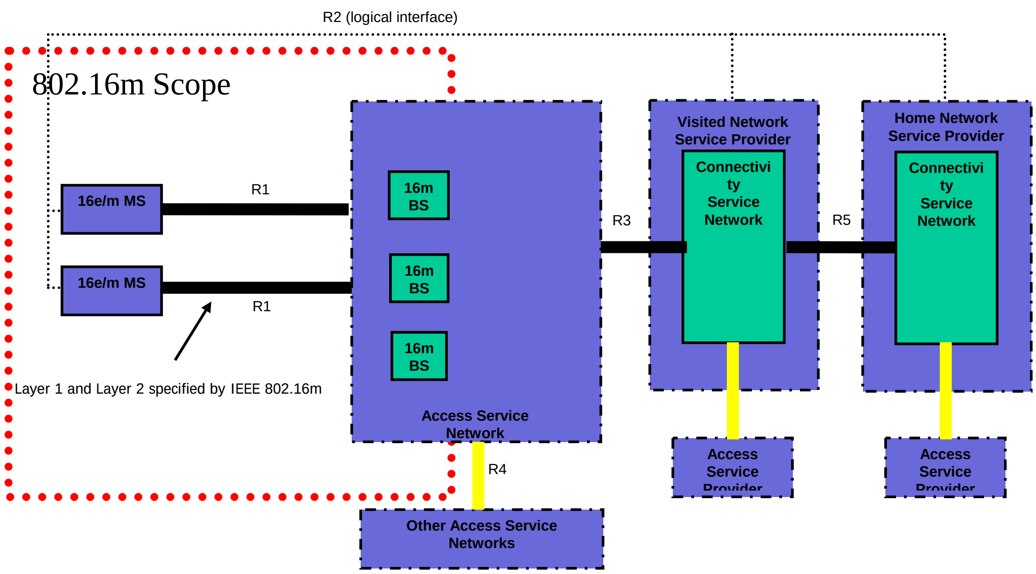

Figure 1 Example of overall network architecture

The ASN is defined as a complete set of network functions needed to provide radio access to an IEEE 802.16e/m subscriber. The ASN provides at least the following functions:

- IEEE 802.16e/m Layer-1 (L1) and Layer-2 (L2) connectivity with IEEE 802.16e/m MS
- Transfer of AAA messages to IEEE 802.16e/m subscriber's Home Network Service Provider (H-NSP) for authentication, authorization and session accounting for subscriber sessions
- Network discovery and selection of the IEEE 802.16e/m subscriber's preferred NSP
- Relay functionality for establishing Layer-3 (L3) connectivity with an IEEE 802.16e/m MS (i.e. IP address allocation)
- Radio Resource Management

In addition to the above functions, for a portable and mobile environment, an ASN further supports the following functions:

- ASN anchored mobility
- CSN anchored mobility
- Paging

- ASN-CSN tunneling

The ASN comprises network elements such as one or more Base Station(s), and one or more ASN Gateway(s). An ASN may be shared by more than one CSN. The CSN is defined as a set of network functions that provide IP connectivity services to the IEEE 802.16e/m subscriber(s). A CSN may provide the following functions:

- MS IP address and endpoint parameter allocation for user sessions
- Internet access
- AAA proxy or server
- Policy and Admission Control based on user subscription profiles
- ASN-CSN tunneling support,
- IEEE 802.16e/m subscriber billing and inter-operator settlement
- Inter-CSN tunneling for roaming
- Inter-ASN mobility

The IEEE 802.16e/m services such as location based services, connectivity for peer-to-peer services, provisioning, authorization and/or connectivity to IP multimedia services and facilities to support lawful intercept services such as those compliant with Communications Assistance Law Enforcement Act (CALEA) procedures.

CSN may further comprise network elements such as routers, AAA proxy/servers, user databases, Interworking gateway MSs. A CSN may be deployed as part of a greenfield IEEE 802.16e/m NSP or as part of an incumbent IEEE 802.16e NSP.

