Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**The Draft IEEE 802.16m System Description Document**
Date Submitted	**2008-06-16**
Source(s)	Shkumbin Hamiti Nokia SDD editor Voice: +358504837349 E-mail: shkumbin.hamiti@nokia.com
Re:	The Draft SDD
Abstract	This version is a clean version of IEEE 802.16m-08/003r2 including few editorial corrections.
Purpose	Call for comments for IEEE 802.16m session #56
Notice	
Release	
Patent Policy	

The Draft IEEE 802.16m System Description Document

Table of Content

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].

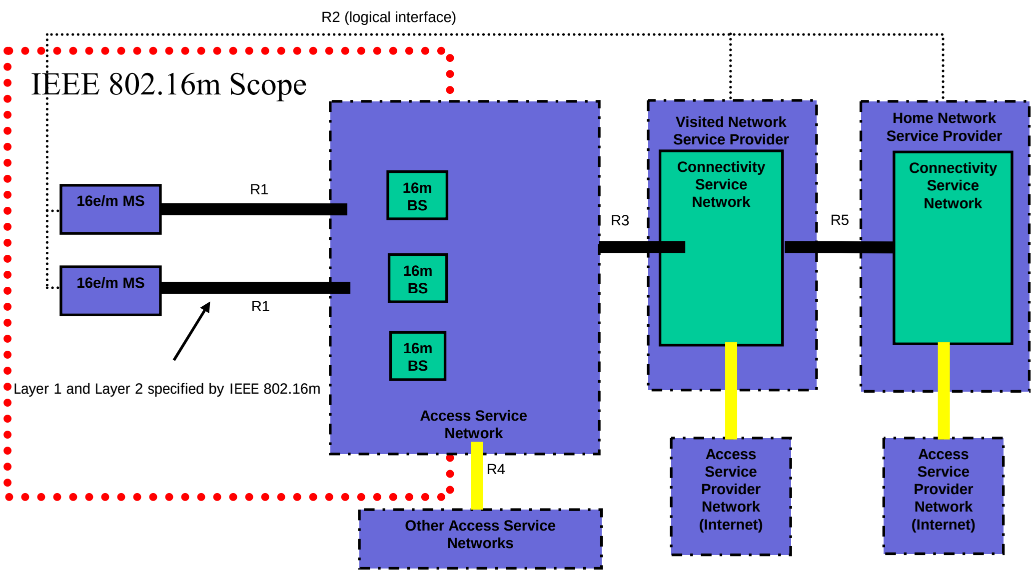

Figure 1 Example of overall network architecture

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
- 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 CSN provides services such as location based services, connectivity for peer-to-peer services, provisioning, authorization and/or connectivity to IP multimedia services and facilities.

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 IEEE 802.16m 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 (Figure 2). When RSs are present, communications between the BS and the MS can occur directly or via relay.

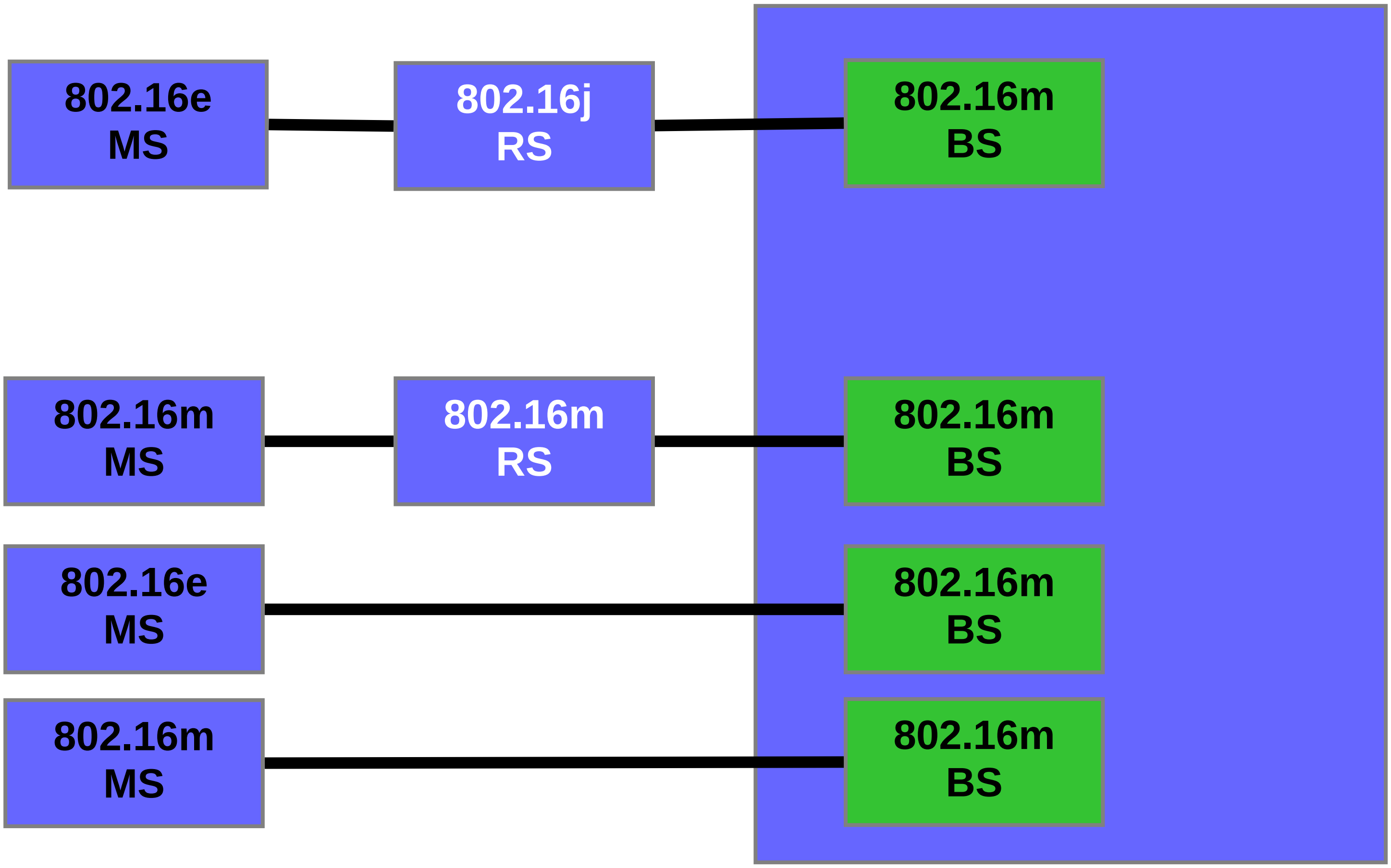

Figure 2 The Relay Station in overall network architecture

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".]

Figure 3 and Table 1, show the 16m relay related interfaces that are to be supported and those which are not required to be supported in the 802.16 specification. Only the interfaces involving RSs (16m and legacy RS) are shown.

The 16j BS, shown in Figure 3 is referred to as an MR-BS in the 16j draft amendment. Figure 3 and Table 1 also indicate the specific 802.16 protocol that is to be used for supporting the particular connection. In Figure 3, it is assumed that the 16m MS supports 16m and 16e air interface per SRD requirements.

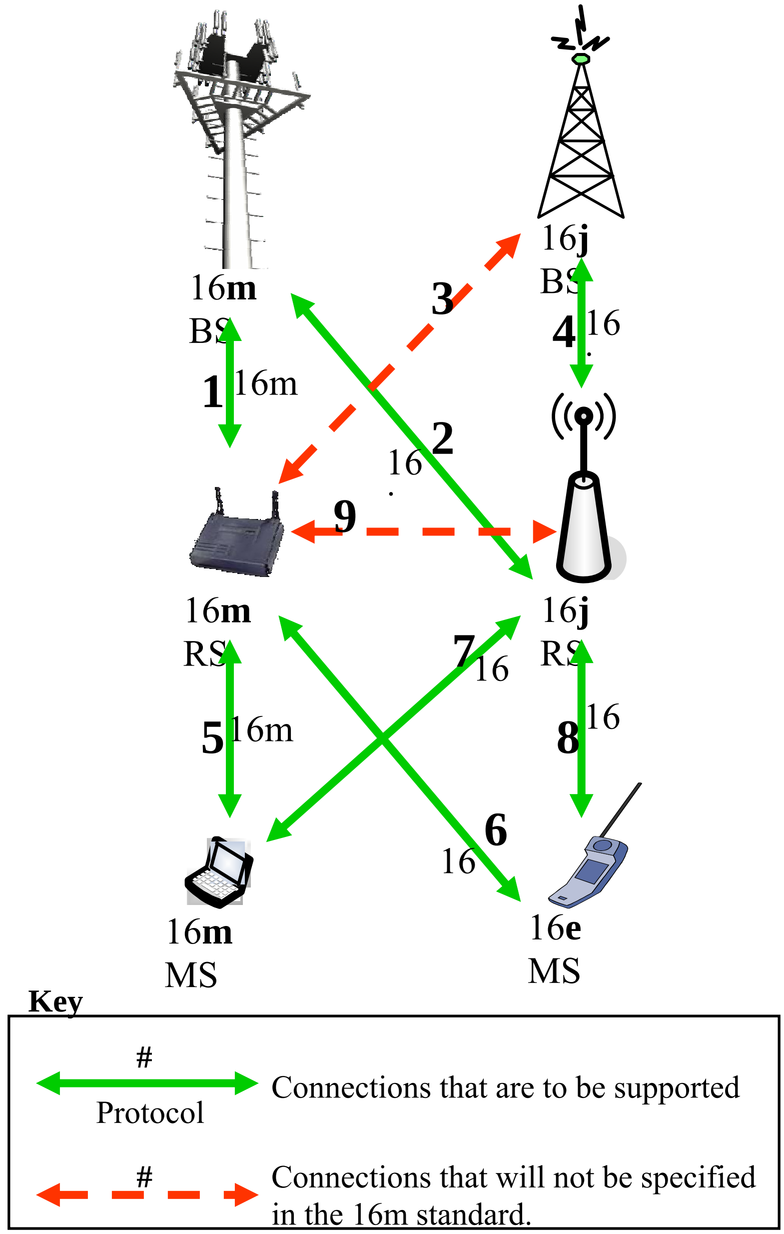

Figure 3 Relay protocol support

Connection #	Connected Entities	Protocol used	Supported (Y/N)
1	16m BS -16m RS	16m	Y
2	16m BS - 16j RS	16j	Y
3	16m RS – 16j BS	N/A	N
4	16j BS - 16j RS	16j	Y
5	16m RS - 16m MS	16m	Y
6	16m RS - 16e MS	16e	Y
7	16m MS – 16j RS	16e	Y
8	16j RS - 16e MS	16e	Y
9	16m RS – 16j RS	N/A	N

Table 1 Relay protocol support

5 IEEE 802.16m System Reference Model

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

As shown in the following Figure 4, 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 into resource control and management functions and medium access control functions (i.e., no SAP is required between the two classes of functions).

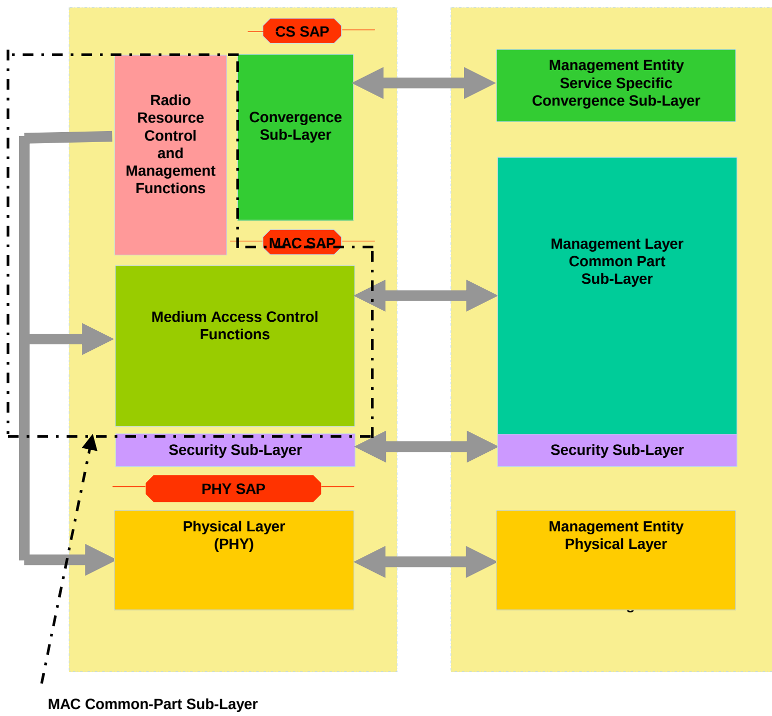

Figure 4 System Reference Model

6 IEEE 802.16m Mobile Station 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.>The following Figure 5 illustrates the system state transition diagram for IEEE802.16m BS and MS. System state diagram for IEEE802.16m systems consists of 4 states, Initialization state, Access state, Connected state and Idle state. The Connected state consists of 3 separated modes which are sleep mode, active mode and scanning mode based on its operation and MAC message generation. The Idle state consists of 2 separated modes, paging listening mode and paging unavailable mode based on its operation and MAC message generation.

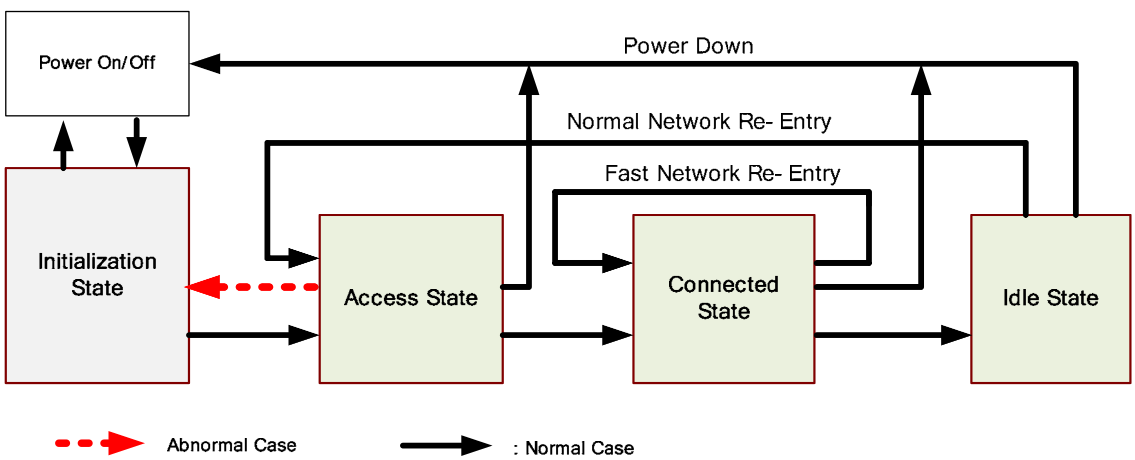

Figure 5 System State Transition Diagram of IEEE802.16m

6.1 Initialization State

Initial State is where an MS performs cell selection by scanning and synchronizing to a BS preamble, and acquiring the system configuration information through BCH before it is ready to perform a ranging process to enter Access State. The MS can return back to scanning step in case that it fails to perform action required to each step.