The Relay Stations (RSs) may be deployed to provide improved coverage and/or capacity (see **Error! Reference source not found.**Figure 2**Error! Reference source not found.**). When RSs are present, communications between the BS and the MS can occur directly or via relay.

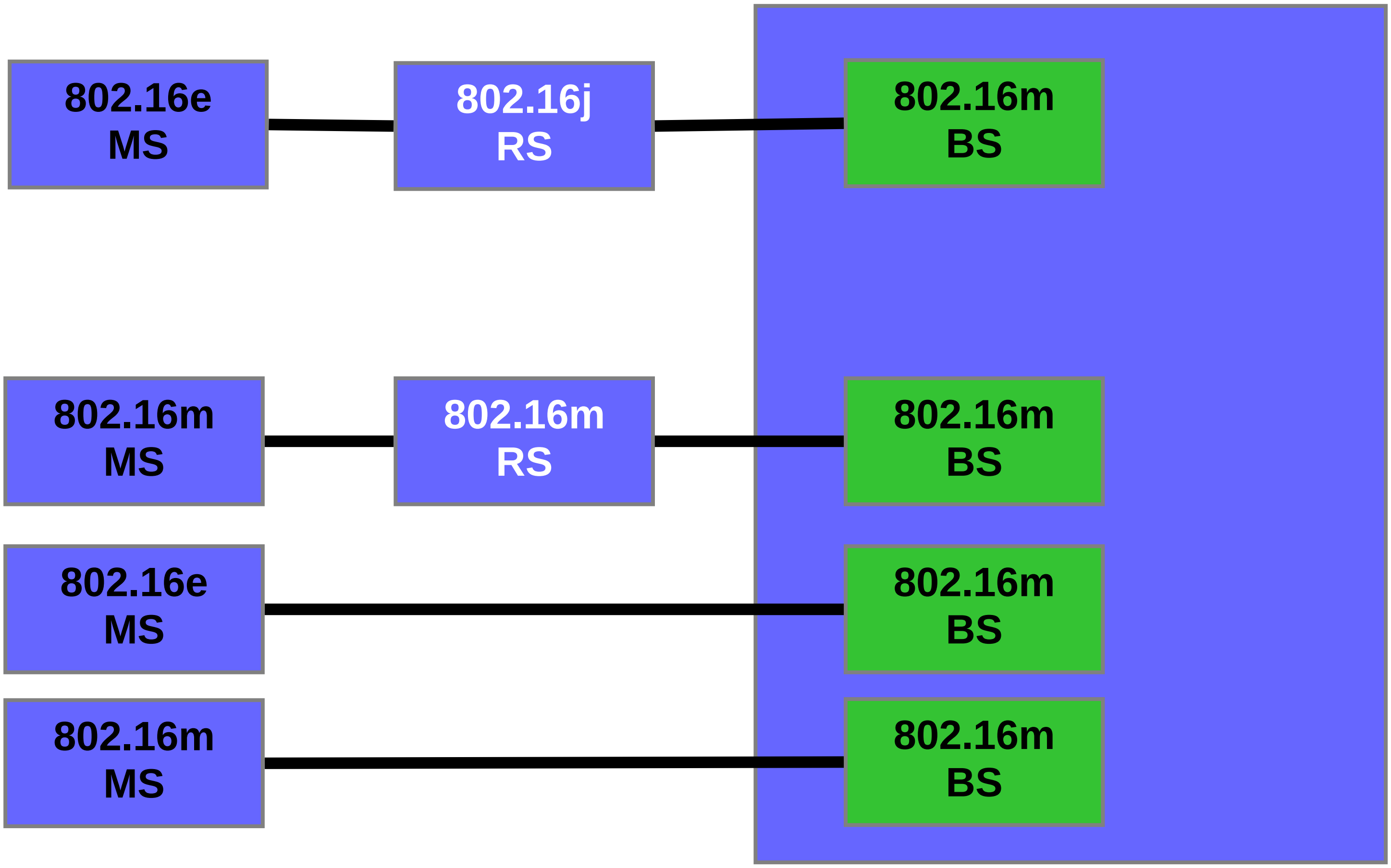

Figure 2 The Relay Station in overall network architecture

A 16m BS that is capable of supporting a 16j RS, shall communicate with the 16j RS in the "legacy zone". The 16m BS is not required to provide 16j protocol support in the "16m zone". The design of 16m relay protocols should be based on the design of 16j wherever possible, although 16m relay protocols used in the "16m zone" may be different from 16j protocols used in the "legacy zone".

5 IEEE 802.16m System Reference Model

<Editor's Note: This section describes system reference model in for those functions introduced in the 802.16m air interface>

As shown in the following Figure 3, the proposed reference model for IEEE 802.16m is very similar to that of IEEE 802.16e with the exception of soft classification of MAC common part sub-layer (i.e., no SAP is required between the two classes of functions) into resource control and management functions and medium access control functions.

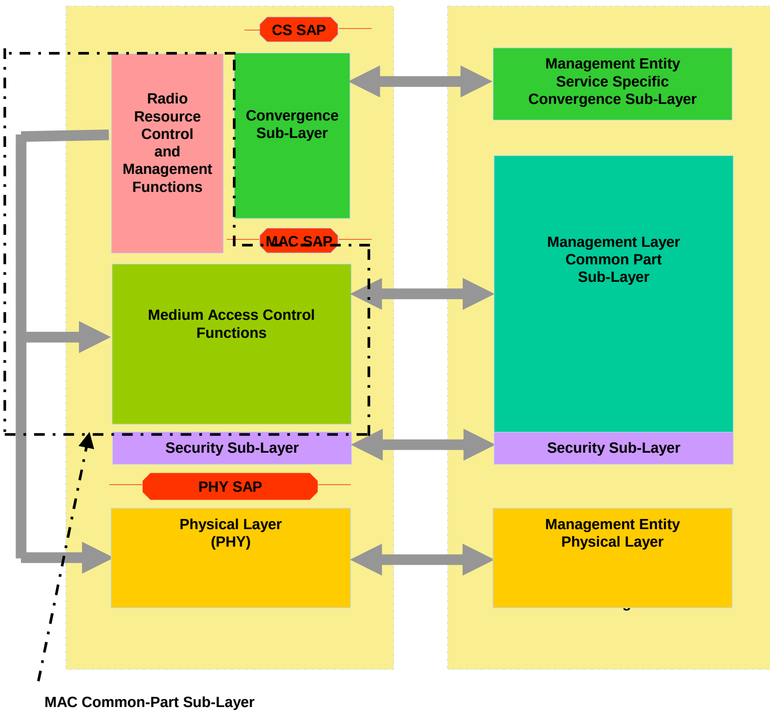

Figure 3 System Reference Model

6 IEEE 802.16m Top Level System State Diagrams

<Editor’s Note: To capture only the top level states of the mobile stations, base stations. Detailed feature specific state diagrams will be captured elsewhere in the respective sections.>

7 Frequency Bands

<Editor’s Note: This section will describe the frequency bands that are applicable to the IEEE 802.16m system>

8 IEEE 802.16m Air-Interface Protocol Structure

8.1 The IEEE 802.16m Protocol Structure

The IEEE 802.16m follows the MAC architecture of current IEEE 802.16e and includes additional functional blocks for 802.16m specific features (see Figure 4). The following additional functional blocks are included:

- Routing
- Self Organization
- Multi-Carrier
- Multi-Radio Coexistence
- Data forwarding
- Interference Management
- Inter-BS coordination

Self Organization block performs functions to support self configuration and self optimization mechanisms. The functions include procedures to request MSs to report measurements for self configuration and self optimization and receive the measurements from the MSs.