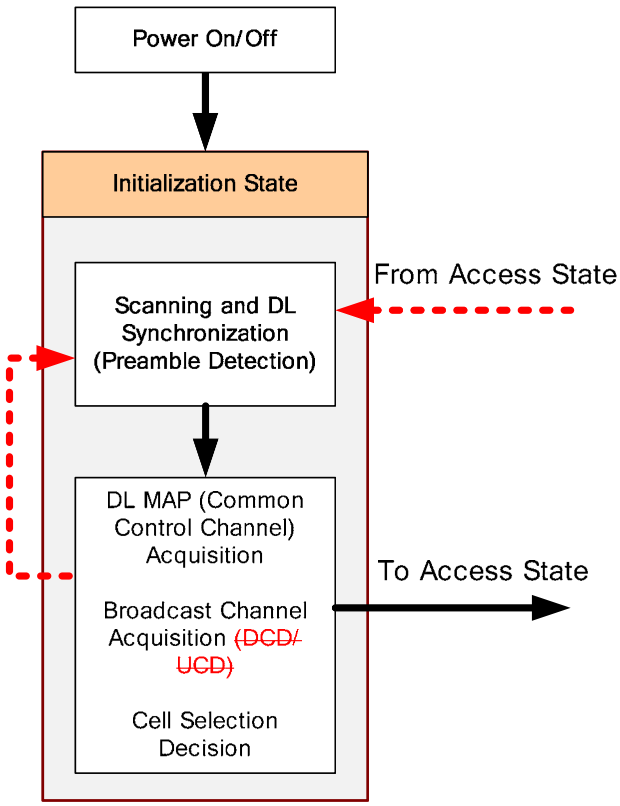

Figure 6 Initialization State Transition Diagram

During this state, if the MS could not properly perform the BCH information decoding and cell selection, it should be back to perform the scanning and DL synchronization. The red dashed line stands the abnormal case. If the MS successfully decodes BCH information, it goes to Access state. If the abnormal case occurs in Access state, the stats transition should be achieved from the Initialization state again.

6.2 Access State

Access State is where the MS performs network entry to the selected BS by going through several processes. A MS performs the ranging process using RNG-REQ/RSP MAC message in order to get UL synchronization. A MS performs the basic capability negotiation with BS using SBC-REQ/RSP MAC message. A MS then performs the authentication and authorization process through key exchanging. And finally a MS performs the registration process using REG-RES/RSP MAC message followed by a MS gets the MAC CID and IP address.

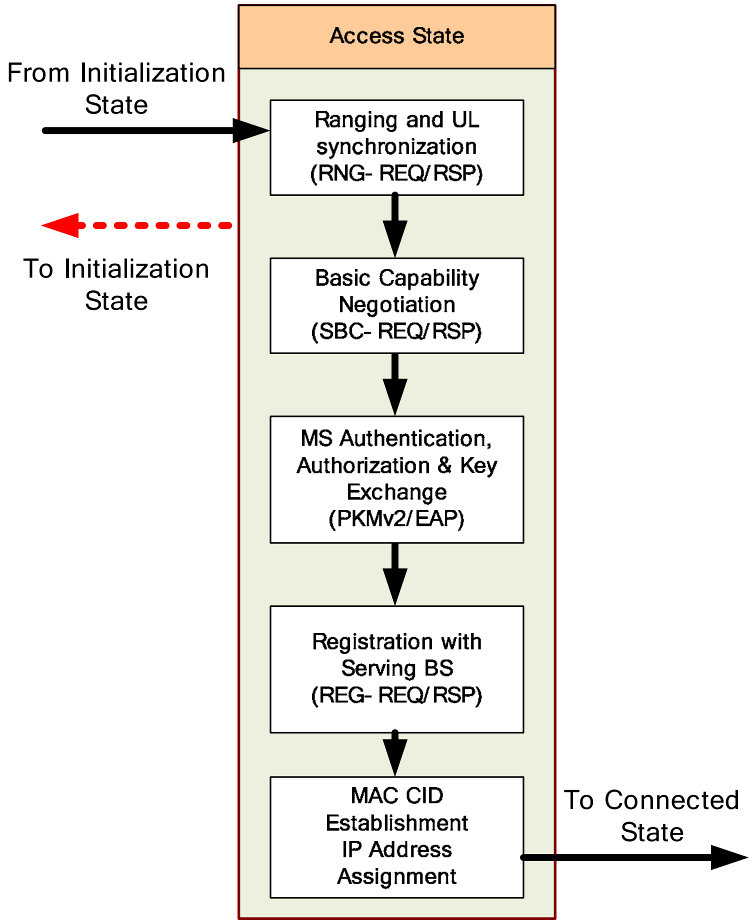

Figure 7 Access State Transition Diagram

Upon successfully performing the access state operation, a MS goes to connected state in order to exchange the user data between BS and MS. Otherwise a MS goes back to Initialization state in case of abnormal operation.

6.3 Connected State

The state consists of 3 modes; sleep mode, active mode and scanning mode. During Connected State, MS maintains at least one connection as established during Access State, while MS and BS may establish additional transport connections. In addition, to save power consumption of the MS during exchanging the user date, a MS or BS can request a transition to sleep mode. And also, MS can scan neighbor cell's signal to reselect a cell which provides robust and reliable services.

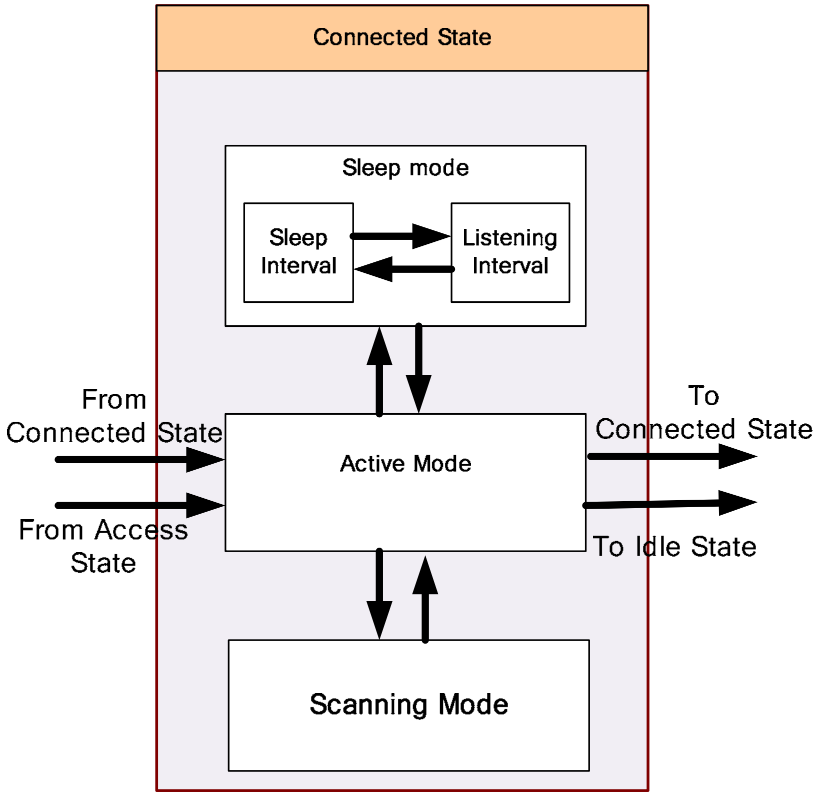

Figure 8 Connected State Transition Diagram

6.3.1 Active mode

During Active Mode, the MS and the BS perform normal operations to exchange the DL/UL traffic transaction between MS and BS. And MS can perform the Fast re-entry procedures after handover: while in handover, MS CID and IP address are remained. Without going through access state, MS can keep in connected state with target BS.

6.3.2 Sleep mode

During Sleep mode, MS can do power saving during traffic interval. MS in Active mode transits to sleep mode through sleep mode MAC management messages such as MOB_SLP-REQ/RSP. MS does not transmit and receive any traffic to/from its BS in sleep interval. A MS can receive a MOB_TRF-IND message during listening interval and then whether a MS can transit to active mode or be stayed in sleep interval according to a indication bit in MOB_TRF-IND message.

6.3.3 Scanning mode

During scanning mode, the MS may be temporarily unavailable to the BS, and performs scanning operation. While in active mode, MS transits to scanning mode through explicit scanning transaction through MOB_SCN-REQ/RSP. In this mode, MS is unavailable to BS. In addition, a MS can perform the implicit scanning procedures that MS performs a scanning other BSs without scanning management messages generation.

6.4 Idle State

During Idle state, the MS performs power saving by switching between Paging listening mode and Paging Unavailable mode

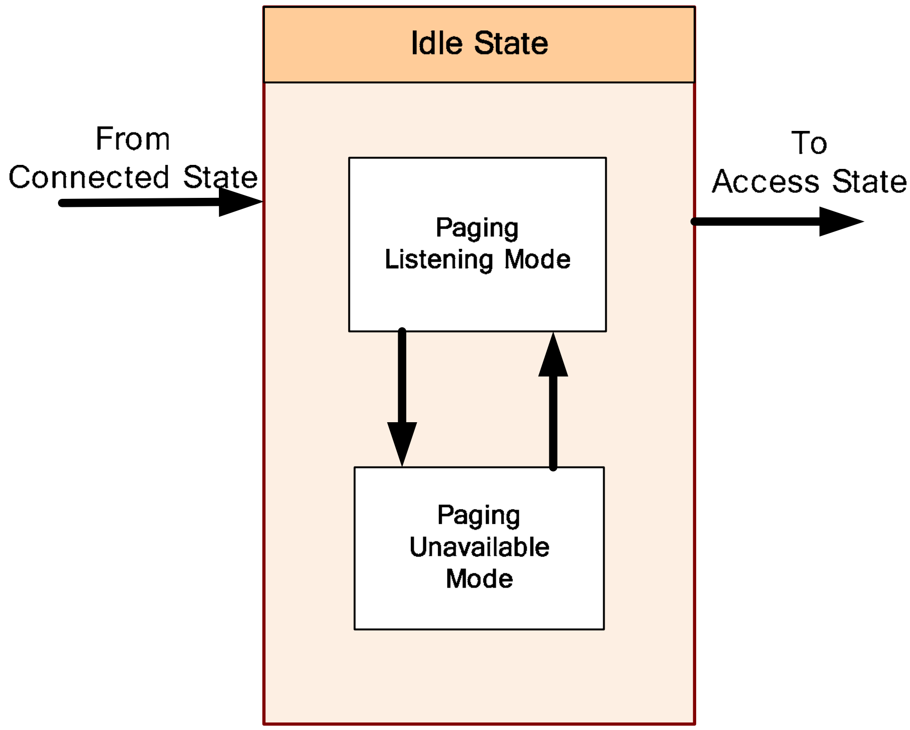

Figure 9 Idle State Transition Diagram

6.4.1 Paging Listening Mode

During the paging listening mode, MOB_PAG-ADV is received. If a MS is paged, MS transits to access state for its network re-entry. Location update procedure is also achieved.

6.4.2 Paging Unavailable Mode

During paging unavailable mode, MS does not need to monitor down link channel in order to save its power consumptions. While in this mode, MS can also transit to access state if required.

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 802.16m MAC is divided into three sublayers:

- Convergence sublayer (CS)
- Radio Resource Control and Management (RRCM) sublayer
- Medium Access Control (MAC) sublayer

The IEEE 802.16m follows RRCM 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
- Relay functions
- Self Organization
- Multi-Carrier

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.

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. For contiguous frequency channels, the overlapped guard sub-carriers shall be aligned in frequency domain in order to be used for data transmission.

The Medium Access Control (MAC) sublayer includes function blocks which are related to the 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
- Multi-Radio Coexistence
- Data forwarding
- Interference Management
- Inter-BS coordination

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.

Multi-Radio Coexistence block performs functions to support concurrent operations of IEEE 802.16m and non-IEEE 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 Intra-RAT/ Inter-RAT handover. It handles the Intra-RAT/ Inter-RAT Network topology acquisition which includes the advertisement and meausrement, and also decides whether MS performs Intra-RAT/ Inter-RAT handover operation.

Inter-BS coordination block performs functions to coordinate the actions of multiple BSs by exchanging information for interference management. The functions include procedures to exchange information for interference management between the BSs by backbone signaling and by MS MAC messaging. The information may include interference characteristics, e.g. interference measurement results, etc.

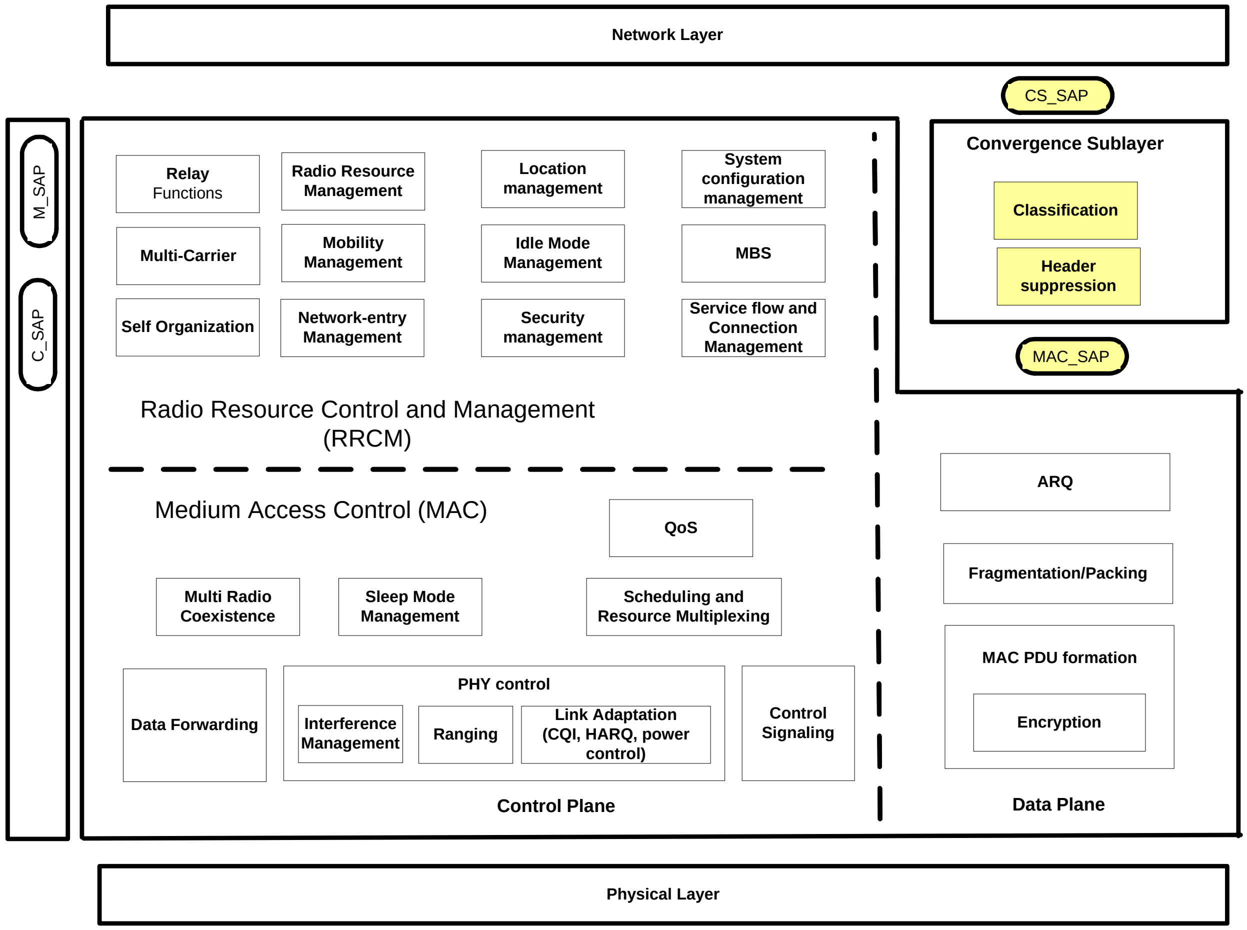

Figure 10 The IEEE 802.16m Protocol Structure

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

The following Figure 11 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.

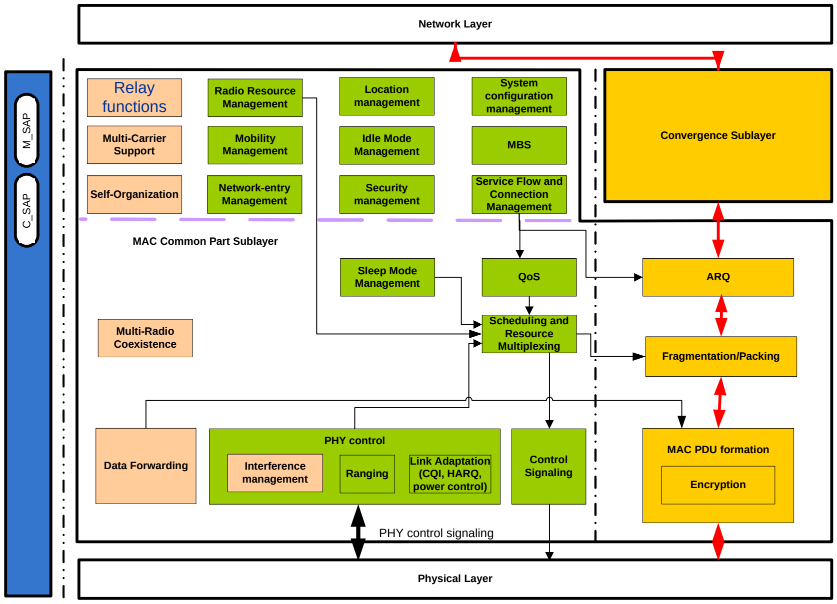

Figure 11 The IEEE 802.16m MS/BS Data Plane Processing Flow Note: The MS may not utilize all the blocks shown in this figure.

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 blue 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. The black arrows between M_SAP/C_SAP and MAC functional blocks show the control and management primitives to/from Network Control and Management Service (NCMS). The primitives to/from M_SAP/C_SAP define the network involved functionalities such as inter-BS interference management, inter/intra RAT mobility management, etc, and management related functionalities such as location management, system configuration etc.

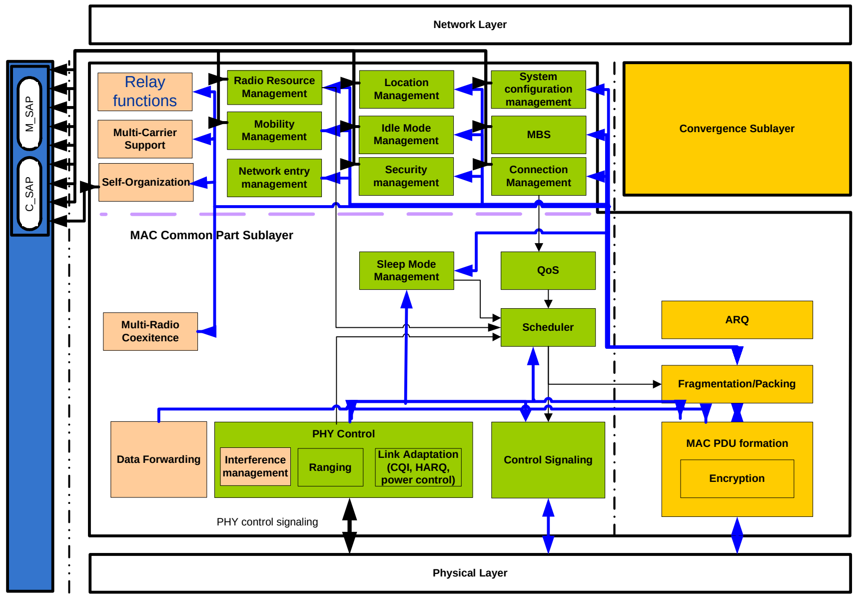

Figure 12 The IEEE 802.16m MS/BS Control Plane Processing Flow Note: The MS may not utilize all the blocks shown in this figure.

8.1.3 Multicarrier Support Protocol Structure

Generic protocol architecture to support multicarrier system is illustrated in Figure 13. 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 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.

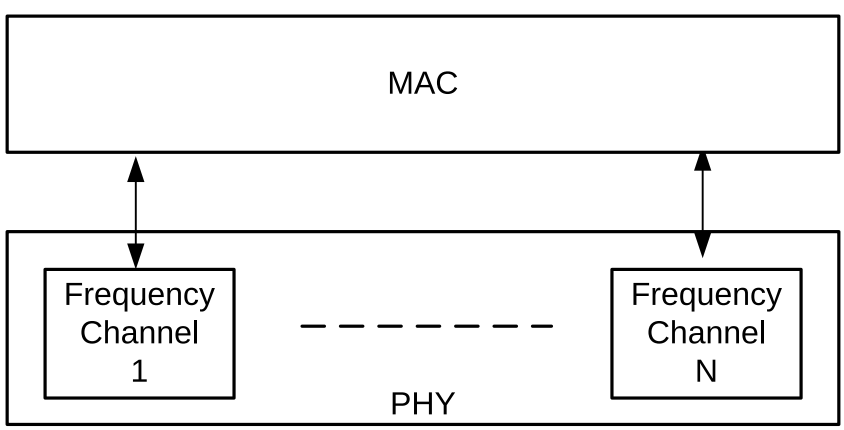

Figure 13 Multicarrier support protocol structure

9 Convergence Sub-Layer

10 Medium Access Control Sub-Layer

11 Physical Layer

11.1 Duplex modes

IEEE 802.16m supports TDD and FDD duplex modes, including H-FDD MS operation, in accordance with the IEEE 802.16m system requirements document [8]. Unless otherwise specified, the frame structure attributes and baseband processing are common for all duplex modes.

11.2 Downlink and Uplink Multiple Access Schemes

IEEE 802.16m uses OFDMA as the multiple access scheme in the downlink and uplink.

11.3 OFDMA Parameters

The OFDMA parameters for the IEEE 802.16m are specified as follows:

Nominal Channel Bandwidth (MHz)		**5**	**7**	**8.75**	**10**	**20**
Over-sampling Factor		**28/25**	**8/7**	**8/7**	**28/25**	**28/25**
Sampling Frequency (MHz)		**5.6**	**8**	**10**	**11.2**	**22.4**
FFT Size		**512**	**1024**	**1024**	**1024**	**2048**
Sub-Carrier Spacing (kHz)		**10.937500**	**7.812500**	**9.765625**	**10.937500**	**10.937500**
useful symbol time T_u (μs)		**91.429**	**128**	**102.4**	**91.429**	**91.429**
Cyclic Prefix (CP) T_g=1/8 T_u	**symbol time T_s (μs)**	**102.857**	**144**	**115.2**	**102.857**	**102.857**
	Number of OFDM symbols per Frame	**48**	**34**	**43**	**48**	**48**
	Idle time (μs)	**62.86**	**104**	**46.40**	**62.86**	**62.86**
Cyclic Prefix (CP) T_g=1/16 T_u	**symbol time T_s (μs)**	**97.143**			**97.143**	**97.143**
	Number of OFDM symbols per Frame	**51**			**51**	**51**
	Idle time (μs)	**47.39**			**47.39**	**47.39**

Table 2 OFDMA parameters for IEEE 802.16m

A longer CP size is used in channels with long delay spread.

11.4 Frame structure

11.4.1 Basic Frame structure

The IEEE 802.16m basic frame structure is illustrated in Figure 14. Each 20 ms superframe is divided into four equally-sized 5 ms radio frames. When using the same OFDMA parameters as in Table 1 with the channel size of 5 MHz, 10 MHz, or 20 MHz, each 5 ms radio frame further consists of eight subframes. A subframe shall be assigned for either DL or UL transmission. There are three types of subframes: 1) the type-1 subframe which consists of six OFDM symbols, 2) the type-2 subframe that consists of five OFDM symbols, and 3) the type-3 subframe that consists of seven OFDM symbols.

The basic frame structure is applied to FDD and TDD duplexing schemes, including H-FDD MS operation. The number of switching points in each radio frame in TDD systems either two or four, where a switching point is defined as a change of directionality, i.e., from DL to UL or from UL to DL.

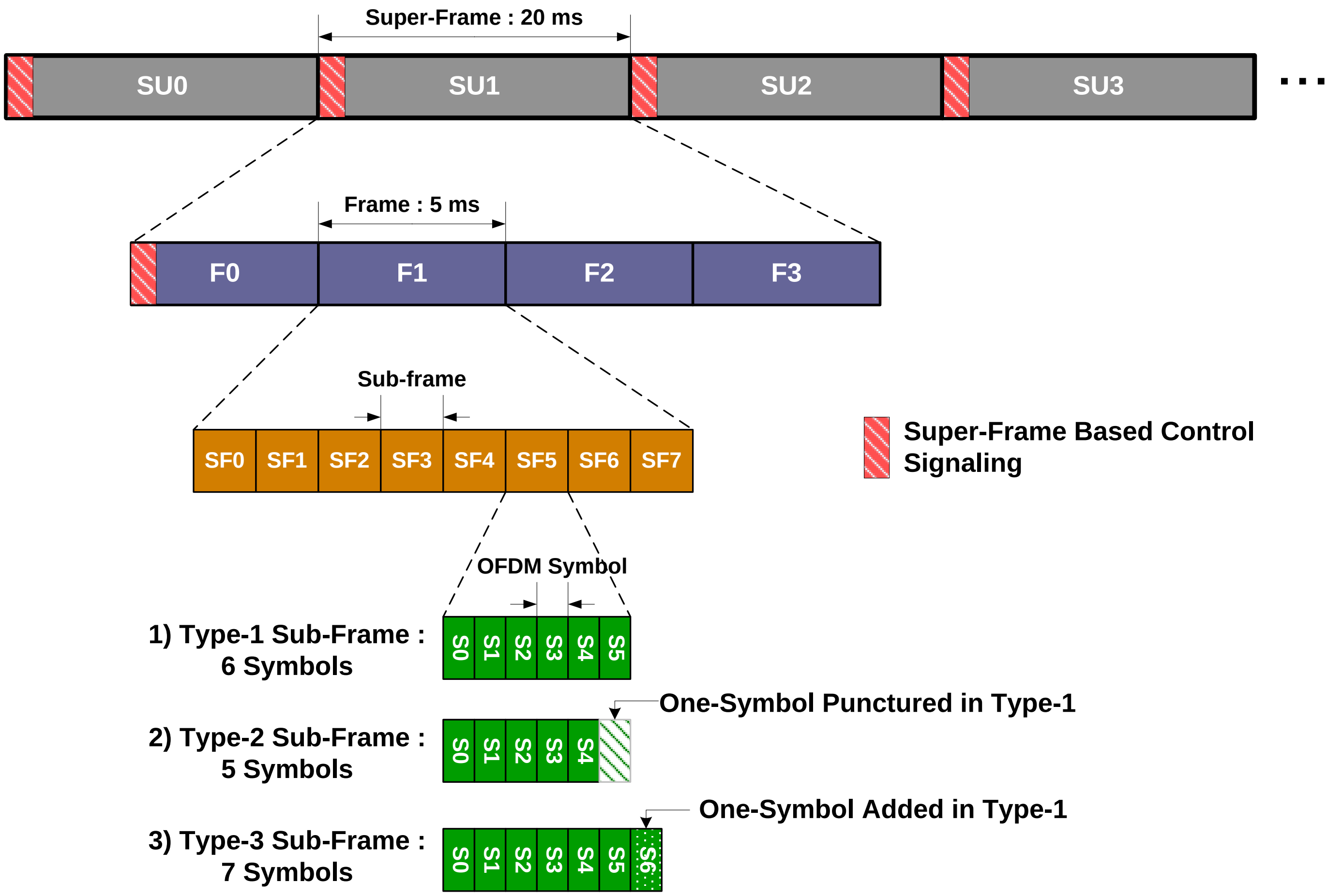

Figure 14 Basic frame structure

Figure 15illustrates an example TDD frame structure with DL to UL ratio of 5:3. Assuming OFDMA symbol duration of 102.82 µs and a CP length of 1/8 T_u, the length of regular and irregular subframes are 0.617 ms. In Figure 9, the last DL subframe, i.e., DL SF4, is an irregular subframe whose last OFDMA symbol is an idle symbol to accommodate the gap required to switch from DL to UL. Other numerologies may result in different number of subframes per frame and symbols within the subframes. Figure 16 shows the frame structure in FDD mode.