Multi-carrier (MC) block enables a common MAC entity to control a PHY spanning over multiple frequency channels. The channels may be of different bandwidths (e.g. 5, 10 and 20 MHz), be non-contiguous or belong to different frequency bands. The channels may be of the same or different duplexing modes, e.g. FDD, TDD, or a mix of bidirectional and broadcast only carriers.

Multi-Radio Coexistence block performs functions to support concurrent operations of 802.16m and non-802.16m radios collocated on the same mobile station.

Interference Management block performs functions to manage the inter-cell/sector interference. The operations may include:

- MAC layer operation
  - Interference measurement/assessment report sent via MAC signaling
  - Interference mitigation by scheduling and flexible frequency reuse
- PHY layer operation
  - Transmit power control
  - Interference randomization
  - Interference cancellation
  - Interference measurement
  - Tx beamforming/precoding

Mobility Management block supports functions related to Inter-RAT handover. It handles the Inter-RAT Network topology acquision which includes the advertisement and meausrement, and also decides whether MS performs Inter-RAT handover operation.

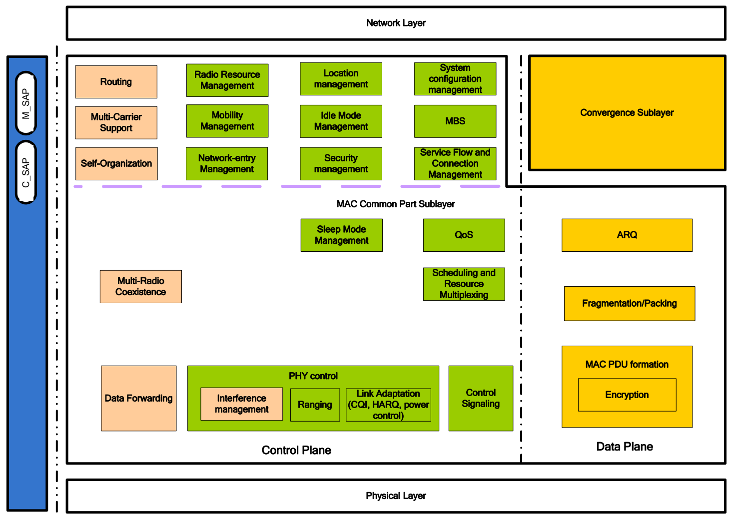

Figure 4 The IEEE 802.16m Protocol Structure

8.1.1 The IEEE 802.16m MS/BS Data Plane Processing Flow

The following Figure 5 shows the user traffic data flow and processing at the BS and the MS. The red arrows show the user traffic data flow from the network layer to the physical layer and vice versa. On the transmit side, a network layer packet is processed by the convergence sublayer, the ARQ function (if present), the fragmentation/packing function and the MAC PDU formation function, to form MAC PDU(s) to be sent to the physical layer. On the receive side, a physical layer SDU is processed by MAC PDU formation function, the fragmentation/packet function, the ARQ function (if present) and the convergence sublayer function, to form the network layer packets. The black arrows show the control primitives among the MAC CPS functions and between the MAC CPS and PHY that are related to the processing of user traffic data.