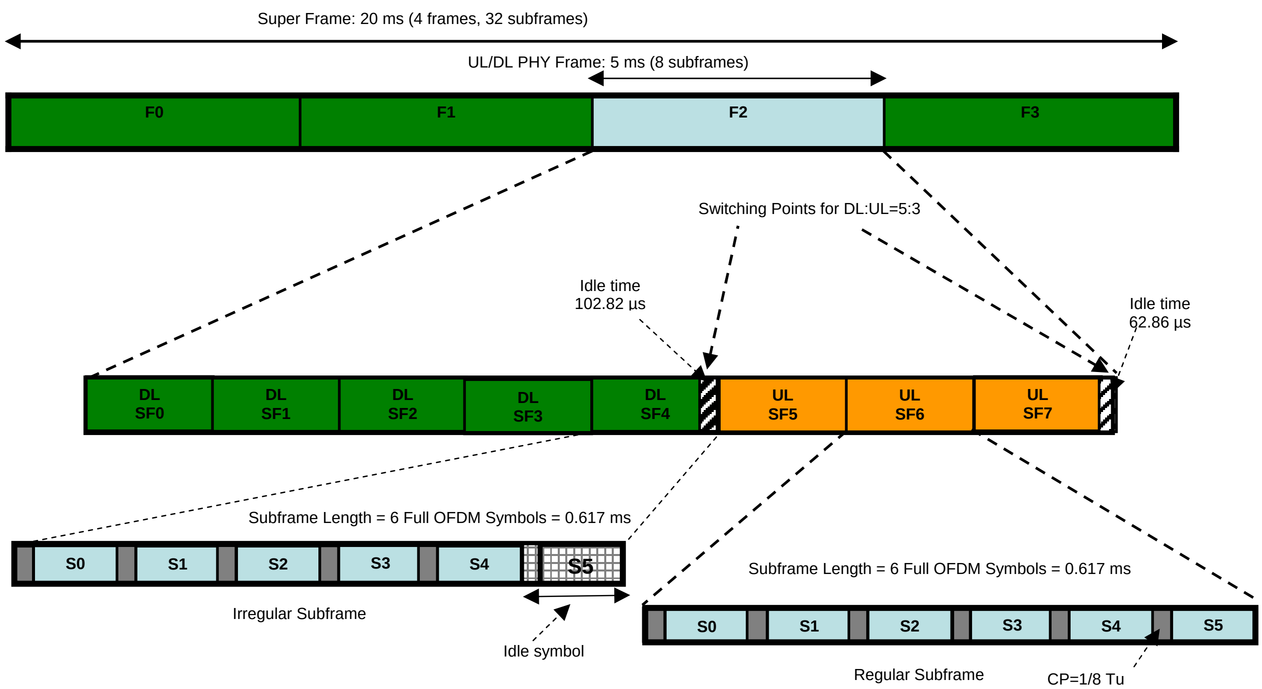

Figure 15 Regular and Irregular subframes in TDD duplex mode (CP=1/8 T_u)

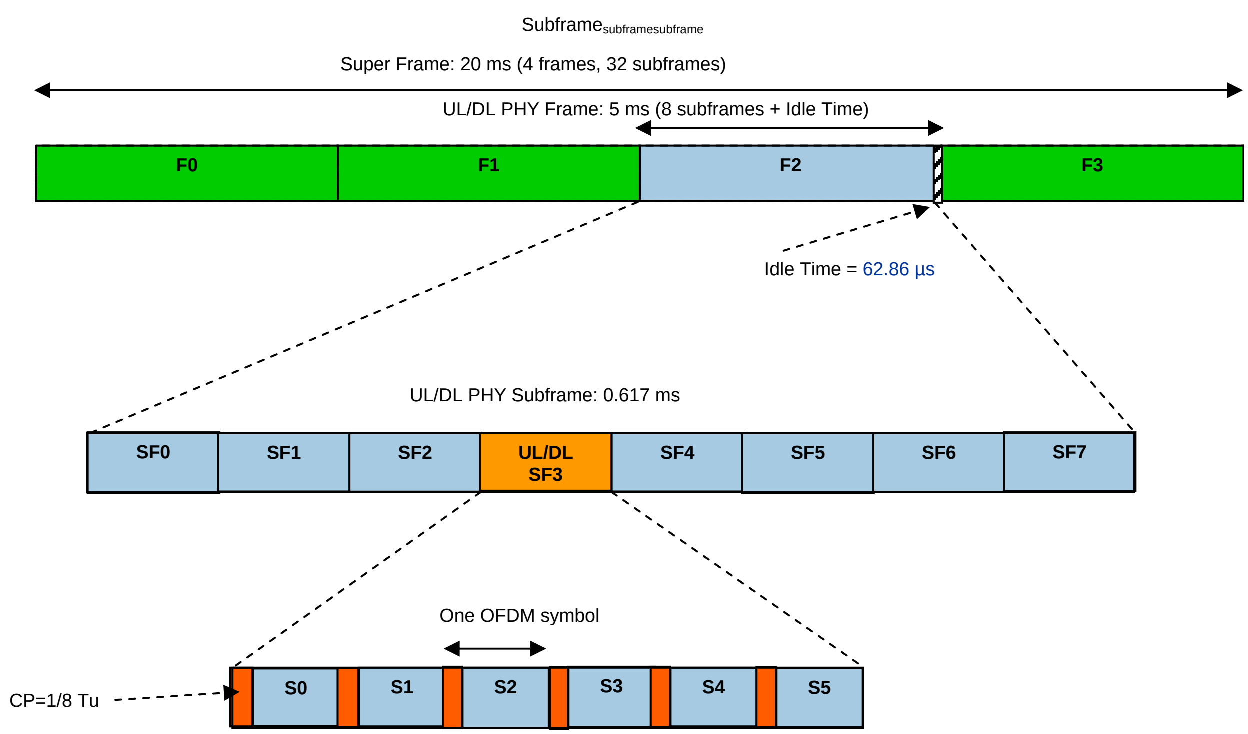

Figure 16 Frame structure in FDD duplex mode (regular subframes) (CP=1/8 T_u)

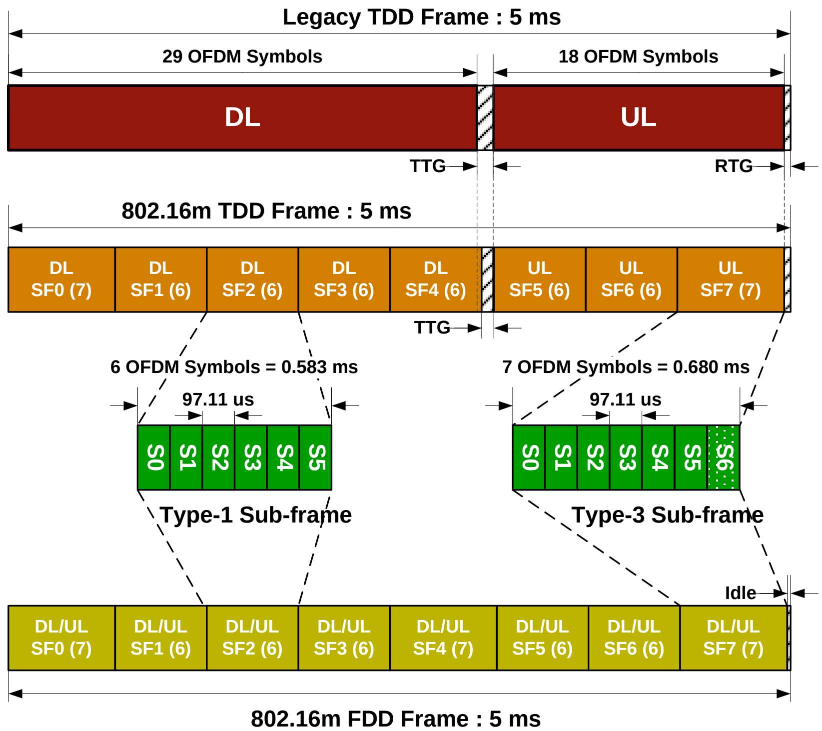

Figure 17 TDD and FDD Frame Structure with a CP of 1/16 T_u (DL to UL ratio of 5:3)

When H-FDD MSs are included in a FDD system, the frame structure from the point of view of the H-FDD mobile station is similar to the TDD frame structure; however, the DL and UL transmissions occur in two separate frequency bands. The transmission gaps between DL and UL (and vice versa) are required to allow switching the TX and RX circuitry.

11.4.1.1 Superframe Header

As shown in Figure 14, each superframe shall begin with a DL sub frame that contains a superframe header.

11.4.1.2 Transmission Time Interval

The transmission time interval (TTI) is the duration of the transmission of the physical layer encoded packet over the radio air interface and is equal to an integer number of subframes (default one subframe).

11.4.1.3 Frame Structure to support multi-carrier operation

The support for multiple RF carriers can be accommodated with the same frame structure used for single carrier support, however, some considerations in the design of protocol and channel structure may be needed to efficiently support this feature.

In general each MS operating under IEEE 802.16m standard is controlled by one RF carrier, here is called the primary RF carrier. When multi-carrier feature is supported, the system may define and utilize additional RF carriers to improve the user experience and QoS or provide services through additional RF carriers configured or optimized for specific services.

Figure 18 shows that the same frame structure would be applicable to both single carrier and multicarrier mode of operation. A number of narrow BW carriers can be aggregated to support effectively wider BW operation. Each carrier may have its own synchronization channel and superframe header (the location and structure is subject to the results of the DL control RG). Further, some carriers may have only part of superframe header.

The multi-carriers involved in multi-carrier operation may be in a contiguous or non-contiguous spectrum. When carriers are in the same spectrum and adjacent and when the separation of center frequency between two adjacent carriers is multiples of subcarrier spacing, no guard subcarriers are necessary between adjacent carriers.

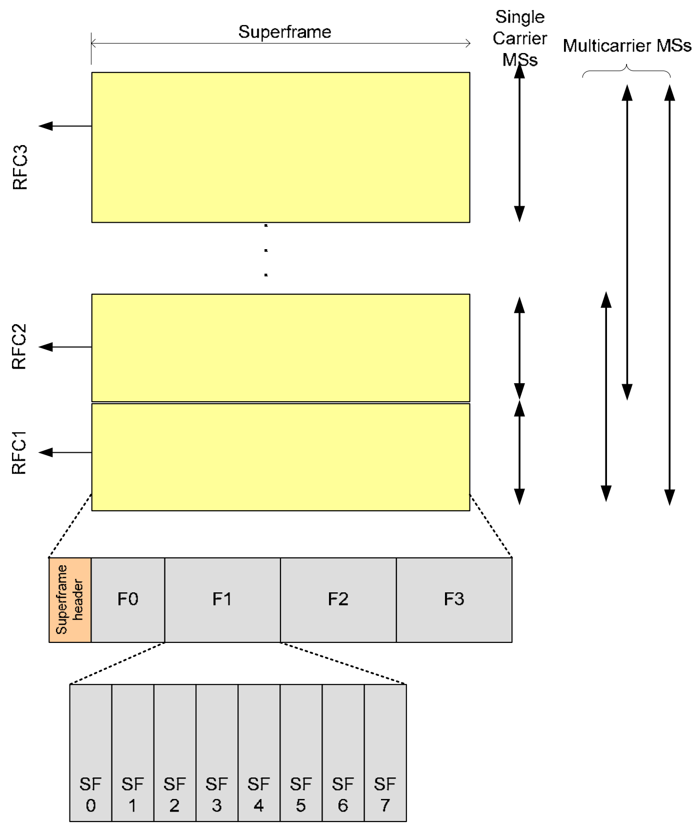

Figure 18 Example of the proposed frame structure to support multi-carrier operation

11.4.2 Frame Structure Supporting Legacy Frames

The legacy and IEEE 802.16m frames are offset by a fixed number of subframes to accommodate new features such as new synchronization channel (preamble), broadcast channel (system configuration information), and control channels, as shown in Figure 19. The FRAME_OFFSET shown in Figure 19 is for illustration. It is an offset between the start of the legacy frame and the start of the new frame carrying the superframe header, defined in a unit of subframes. In the case of coexistence with legacy systems, two switching points shall be selected in each TDD radio frame.

For UL transmissions both TDM and FDM approaches should be supported for multiplexing of legacy and 16m mobiles.