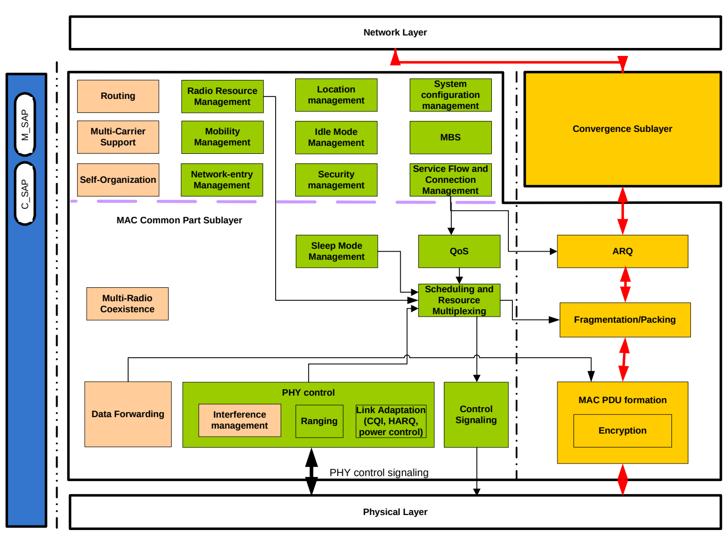

Figure 5 The IEEE 802.16m MS/BS Data Plane Processing Flow

8.1.2 The IEEE 802.16m MS/BS Control Plane Processing Flow

The following figure shows the MAC CPS control plane signaling flow and processing at the BS and the MS. On the transmit side, the blue arrows show the flow of control plane signaling from the control plane functions to the data plane functions and the processing of the control plane signaling by the data plane functions to form the corresponding MAC signaling (e.g. MAC management messages, MAC header/sub-header) to be transmitted over the air. On the receive side, the black arrows show the processing of the received over-the-air MAC signaling by the data plane functions and the reception of the corresponding control plane signaling by the control plane functions. The black arrows show the control primitives among the MAC CPS functions and between the MAC CPS and PHY that are related to the processing of control plane signaling.

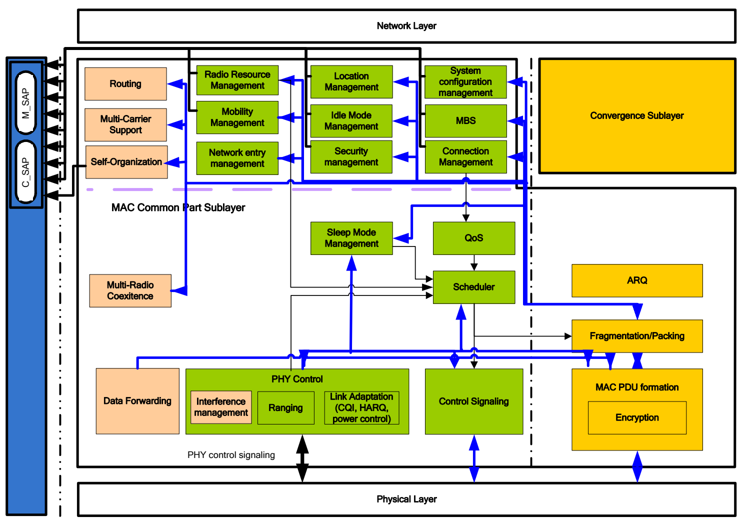

Figure 6 The IEEE 802.16m MS/BS Control Plane Processing Flow

8.1.3 Basic Protocol architecture for Multicarrier Support

Generic protocol architecture to support multicarrier system is illustrated in Figure 7. A common MAC entity may control a PHY spanning over multiple frequency channels. Some MAC messages sent on one carrier may also apply to other carriers. The channels may be of different bandwidths (e.g. 5, 10 and 20 MHz), be non-contiguous or belong to different frequency bands. The channels may be of different duplexing modes, e.g. FDD, TDD, or a mix of bidirectional and broadcast only carriers.

The multicarrier functionality may similarly be applied to multiple groups of subchannels within the frequency channels.

The MAC entity may support simultaneous presence of MSs with different capabilities, such as operation over one channel at a time only or aggregation across channels, operation over contiguous or non-contiguous channels.