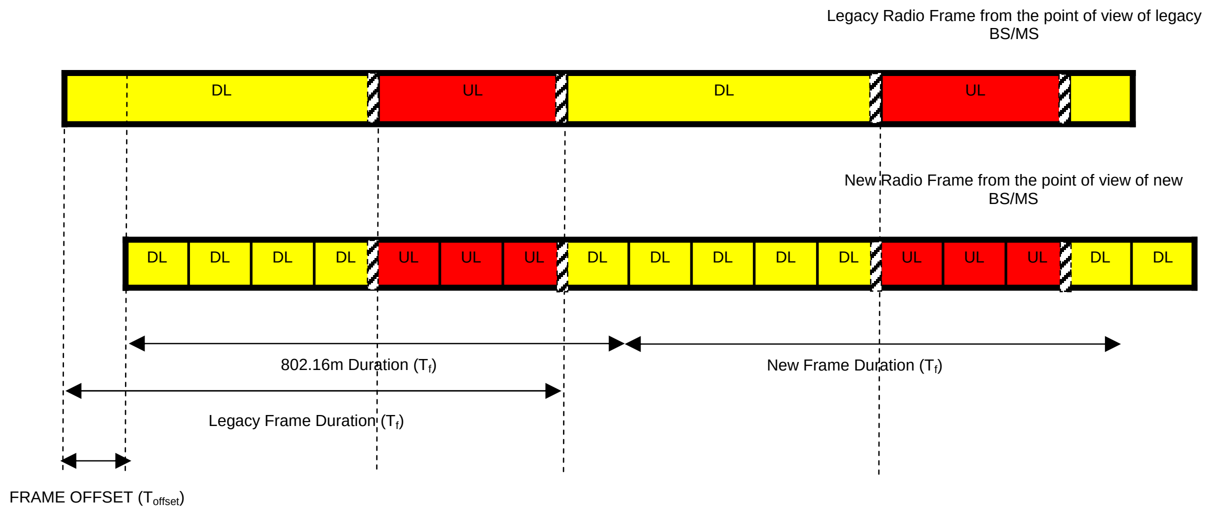

Figure 19 Relative position of the new and legacy radio frames (example TDD duplex mode)

11.4.3 Frame Structure Supporting Legacy Frames with a Wider Channel for the IEEE 802.16m

Figure 20 shows an example for the IEEE 802.16m frame structure supporting legacy frame in a wider channel. A number of narrow bandwidth carriers of the IEEE 802.16m can be aggregated to support wide bandwidth operation of IEEE 802.16m MSs. One or multiple of the narrowband carriers can be designated as the legacy carrier(s). When the center carrier spacing between two adjacent carriers is an integer multiple of subcarrier spacing, there is no necessity to reserve guard subcarriers for the IEEE 802.16m carriers. Different number of usable guard sub-carriers can be allocated on both sides of the carrier.

For UL transmissions both TDM and FDM approaches should be supported for multiplexing of legacy and IEEE 802.16m MSs in the legacy and IEEE 802.16m mixed carrier. The TDM in the figure is only for example.

In the case when the edge carrier is a legacy carrier, the impact of the small guard bandwidth on the edge of the wider channel on the filter requirements is FFS.

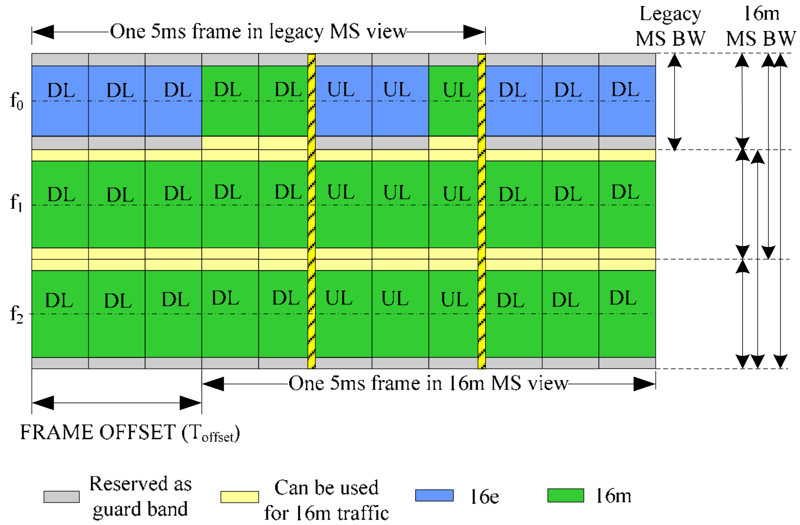

Figure 20 Illustration of frame structure supporting legacy frames with a wider channel

11.4.4 The Concept of Time Zones

The time zone is defined as an integer number (greater than 0) of consecutive subframes. The concept of time zones is introduced that is equally applied to TDD and FDD systems. The new and legacy time zones are time-multiplexed (TDM) across time domain for the downlink. For UL transmissions both TDM and FDM approaches should be supported for multiplexing of legacy and new terminals. Note that DL/UL traffic for the new MS can be scheduled in both zones whereas the DL/UL traffic for the legacy MS can only be scheduled in the legacy zones.

In the absence of any legacy system, the legacy zones will disappear and the entire frame will be allocated to the new zones and thereby new systems.

11.4.4.1 Time Zones in TDD

In a mixed deployment of legacy terminals and new IEEE 802.16m terminals, the allocation of time zones in the TDD mode shall be as shown in Figure 21 and Figure 22 for the two and four switching point case respectively. The duration of the zones may vary. Every frame shall start with a preamble and the MAP followed by legacy DL zone since legacy terminals/relays expect IEEE 802.16e zones in this region. Similarly In a mixed deployment of legacy terminals and new IEEE 802.16m terminals, the UL portion shall start with legacy UL zone since legacy BS/terminals/relays expect IEEE 802.16e UL control information be sent in this region. Here the coexistence is defined as a deployment where legacy and new BSs co-exist on the same frequency band and in the same or neighboring geographical areas and in this case, four switching points should not be used. In a green-field deployment where no legacy terminal exists, the legacy zones can be removed.

Switching points should be synchronized across network to reduce inter-cell interference.

The switching points would require use of idle symbols to accommodate the gaps. In case of TDD operation with the generic frame structure, the last symbol in the slot immediately preceding a downlink-to-uplink/uplink-to-downlink switching point may be reserved for guard time and consequently not transmitted.

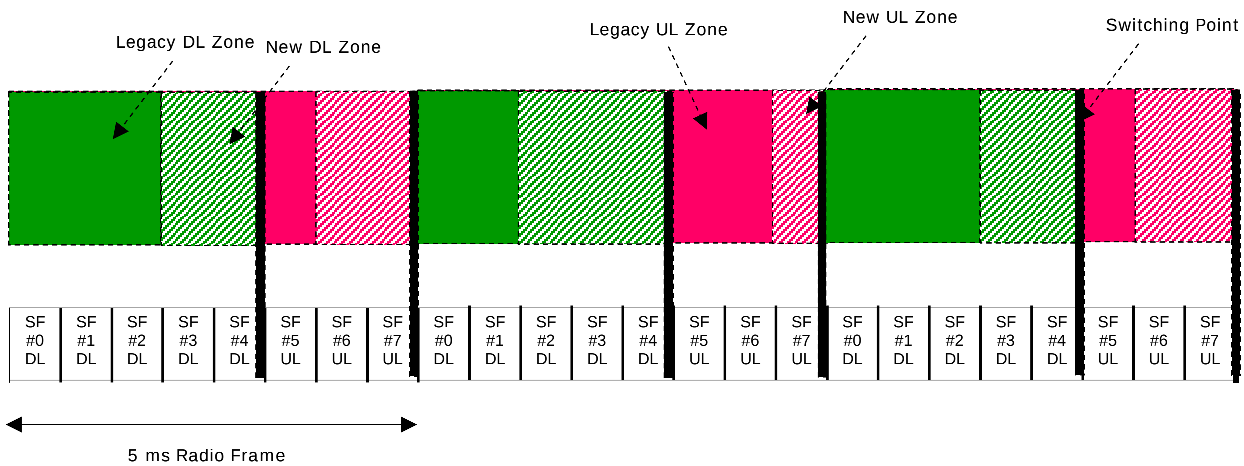

Figure 21 Figure 11.4-5: Time zones in TDD mode

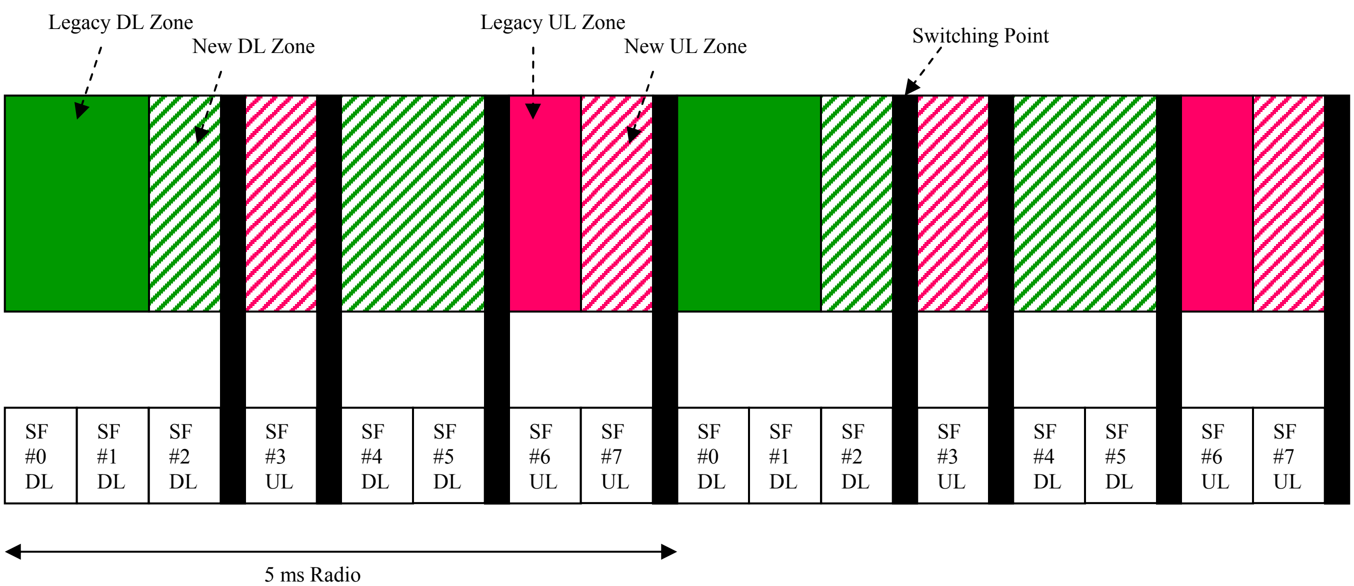

Figure 22 Time zones in a TDD system with four switching points per radio frame.

11.4.5 Relay Support in Frame Structure

A 16m BS that supports 16m relay stations shall communicate with the 16m RS in the 16m zone. The 16m BS shall multiplex the legacy zone and the 16m zone using TDM in the DL. In the UL, the 16m BS should support TDM as well as FDM for multiplexing legacy zone and the 16m zone. The 16m specification shall not alter the legacy zone operation. The access link and the relay link communications in the legacy zone shall be multiplexed in accordance with the IEEE 802.16j specifications.

A 16m RS shall communicate with the 16e MS in the "legacy zone".

The Legacy zone and 16m zone for the 16m entities shall be time aligned.

The duration of the legacy zone of the BS and the RS may be different.

- Legacy Zone
  - where 16m BS communicates with 16j RS or 16e MS, and where 16m RS communicates with a 16e MS.
- 16e Access Zone
  - where 16m BS, a 16j RS or a 16m RS communicates with a 16e MS.
- 16j Relay Zone
  - where 16m BS communicates with a 16j RS.
- 16m Zone
  - where 16m BS communicates with 16m RS or 16m MS, and where 16m RS communicates with other 16m entities (i.e. 16m BS, 16m RS or 16mMS).

11.4.6 Coexistence Supports in Frame Structure

IEEE 802.16m downlink radio frame shall be time aligned with reference timing signal as defined in section 21.1 and should support symbol puncturing to minimize the inter-system interference.

11.4.6.1 Coexistence with E-UTRA (LTE-TDD)

Coexistence between IEEE 802.16m and E-UTRA in TDD mode may be facilitated by inserting either idle symbols within the IEEE 802.16m frame or idle subframes. The IEEE 802.16m system shall be able of applying an operator configurable delay or offset between the beginnings of the IEEE 802.16m frame and the E-UTRA TDD frame may allow the time allocated to idle symbols or idle subframes to be minimized. Figure 23 shows two examples using frame offset to support coexistence with E-UTRA TDD in order to support minimization of the number of punctured symbols within the IEEE 802.16m frame.

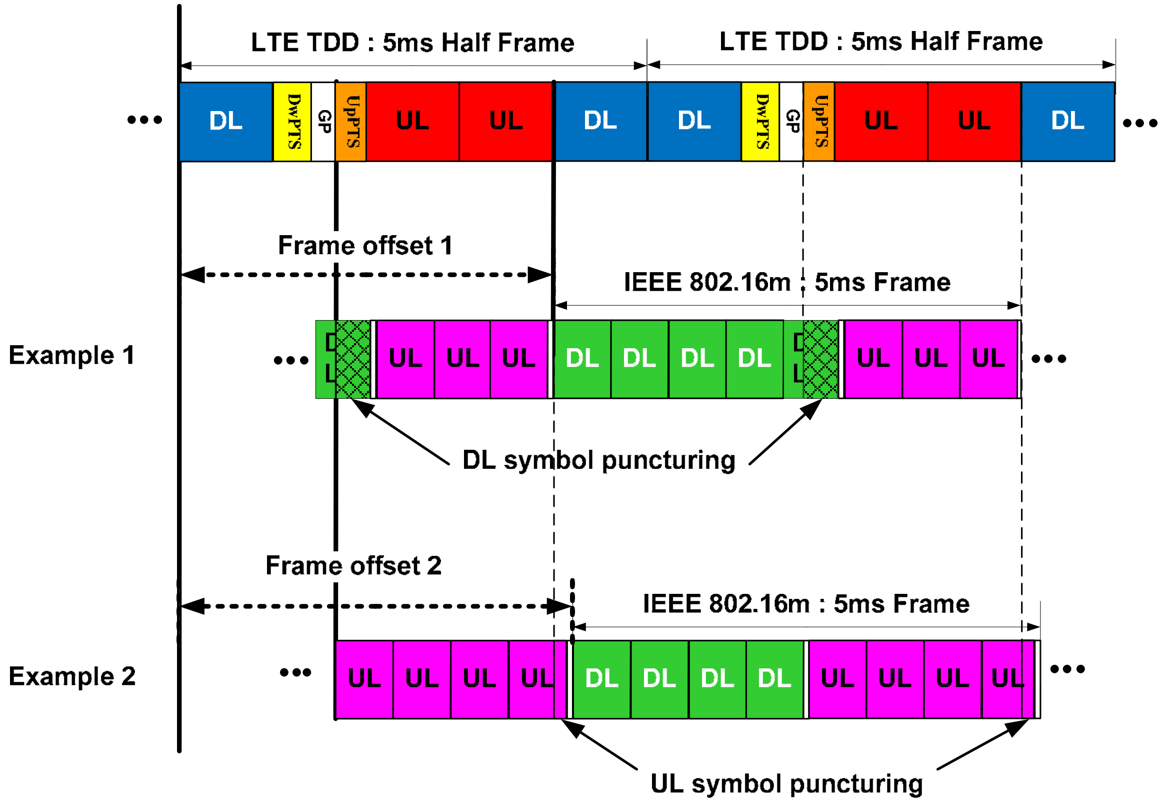

Figure 23 Alignment of IEEE 802.16m frame and E-UTRA frame in TDD mode

11.4.6.2 Coexistence with UTRA LCR-TDD (TD-SCDMA)

Coexistence between IEEE 802.16m and UTRA LCR-TDD may be facilitated by inserting either idle symbols within the IEEE 802.16m frame or idle subframes. The IEEE 802.16m system shall be able of applying an operator configurable delay or offset between the beginnings of the IEEE802.16m frame and the UTRA LCR-TDD frame may allow the time allocated to idle symbols or idle subframes to be minimized. Figure 24 demonstrates how coexistence between IEEE802.16m and UTRA LCR-TDD can be achieved to minimize the inter-system interference.

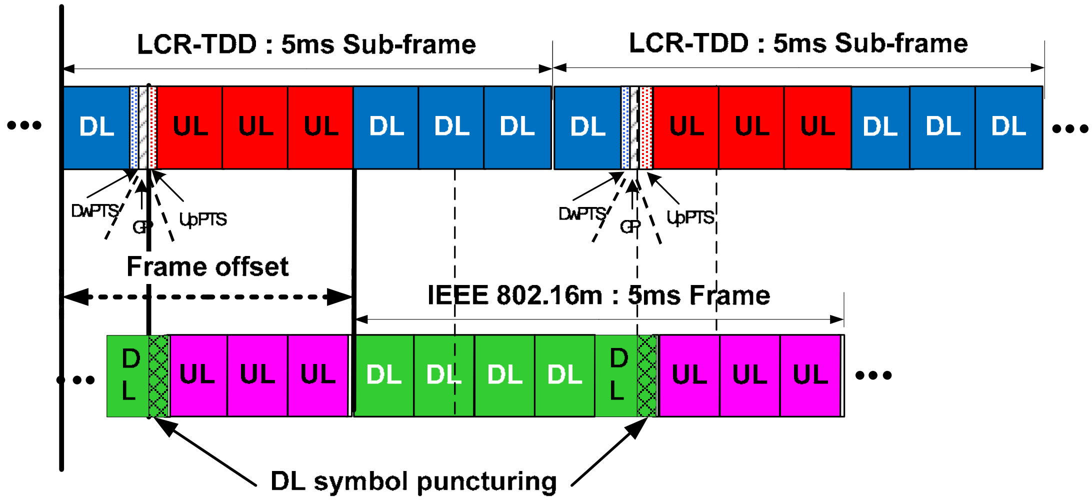

Figure 24 Alignment of IEEE 802.16m frame with UTRA LCR-TDD frame in TDD mode

11.4.7 Staggered super-frame transmissions

The start of super-frames between neighbor IEEE 802.16m cells may be staggered by one-frame increments. Figure 25 illustrates the concept of staggered super-frames in a TDD system, where staggering of super-frames is applied to a cluster of 4 neighboring BSs, BS1-BS4. In the figure, BS #1, #2, #3, and #4 transmit 20ms super-frames periodically and the super-frame timing between four BSs are offset one frame in order from #1 to #4.

The cluster size for staggered super-frames is a network-configurable parameter and can range from 1 to 4. This allows for the option of a deployment with non-staggered super-frames, such as might be the case for MBSFN transmissions or other scenarios, depending on the requirements.

The concept of staggered super-frame transmissions across neighboring cells is equally applicable to FDD systems.

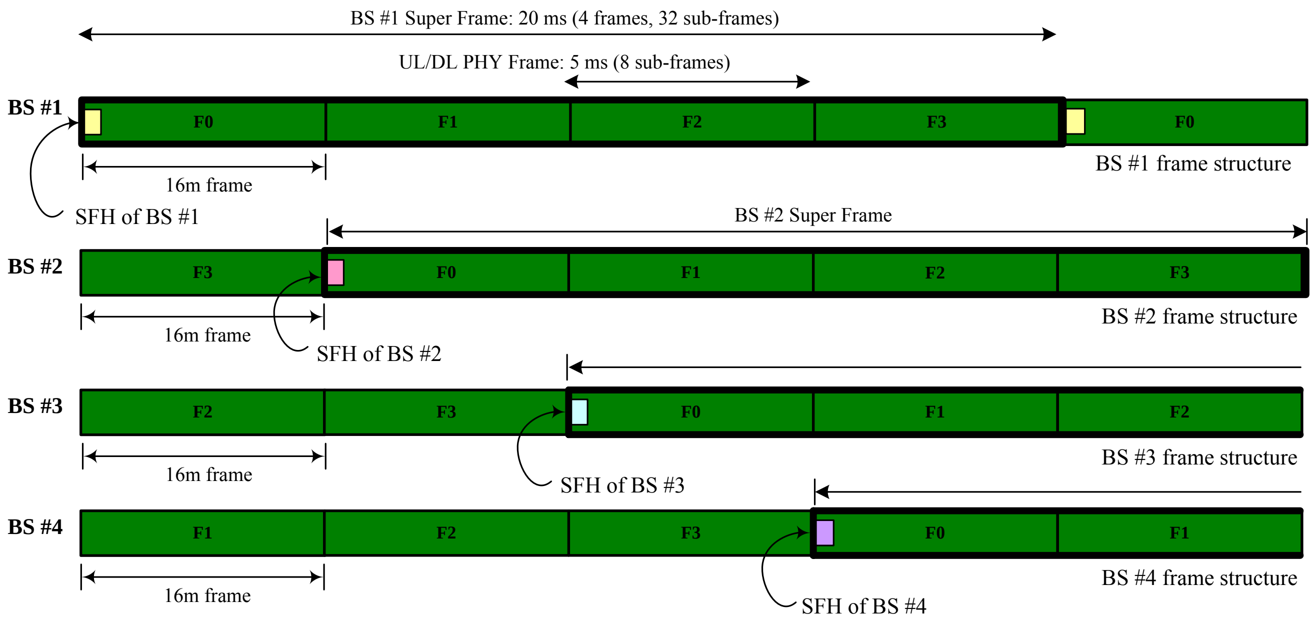

Figure 25 Staggered super-frame transmissions between neighboring BSs.

11.5 Downlink Physical Structure

As described in section 11.4, the 5 ms radio frame is divided into 8 subframes. Each of the subframes can be allocated for downlink transmission. Each subframe is divided into a number of frequency partitions, where each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR) or multicast and broadcast services (MBS). Figure 26 illustrates the downlink physical structure in the example of two frequency partitions with frequency partition 2 including both localized and distributed resource allocations.

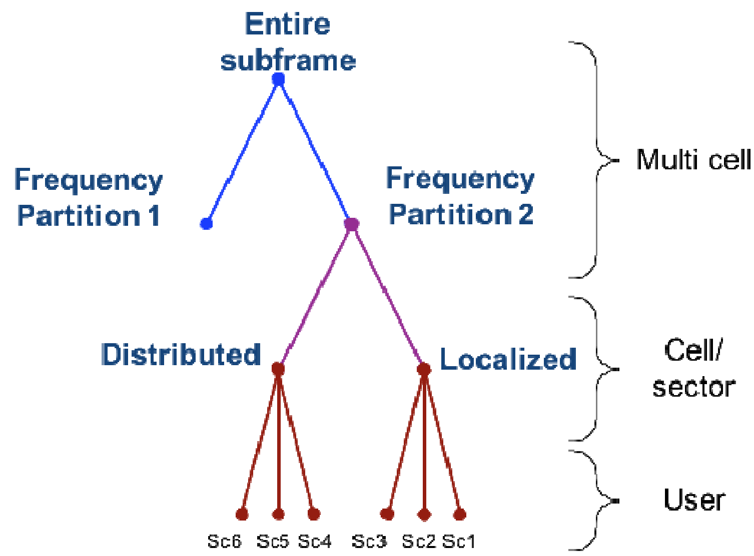

Figure 26 **Hierarchical representation of the downlink physical structure**

11.5.1 Physical and Logical Resource Unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 subcarriers and N_{sym} is 6 OFDMA symbols for regular subframes, and N_{sym} is 5 OFDM symbols for irregular subframes. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. A LRU is P_{sc}*N_{sym} subcarriers for regular subframes and irregular subframes. Note that the LRU includes in its numerology the number of pilots that are used in a PRU, and may include control information. So, the effective number of data subcarriers in an LRU depends on the number of allocated pilots and control channel presence.

11.5.1.1 Distributed resource unit

The distributed resource unit (DRU) can be used to achieve frequency diversity gain. The DRU contains a group of subcarriers which are spread across the distributed resource allocations. The size of the DRU equals the size of LRU for distributed allocations. The minimum unit for forming the DRU is equal to one subcarrier.

11.5.1.2 Localized resource unit

The localized resource unit (LLRU) can be used to achieve frequency-selective scheduling gain. The LLRU contains a group of subcarriers which are contiguous across the localized resource allocations. The size of the LLRU equals the size of the PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

11.5.2 Subchannelization and Resource mapping

11.5.2.1 Basic Symbol Structure

The subcarriers of an OFDMA are partitioned into $N_{g,left}$ left guard subcarriers, $N_{g,right}$ right guard subcarriers, and N_{used} used subcarriers. The DC subcarrier is not loaded. The N_{used} subcarriers are divided into PRUs. Each PRU contains pilot and data subcarriers. The number of used pilot and data subcarriers depends on the type of resource allocation, i.e., distributed or localized resource allocations, as well as the type of the subframe, i.e., regular or irregular.

11.5.2.2 Downlink subcarrier to resource unit mapping

The DL subcarrier to resource unit mapping process is defined as follows and illustrated in the Figure 27:

1. First-level or outer permutation is applied to the PRUs in the units of N PRUs, where N is TBD;
2. Distributing (TBD) the reordered PRUs into frequency partitions.
3. The frequency partition is divided into localized (LLRU) and/or distributed (DRU) resources using the PRU as unit for each resource. The sizes of the groups are flexibly configured per sector (TBD). Adjacent sectors do not need to have same configuration of localized and diversity groups;
4. The localized and distributed groups are further mapped into LRUs (by direct mapping of LLRU and by "Subcarrier permutation" on DRUs) as shown in the following figure.

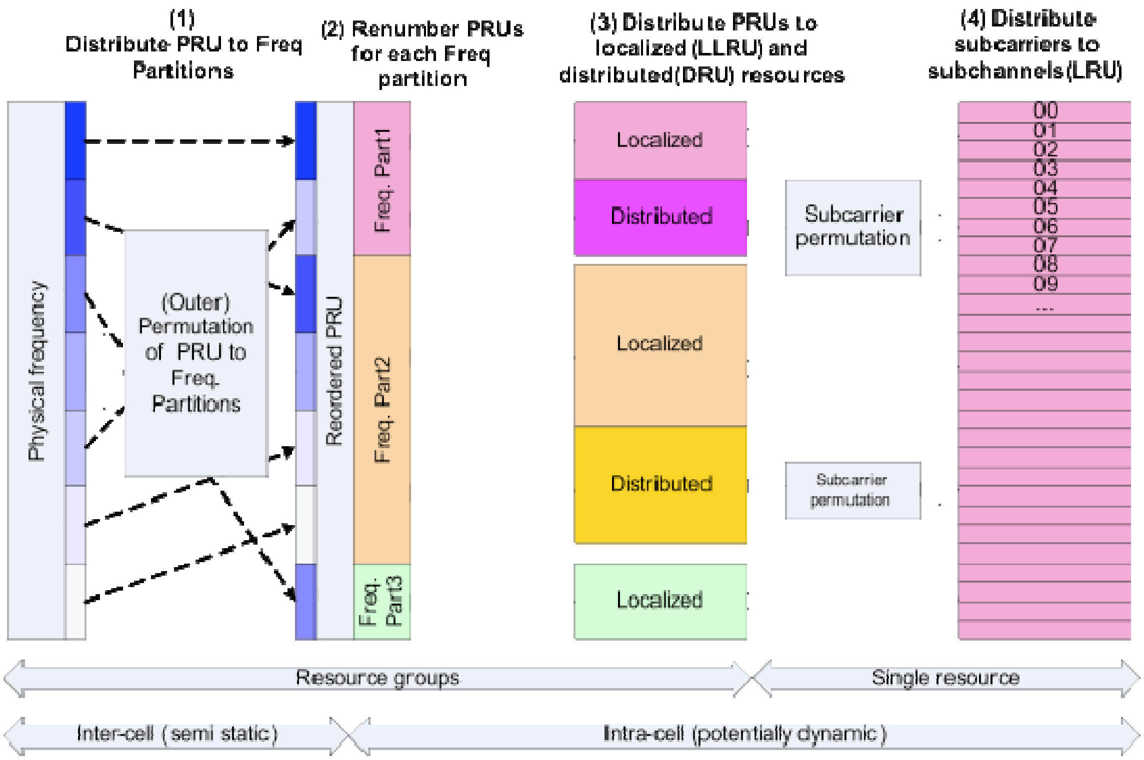

Figure 27 Illustration of the downlink subcarrier to resource block mapping

11.5.2.3 Subchannelization for DL distributed resource

The second-level or inner permutation defined for the DL distributed resource allocations spreads the subcarrriers of the DRU across the whole frequency band. The granularity of the inner permutation is equal to the minimum unit for forming a DRU according to 11.5.1.1.