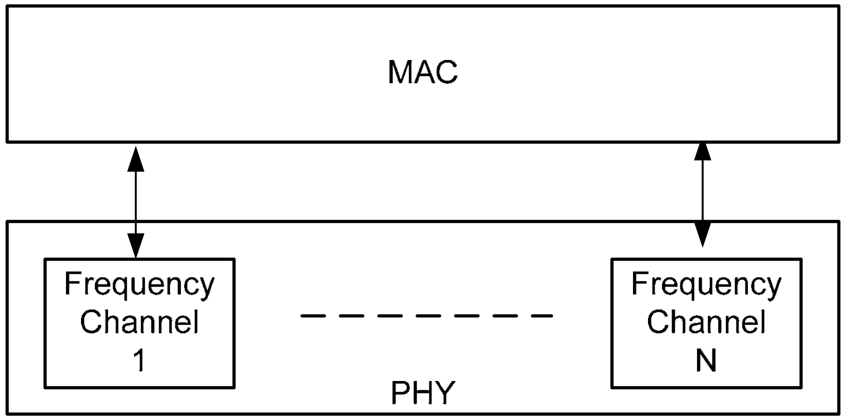

Figure 7 Generic protocol architecture to support multicarrier system

9 Convergence Sub-Layer

10 Medium Access Control Sub-Layer

11 Physical Layer

12 Security

13 Inter-Radio Access Technology Functions

14 Support for Location Based Services

15 Support for Enhanced Multicast Broadcast Service

16 Support for multi-hop relay

17 Solutions for Co-deployment and Co-existence

18 Support for Self-organization

19 Support for Multicarrier

20 RF Requirements

Appendix 1 IEEE 802.16e Protocol Structure

The following Figure 8 shows the protocol architecture of IEEE 802.16e which will be used as reference system. The MAC layer is composed of two sub-layers: Convergence Sublayer (CS) and MAC Common Part Sublayer (MAC CPS).

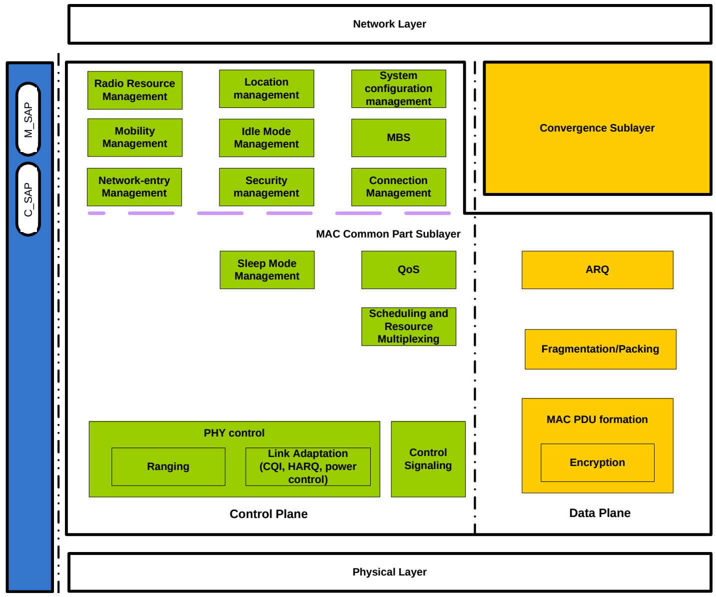

Figure 8 The IEEE 802.16e protocol architecture

For convenience, the MAC CPS functions are classified into two groups based on their characteristics. The upper one is named as resource control and management functions group, and the lower one is named as medium access control functions. Also the control plane functions and data plane functions are also separately classified.

The resource control and management functional group includes several functional blocks that are related with radio resource functions such as:

- Radio Resource Management
- Mobility Management
- Network-entry Management
- Location Management
- Idle Mode Management
- Security Management
- System Configuration Management
- MBS
- Connection Management

Radio Resource Management block adjusts radio network parameters related to the traffic load, and also includes function of load control (load balancing), admission control and interference control.

Mobility Management block handles related to handover procedure. Mobility Management block manages candidate neighbor target BSs based on some criteria, e.g. PHY signaling report, loading, etc. and also decides whether MS performs handover operation.