Suppose that there are N_{RU} LRUs in a distributed group. A permutation sequence P (TBD) for the distributed group is provided. The subchannelization for DL distributed resource spreads the subcarriers of LRUs into the whole available bandwidth of distributed resource, as indicated in the following procedure:

- Let n_k denote the number of pilot tones in each OFDMA symbol within a PRU, and N_{RU} be the number of LRUs within the distributed resource .
- For each k-th OFDMA symbol in the subframe
    1. Allocate the n_k pilots in each OFDMA symbol within each PRU;
    2. Renumber the remaining N_{RU} * (P_{sc} - n_k) data subcarriers in order, from 0 to N_{RU} * (P_{sc} - n_k)-1 subcarriers. Apply the permutation sequence P (TBD) to form the permuted subcarriers 0 to N_{RU} * (P_{sc} - n_k)-1. The contiguous renumbered subcarriers are grouped into pairs/clusters before applying permutation, for example, to support SFBC, renumbered subcarriers 0 to N_{RU} * (P_{sc} - n_k)-1 are first paired into (N_{RU} * (P_{sc} - n_k)-1)/2 clusters.
    3. Map each logically contiguous (P_{sc} - n_k) subcarriers into a distributed LRUs (i.e. subchannels) and form a total of NRU distributed LRUs.

11.5.2.4 Subchannelization for DL localized resource

There is no second-level or inner permutation defined for the DL localized resource allocations. The PRUs are directly mapped to LLRUs within each frequency partition defined in 11.5.

11.5.3 Pilot Structure

The transmission of pilot subcarriers in the downlink is necessary for enabling channel estimation, measurements of channel quality indicators such as the SINR, frequency offset estimation, etc. To optimize the system performance in different propagation environments and applications, IEEE 802.16m supports both common and dedicated pilot structures. The categorization in common and dedicated pilots is done with respect to their usage. The common pilots can be used by all MSs. Dedicated pilots can be used with both localized and diversity allocations. Pilot subcarrriers that can be used only by a group of MSs is a special case of common pilots and are termed shared pilots. The dedicated pilots are associated with a specific resource allocation, can be only used by the MSs allocated to said specific resource allocation, and therefore can be precoded or beamformed in the same way as the data subcarriers of the resource allocation. The pilot structure is defined for up to four transmission (Tx) streams and there is [a unified] [a non-unified] pilot pattern design for common and dedicated pilots. There is equal pilot density per Tx stream, while there is not necessarily equal pilot density per OFDMA symbol of the downlink subframe. Further, there is equal number of pilots for each PRU.

11.5.3.1 11.5.3.1 Common pilot structure

11.5.3.2 11.5.3.2 Dedicated pilot structure

11.6 DL Control Structure

DL control channels are needed to convey information essential for system operation. The basic frame structure is illustrated in Figure 8 in Section 11.4.1. In order to reduce the overhead and network entry latency, and improve robustness of the DL control channel, information is transmitted hierarchically over different time scales from the superframe level to the subframe level. Broadly speaking, control information related to system parameters and system configuration is transmitted at the superframe level, while control and signaling related to traffic transmission and reception is transmitted at the frame/subframe level.

In mixed mode operation (legacy/802.16m), an 802.16m MS can access the system without decoding legacy FCH and legacy MAP messages.

Details of the DL control structure are described in the following sections.

11.6.1 DL Control Information Classification

Information carried in the control channels is classified as follows.

11.6.1.1 Synchronization information

This type of control information is necessary for system acquisition and synchronization.

11.6.1.2 Essential system parameters and system configuration information

This includes a minimal set of time critical system configuration information and parameters needed for the mobile station (MS) to complete access in a power efficient manner, including the following three types:

11.6.1.2.1 Deployment-wide common information

Deployment-wide common information and parameters such as downlink system bandwidth and TDD downlink/uplink ratio.

11.6.1.2.2 Downlink sector-specific information

Downlink sector-specific essential information and parameters to enable MS to further receive downlink extended broadcast information, control signaling and data. Examples of such information include antenna configuration, DL resource allocation configuration, pilot configuration.

11.6.1.2.3 Uplink sector-specific information

Uplink sector-specific essential information and parameters that are needed for the MS to perform access on the uplink. Examples include UL resource allocation configuration, system configuration for initial ranging, UL bandwidth, UL power control parameters.

11.6.1.3 Extended system parameters and system configuration information

This category includes additional system configuration parameters and information not critical for access, but needed and used by all MSs after system acquisition. Examples of this class include information required for handover such as handover trigger, neighbor BS information, etc.

11.6.1.4 Control and signaling for DL notifications

Control and signaling information may be transmitted in the DL to provide network notifications to a single user or a group of users in the idle mode and sleep mode. Example of such notification is paging, etc.

11.6.1.5 Control and signaling for traffic

The control and signaling information transmitted in the DL for resource allocation to a single user or a group of users in active or sleep modes is included in this category. This class of information also includes feedback information such as power control and DL acknowledgement signaling related to traffic transmission/reception.

11.6.2 Transmission of DL Control Information

11.6.2.1 Synchronization Channel (SCH)

Editors' Notes:

[Since text in this section will depend on contributions submitted in Session #55 or later and will be developed by rapporteur groups constituted to develop such text, the majority of proposals did not cover details of the SCH. Based on contributions submitted, it was identified that proposals on preamble design and support for multicarrier operation (Section 19 of the SDD) would influence the development of control structures carrying synchronization information.

The synchronization channel is a DL physical channel which provides a reference signal for time, frequency and frame synchronization and BS identification for system acquisition.]

11.6.2.2 Broadcast Channel (BCH)

The Broadcast Channel (BCH) carries essential system parameters and system configuration information.

11.6.2.2.1 Primary Broadcast Channel (PBCH) and Secondary Broadcast Channel (SBCH)

The Primary Broadcast Channel (PBCH) and the Secondary Broadcast Channel (SBCH) carry essential system parameters and system configuration information. The PBCH carries deployment wide common information. The SBCH carries sector specific information The information in the PBCH and SBCH may be transmitted over one or more superframes.

11.6.2.2.2 Location of the BCH

The PBCH and SBCH are transmitted in the SFH.

11.6.2.2.3 Multiplexing of the BCH with other control channels and data channels

The BCH is TDM with the SCH.

The SFH contains the PBCH and the SBCH.

The BCH, which contains the PBCH and SBCH in the SFH, is FDM with data within the same subframe.

11.6.2.2.4 Transmission format

The PBCH and SBCH are transmitted using fixed modulation and coding rates.

The modulation and coding rate for PBCH and the modulation and coding rate for SBCH are TBD.

Multiple antenna schemes for transmission of the BCH are supported.

If needed, signaling of the multiple antenna scheme used to transmit the BCH is TBD.

11.6.2.2.5 Resource allocation (physical to logical mapping, pilots, block size)

Editors' Notes:

This section depends on SDD text included in the DL PHY Structure.

11.6.2.3 Unicast Service Control Channels

11.6.2.3.1 Unicast service control information/content

Unicast service control information consists of both user-specific control information and non-user-specific control information.

11.6.2.3.1.1 Non-user-specific control information

Non-user-specific control information consists of information that is not dedicated to a specific user or a specific group of users. It includes information required to decode the user-specific control. Non-user-specific control information that is not carried in the BCH may be included in this category.

11.6.2.3.1.2 User-specific control information

User specific control information consists of information intended for one user or more users. Examples of this subclass of information include scheduling assignment, power control information, ACK/NACK information.

11.6.2.3.2 Multiplexing scheme for data and unicast service control

The multiplexing scheme between control and data channels is FFS.

11.6.2.3.3 Location of control blocks

The first 802.16m DL sub-frame of each frame contains user-specific control information.

The location of control blocks for non-user specific control information is TBD.

Control blocks for user specific control information are located 'n' 802.16m subframes apart, where 'n' is a subset of {1,2,3,4}. The selection of the specific value and signaling of 'n' is FFS.

11.6.2.3.4 Transmission format

A unicast service control information element is defined as the basic element of unicast service control. A unicast service control information element may be addressed to one user using a unicast ID or to multiple users using a multicast/broadcast ID. It may contain information related to resource allocation, HARQ, transmission mode etc.

If each unicast service control information element is coded separately, this type of coding is referred to as "separate coding", whereas if multiple unicast service control information elements are coded jointly, this type of coding is referred to as "joint coding".

A coded control block is the output of separate coding or joint coding. The MCS of each coded control block may be controlled individually. Coded control blocks may all be transmitted at the same MCS and this transmission scheme is referred to as "fixed MCS". If each coded block may be transmitted at a different MCS, this scheme is referred to as "variable MCS".

Coding of multiple unicast service control information elements may therefore either be joint coding or separate coding.

MCS of coded control blocks may either be with a fixed MCS or a variable MCS.

Non-user-specific control information is encoded separately from the user-specific control information.

The transmission format (joint/separate and fixed/variable MCS) for user-specific control information and non-user-specific control information is FFS.

11.6.2.3.5 Resource allocation (physical to logical mapping, pilots, block size)

Editors' Notes:

This section depends on SDD text included in the DL PHY Structure.

11.6.2.3.5.1 Pilot structure for unicast service control channels

Editors' Notes:

This section depends on SDD text included in the DL PHY Structure.

11.6.2.4 Multicast Service Control Channels

Editors' Notes :

This section is a placeholder for text to be developed based on SDD text that will be added to Section 15 of the SDD (Support for Enhanced Multicast Broadcast Service).

11.6.2.4.1 Multicast service control information/content

11.6.2.4.2 Multiplexing scheme of data and multicast service control and (e.g. TDM, FDM, Hybrid TDM//FDM)

11.6.2.4.3 Location of control blocks within a frame/subframe

11.6.2.4.4 Transmission format (e.g. modulation, coding, multiple antenna schemes)

11.6.2.4.5 Resource allocation (physical to logical mapping, pilots, block size)

11.6.2.5 Transmission of Additional Broadcast information

Examples of additional broadcast information include system descriptors, neighbor BS information and paging information. The indication of the presence of additional broadcast information is FFS.

MAC management messages may be used to transmit additional broadcast information.

11.6.3 Mapping information to DL control channels

Information		Channel	Location
Synchronization information		Synchronization Channel (SCH)	FFS
Essential system parameters and system configuration information	Deployment-wide common information	Primary Broadcast Channel (PBCH)	Inside of SFH
	Downlink sector-specific information	Secondary Broadcast Channel (SBCH)	Inside of SFH
	Uplink sector-specific information		
Extended system parameters and system configuration information		FFS	FFS
Control and signaling for DL notifications		FFS	FFS
Control and signaling for traffic		FFS	Outside of SFH

Table 3 Mapping information to DL control channels

11.6.4 Multi-carrier Control Structure

Editors' Notes :

This section is a placeholders for text to be developed based on SDD text that will be added to Section 19 of the SDD (Support for Multi-carrier Operation).

The carriers involve in a multi-carrier system, from one MS point of view, can be divided into two types:

- Primary carrier is the carrier where the BS and the MS exchange traffic and full PHY/MAC control information defined in 16m specification. Further, the primary carrier is in charge of delivering all control information for proper MS operation. Each MS shall have only one primary carrier.
- Secondary carrier is the carrier which the MS may use for traffic, only per BS's specific allocation commands and rules received from the primary carrier. The secondary carrier may also include control signaling to support multi-carrier operation..

Based on the primary and/or secondary usage, the carriers of a multi-carriers system may be configured differently as follows:.

- Fully configured carrier: A carrier for which all control channels including synchronization, broadcast, multicast and unicast control signaling are configured. Further, information and parameters regarding multi-carrier operation and the other carriers can also be included in the control channels.

- Partially configured carrier: A carrier with essential control channel configuration to support traffic exchanges during multi-carrier operation.

A primary carrier shall be fully configured while a secondary carrier may be fully or partially configured depending on usage and deployment model.

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 Multi-carrier

When multiple contiguous frequency channels are available, the guard sub-carriers between contiguous frequency channels can be utilized for data transmission only if the sub-carriers from adjacent frequency channels are well aligned. In order to align those sub-carriers from adjacent frequency channel, a frequency offset ($\Delta f'$) can be applied to its FA. The basic idea is shown by the example in Figure 28.

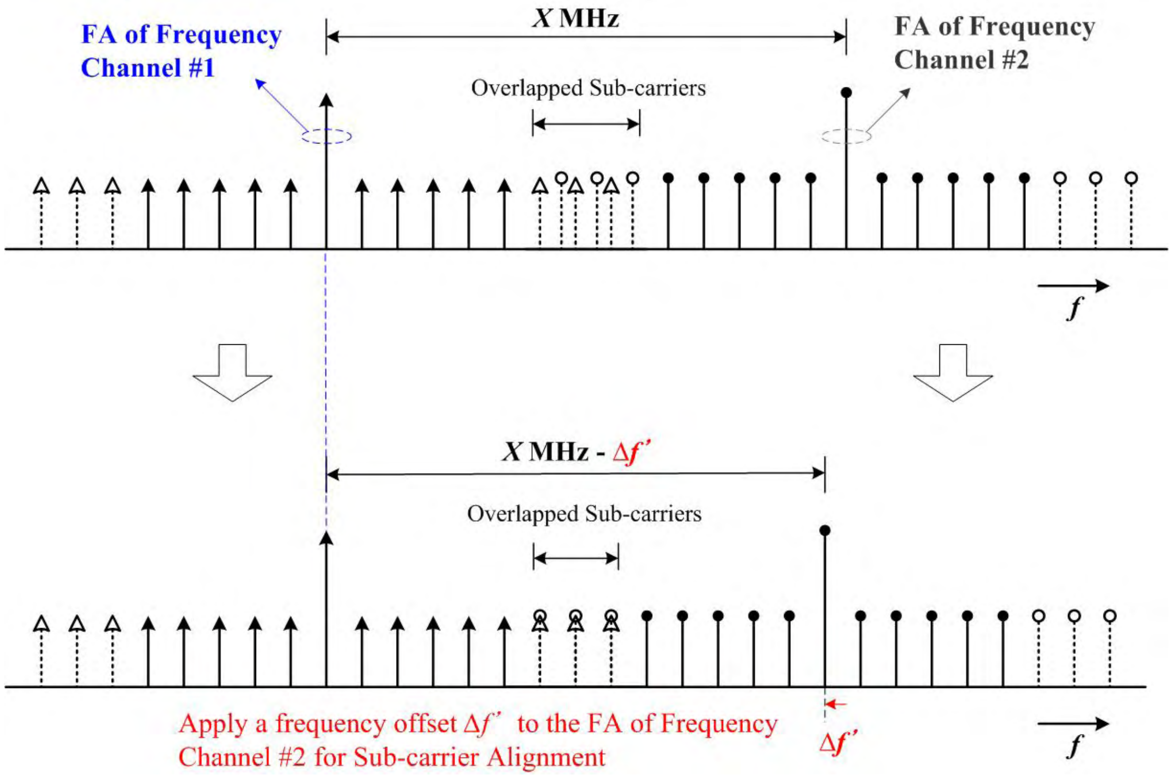

Figure 28 Sub-carrier alignment by applying a fraction of sub-carrier spacing to the FA of adjacent frequency channel

In order to utilize the guard sub-carrier for data transmission, the information of the available guard sub-carriers eligible for data transmission shall be sent to MS. This information shall include the numbers of available sub-carriers in upper side and in lower side with respect to the DC sub-carrier of each frequency channel.

19.1 Multi-carrier operation Principles

The following is common in all modes of multi-carrier operation:

- The system defines N standalone primary RF carriers as defined in section 11.x.6, each fully configured with all synchronization, broadcast, multicast and unicast control signaling channels. Each MS in the cell is connected to and its state being controlled through only one of the primary carriers.
- In the multicarrier operation a common MAC can utilize radio resources in one or more of the secondary carriers as defined in section 11.x.6, while maintaining full control of MS mobility, state and context through the primary carrier.
- Some information about the secondary carriers including their presence and location shall be made available to the user through the primary carriers. The primary carrier may also provide user the information about the configuration of the secondary carrier.
- The resource allocation can span across multiple RF carriers. Link adaptation feedback mechanisms would need to incorporate measurements relevant to both primary and secondary carriers.
- The multi-carrier may be used in the downlink and/or uplink asymmetrically based on system load (i.e.,

for static/dynamic load balancing), peak data rate, or QoS demand.

- A primary RF carrier may dynamically utilize resources across multiple secondary RF carriers. Multiple primary RF carriers may also share the same secondary carrier.
- The multiple carriers may be in different parts of the same spectrum block or in non-contiguous spectrum blocks.
- Each user will be connected to only one primary carrier. A secondary carrier for a MS, if fully configured, may serve as primary carrier for other MS's.

There are two scenarios to multicarrier deployment.

Scenario 1: All carriers in the system are fully configured to operate standalone and may support some users as their primary carrier.

Scenario 2: In this case, in addition to fully configured and standalone RF carriers the system also utilizes additional supplementary radio carriers optimized as data pipes for certain services or traffic types using limited control signaling capability. Such supplementary carriers may be used only in conjunction with a primary carrier and cannot operate standalone to offer IEEE 802.16m services for a MS.

In multi-carrier operation, MS can access multiple carriers. The following multi-carrier operations are identified:

- Carrier aggregation
  - MS shall always maintain its physical layer connection and monitor the control information on the primary carrier.
- Carrier switching
  - MS can switch its physical layer connection from the primary to the secondary carrier per BS' instruction. When the MS is connected to the secondary carrier, the MS doesn't need to maintain its physical layer connection to the primary carrier.
  - This mode may be used for the cases of single radio MS or non-contiguous spectrum.

20 RF Requirements

21 Inter-BS Synchronization

21.1 Network synchronization

For TDD and FDD realizations, it is recommended that all BSs be time synchronized to a common timing signal. In the event of the loss of the network timing signal, BSs shall continue to operate and shall automatically resynchronize to the network timing signal when it is recovered. The synchronizing reference shall be a 1 pps timing pulse and a 10 MHz frequency reference. These signals are typically provided by a GPS receiver but can be derived from any other source which has the required stability and accuracy. For both FDD and TDD realizations, frequency references derived from the timing reference may be used to control the frequency accuracy of BSs provided that they meet the frequency accuracy requirements of [tbd]. This applies during normal operation and during loss of timing reference.

21.2 Downlink frame synchronization

At the BS, the transmitted downlink radio frame shall be time-aligned with the 1pps timing pulse with a possible delay shift of n micro-seconds (n being between 0 and 4999). The start of the preamble symbol, excluding the CP duration, shall be time aligned with 1pps plus the delay of n micro-seconds timing pulse when measured at the antenna port.

Appendix 1 IEEE 802.16e Protocol Structure

The following Figure 29 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).

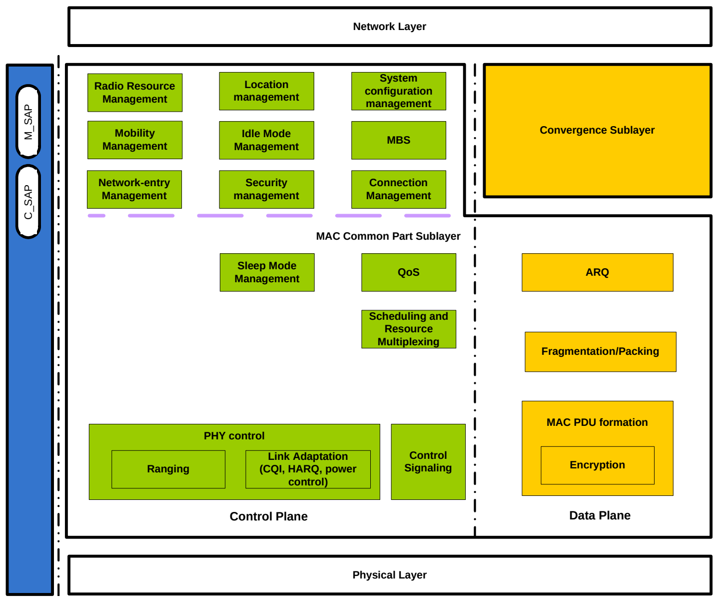

Figure 29 The IEEE 802.16e protocol architecture

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 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.

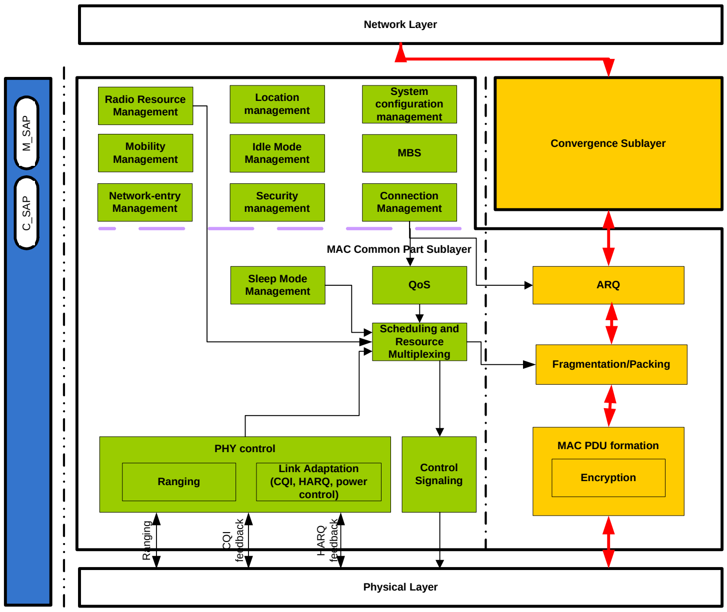

Figure 30 The IEEE 802.16e MS/BS Data Plane Processing Flow

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

The following Figure 31 describes the MAC message transmission flow in IEEE 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 IEEE 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).

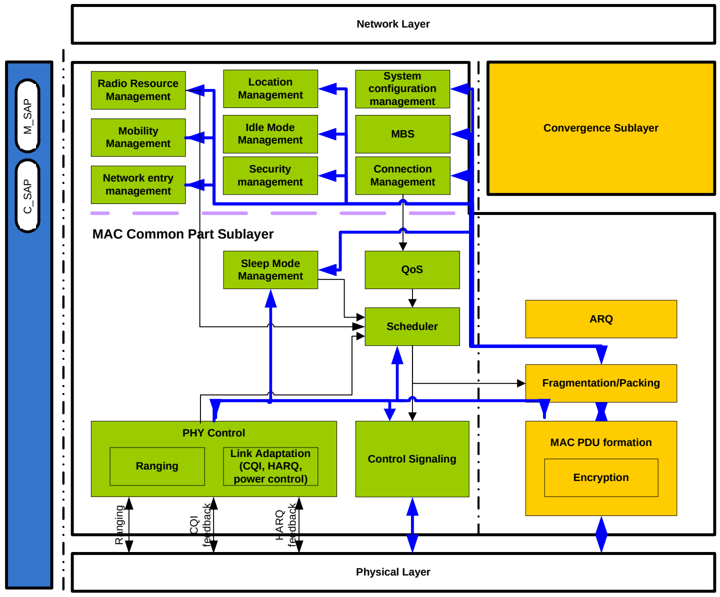

Figure 31 The IEEE 802.16e MS/BS Control Plane Processing Flow

[Editor note: the following text has been generated based on minority opinion and the TBD responses from a large number of members to latency attributes of the frame structure in the Excel Sheet [C802.16m-08/096r10] and the necessity to demonstrate the frame structure compliance with the IEEE 802.16m SRD [8]. The content of the following tables will be updated based on the ultimate decisions that will be made in the group on the frame structure parameters.]

Appendix 2. Data Plane and Control Plane Access Latencies

[In order to justify the choice of parameters for the proposed frame structure, it is imperative to demonstrate that the frame structure and associated parameters satisfy the IEEE 802.16m system requirements. In the following sections, the break down of the data and control planes access latencies is provided for the reference and the IEEE 802.16m systems.

A2.1 Data Plane Access Latency

The break down of the components of data plane access latency is shown in Table 4. The access latency with 30% frame error rate over the airlink is 4.67 ms which is less than 10 ms limit specified by the IEEE 802.16m SRD.

Step	Description	IEEE 802.16e Value	IEEE 802.16m Value
0	MS wakeup time	Implementation Dependent	Implementation Dependent
1	MS Processing Delay	2.5 ms	1.23 ms
2	Frame Alignment	2.5 ms	0.31 ms
3	TTI for UL DATA PACKET (Piggy back scheduling information)	5 ms	0.617 ms
4	H-ARQ Retransmission (FER = 30%)	0.3*20 ms	0.3* 4.3 ms
5	BS Processing Delay	2.5 ms	1.23 ms
6	R6 Transfer delay	T_{R6}	T_{R6}
7	ASN-GW Processing delay	T_{ASN_GW}	T'_{ASN_GW}
	Total one way access delay	18.50 ms + T_{ASN_GW}+T_{R6}	4.67 ms + T'_{ASN_GW}+T_{R6}

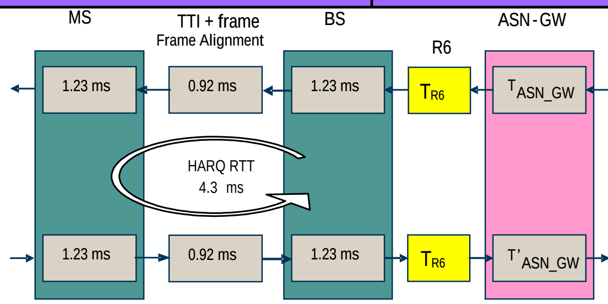

Table 4 Data plane access latency. The above processing time is FFS.

A2.2 Control Plane Access Latency

The break down of system entry procedure from DL scanning and synchronization to the point where the radio resource control (RRC) connection is established is shown in Table 5. Note that the use of superframe header, that encompasses the system configuration information, would significantly reduce the time spent in step 1. Also, since the probability of error required for transmission of some of the MAC control messages is typically 10^{-3}, H-ARQ is used to ensure more reliability. The use of shorter TTI and faster transmissions would enable shorter H-ARQ retransmission, consequently reducing the total time for IDLE_STATE to ACTIVE_STATE transition.

In addition, we assume that the base station, relay station, or mobile station processing time is approximately 2*TTI = 1.23 ms, that further reduces the total delay budget. It is shown that the IDLE_STATE to ACTIVE_STATE transition time of less than 80 ms is achievable through the use of proposed frame structure which is less the 100 ms value specified by the SRD.

It must be noted that some of the radio resource control and management messages require probability errors in the order of 10^{-6}; ARQ is used in conjunction with H-ARQ to achieve higher transmission reliability.

Step	Description	IEEE 802.16e Value	IEEE 802.16m Value
0	MS wakeup time	Implementation dependent	Implementation dependent
1	DL scanning and synchronization + DL MAP acquisition + DCD/UCD acquisition	> 300 ms (Assuming 0.5 s DCD/UCD interval)	20 ms
2	Random Access Procedure (UL CDMA Code + BS Processing + DL CDMA_ALLOC_IE)	> 15 ms	< 5 ms
3	Initial Ranging (RNG-REQ + BS Processing + RNG-RSP)	> 15 ms (0.3*20 ms for H-ARQ ReTX)	< 5 ms (0.3* 4.3 ms for H-ARQ
4	Capability Negotiation (SBC-REQ + BS Processing + SBC-RSP) + H-ARQ Retransmission @ 30%	> 15 ms (0.3*20 ms for H-ARQ ReTX)	< 5 ms (0.3* 4.3 ms for H-ARQ ReTX)
5	Authorization and Authentication/Key Exchange (PKM-REQ + BS Processing + PKM-RSP + …) +H-ARQ Retransmission @30%	> 15 ms (0.3*20 ms for H-ARQ ReTX)	< 5 ms (0.3* 4.3 ms for H-ARQ ReTX)
6	Registration (REG-REQ + BS/ASN-GW Processing + REG-RSP) + H-ARQ Retransmission @30%	> 15 ms (0.3*20 ms for H-ARQ ReTX)	< 5 ms (0.3* 4.3 ms for H-ARQ ReTX)
7	RRC Connection Establishment (DSA-REQ + BS Processing + DSA-RSP + DSA-ACK) + H-ARQ Retransmission @30%	> 15 ms (0.3*20 ms for H-ARQ ReTX)	< 5 ms (0.3* 4.3 ms for H-ARQ ReTX)
	Total C-plane connection establishment Delay	> 90 ms	< 30 ms
	Total IDLE_STATE –> ACTIVE_STATE Delay	> 390 ms	< 50 ms

Table 5 Control plane access latency. The above processing time is FFS.