Network-entry Management block is in charge of initialization procedures. Network-entry Management block may generate management messages which needs during initialization procedures, i.e., ranging (this does not mean physical ranging, but ranging message in order to identification, authentication, and CID allocation), basic capability, registration, and so on.

Location Management block is in charge of supporting location based service (LBS). Location Management block may generate messages including the LBS information. The Idle Mode Management block manages location update operation during idle mode.

Idle Mode Management block controls idle mode operation, and generates the paging advertisement message based on paging message from paging controller in the core network side.

Security Management block is in charge of key management for secure communication. Using managed key, traffic encryption/decryption and authentication are performed.

System Configuration Management block manages system configuration parameters, and generates broadcast control messages such as downlink/uplink channel descriptor (DCD/UCD).

MBS (Multicast and Broadcasting Service) block controls management messages and data associated with broadcasting and/or multicasting service.

Connection Management block allocates connection identifiers (CIDs) during initialization/handover/ service flow creation procedures. Connection Management block interacts with convergence sublayer to classify MAC Service Data Unit (MSDU) from upper layer, and maps MSDU onto a particular transport connection.

The medium access control functional group includes function blocks which are related with physical layer and link controls such as:

- PHY Control
- Control Signaling
- Sleep Mode Management
- QoS
- Scheduling and Resource and Multiplexing
- ARQ
- Fragmentation/Packing
- MAC PDU formation

PHY Control block handles PHY signaling such as ranging, measurement/feedback (CQI), and HARQ ACK/NACK. Based on CQI and HARQ ACK/NACK, PHY Control block estimates channel environment of MS, and performs link adaptation via adjusting modulation and coding scheme (MCS) or power level.

Control Signaling block generates resource allocation messages such as DL/UL-MAP as well as specific control signaling messages, and also generates other signaling messages not in the form of general MAC messages (e.g., DL frame prefix also known as FCH).

Sleep Mode Management block handles sleep mode operation. Sleep Mode Management block may also generate management messages related to sleep operation, and may communicate with Scheduler block in order to operate properly according to sleep period.

QoS block handles rate control based on QoS parameters input from Connection Management function for each connection, and scheduler shall operate based on the input from QoS block in order to meet QoS requirement.

Scheduling and Resource and Multiplexing block schedules and multiplexes packets based on properties of connections. In order to reflect properties of connections Scheduling and Resource and Multiplexing block receives QoS information from QoS block for each connection.

ARQ block handles MAC ARQ function. For ARQ-enabled connections, ARQ block logically splits MAC SDU to ARQ blocks, and numbers to each logical ARQ block. ARQ block may also generate ARQ management messages such as feedback message (ACK/NACK information).

Fragmentation/Packing block performs fragmenting or packing MSDUs based on scheduling results from Scheduler block.

MAC PDU formation block constructs MAC protocol data unit (PDU) so that BS/MS can transmit user traffic or management messages into PHY channel. MAC PDU formation block may add sub-headers or extended sub-headers. MAC PDU formation block may also add MAC CRC if necessary, and add generic MAC header.

A1.1 The IEEE 802.16e MS/BS Data Plane Processing Flow

The following figure describes data transmission flow in the 802.16e. On the transmitter side, after a packet arrives from higher layer, Convergence Sublayer classifies a packet according to classification rules, and maps a packet onto a particular transport connection. If a packet is associated with ARQ connection, then ARQ block logically splits a packet into ARQ blocks. After scheduling, a packet may be fragmented or packed, and add sub-header if necessary. A packet including sub-headers may be encrypted if negotiated. MAC PDU formation block adds generic MAC header, then MAC Protocol Data Unit (MPDU) is constructed. Several MPDUs may be concatenated according to the size of the data burst.

On the receiver side, after a packet arrives from physical layer, MAC PDU formation block constructs MPDU, and Fragmentation/Packing block defragments/unpacks MPDU to make MSDU. After reconstituted in Convergence Sublayer, MSDU is transferred to higher layer.

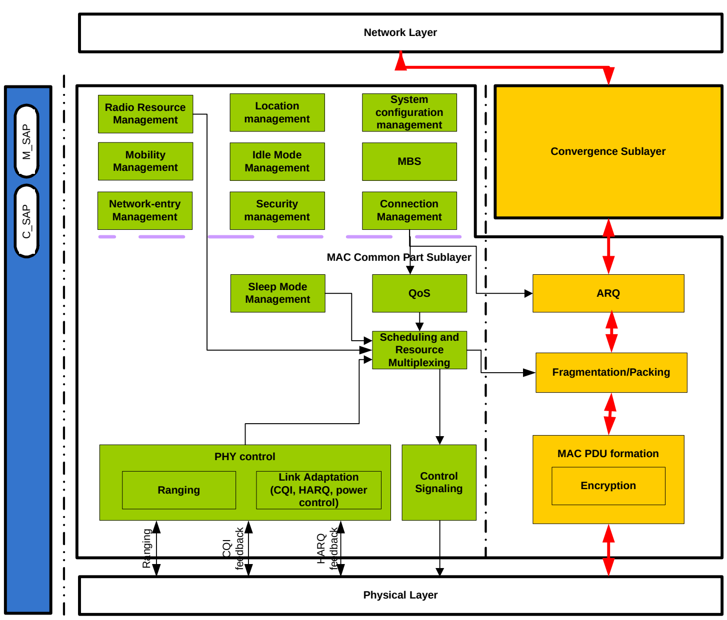

Figure 9 The IEEE 802.16e MS/BS Data Plane Processing Flow

A1.2 The IEEE 802.16e MS/BS Control Plane Processing Flow

The following Figure 10 describes the MAC message transmission flow in 802.16e. Most of the MAC functional block generates its own management messages, and these messages are transported to Fragmentation/Packing block. Basically the MAC management message does not use ARQ block (Management messages will be operated in request-and-response manner, that is, if there is no response, sender retransmits request. Therefore additional ARQ operation is not required). Management message may be fragmented or packed, and authentication information (e.g., CMAC/HMAC in 802.16e) may be appended to the management message if necessary. Some of MAC message may be transmitted via Control Signaling block in the form of control message (e.g., MAP). On the receiver side, most of MAC functional block also receives and handles MAC management messages from the MAC functional block of the opposite side (MS to BS, BS to MS).

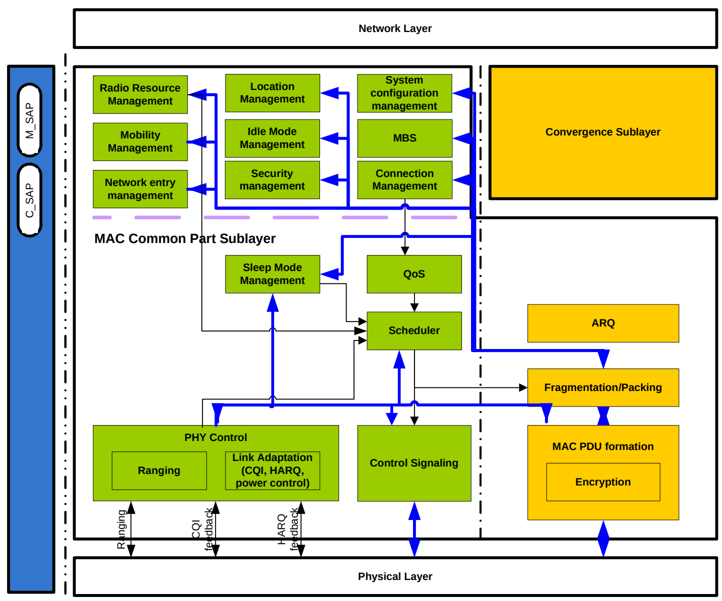

Figure 10 The IEEE 802.16e MS/BS Control Plane Processing Flow