IEEE Std 802.16™-2017
(Revision of
IEEE Std 802.16-2012)

IEEE Standard for Air Interface for Broadband Wireless Access Systems-

Amendment t: Fixed and Mobile Wireless Access in Narrowband Channels

Sponsor

LAN/MAN Standards Committee
of the
IEEE Computer Society
and the
IEEE Microwave Theory and Techniques Society

Approved 1 April 2234

IEEE-SA Standards Board

Abstract: This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support multiple PHY specifications, including WirelessMAN-SC, WirelessMAN-OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment.

Keywords: broadband wireless access, BWA, cellular layer, fixed broadband wireless access, IEEE 802.16™, IMT-2000, MAN, management information base, MIB, microwave, mobile broadband, mobile broadband wireless access, OFDM, OFDMA, radio, standard, WAS, wireless access systems, WirelessMAN®, wireless metropolitan area network

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This standard was developed by the IEEE 802.15.16t Working Group on Broadband Wireless Access, which develops the WirelessMAN® Standard for Wireless Metropolitan Area Networks.

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IEEE Std 802.16e™-2005 and IEEE Std 802.16-2004/ Cor1-2005 (amendment and corrigendum)	7 December 2005 (amendment) and 8 November 2005 (corrigendum)	**Roger B. Marks,** *Working Group Chair* **Kenneth Stanwood,** *Vice Chair* **Dean Chang,** *Working Group Secretary* **Brian Kiernan,** *Task Group e Chair* **Ronald Murias,** *Chief Technical Editor* **Itzik Kitroser,** *Assistant Editor* **Jose Puthenkulam,** *Assistant Editor* **Jonathan Labs,** *Maintenance Task Group Chair* **Itzik Kitroser,** *Chief Technical Editor* **Kenneth Stanwood,** *Former Maintenance Task Group Chair*

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IEEE Std 802.16s™-2017 (amendment)	September 2017	**Roger B. Marks,** *Working Group Chair* **Harry Bims,** *Working Group Vice Chair* **Tim Godfrey,** *Task Group Chair* **Doug Gray,** *Editor*

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Introduction

This introduction is not part of IEEE Std 802.16-2017, IEEE Standard for Air Interface for Broadband Wireless Access Systems.

This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support the WirelessMAN-SC, WirelessMAN-OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment. The standard enables rapid worldwide deployment of innovative, cost-effective, and interoperable multi-vendor broadband wireless access products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages consistent worldwide spectrum allocation, and accelerates the commercialization of broadband wireless access systems.

This standard is a revision of IEEE Std 802.16-2012 and consolidates material from IEEE Std 802.16p-2012, IEEE Std 802.16n-2013, IEEE Std 802.16q-2015, and IEEE Std 802.16s-2017.

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IEEE Standard for Air Interface for Broadband Wireless Access Systems

1. Overview

1.1 Scope

This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support multiple PHY specifications, including WirelessMAN-SC, WirelessMAN-OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment.

This project specifies operation in licensed spectrum with channel bandwidths greater than or equal to 5 kHz and less than 100 kHz. The project specifies a new PHY, and changes to the MAC as necessary to support the PHY. The amendment is frequency independent but focuses on spectrum less than 2 GHz. The range and data rate supported by the narrower channels are commensurate with those of the base standard, as scaled by the reduced channel bandwidth. The project also amends IEEE Std 802.16 as required to support aggregated operation in adjacent and non-adjacent channels.

This document describes the technical approach for IEEE 802.16 operation in channels less than 100 kHz bandwidth.

1.2 Purpose

This standard enables rapid worldwide deployment of innovative, cost-effective, and interoperable multivendor broadband wireless access products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages consistent worldwide spectrum allocation, and accelerates the commercialization of broadband wireless access systems.

1.3 Variants and frequency bands

Several conforming variants of this standard are specified. The appropriate variant depends on the radio frequency band in which it operates. The primary bands of interest are described in 1.3.1 through 1.3.6. The variants are listed in 1.3.7.

1.3.1 160 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.2 450 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.3 700 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.4 900 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.5 VHF/UHF licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.6 ??? MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.7 Air interface nomenclature and compliance

Table 1-1 summarizes the nomenclature for the various air interface variants in this standard.

Table 1-1—Air interface variant nomenclature and compliance

Designation	Applicability	PHY specification	System features	Duplexing alternative
WirelessMAN-SC Release 1.0	10–66 GHz	8.1	13.1	TDD FDD
Fixed WirelessMAN-OFDM™	Below 11 GHz licensed bands	8.3	12.3	TDD FDD
Fixed WirelessMAN-OFDMA	Below 11 GHz licensed bands	8.4	12.4	TDD FDD
WirelessMAN-OFDMA TDD Release 1.0	Licensed bands below 11 GHz	8.4	12.5	TDD
WirelessMAN-OFDMA TDD Release 1.5	Licensed bands below 11 GHz	8.4	12.6	TDD
WirelessMAN-OFDMA FDD Release 1.5	Licensed bands below 11 GHz	8.4	12.7	FDD
WirelessMAN-OFDMA MR	Licensed bands below 11 GHz	8.4	—	TDD

All implementations of this standard shall comply with the requirements of Clause 6 and Clause 7.

Implementations of this standard for licensed frequencies below 11 GHz (such as those listed in B.1) shall comply with the WirelessMAN-OFDM PHY as described in 8.3, the WirelessMAN-OFDMA PHY as described in 8.4, or the WirelessMAN-SC PHY as described in 8.1 for licensed frequencies above 10 GHz.

1.4 Reference models

Figure 1-1 illustrates the reference model and scope of this standard.

The MAC comprises three sublayers. The service-specific convergence sublayer (CS) provides any transformation or mapping of external network data, received through the CS service access point (SAP), into MAC service data units (SDUs) received by the MAC common part sublayer (CPS) through the MAC SAP. This includes classifying external network SDUs and associating them to the proper MAC service flow identifier (SFID) and connection identifier (CID). It may also include such functions as payload header suppression (PHS). Multiple CS specifications are provided for interfacing with various protocols. The internal format of the CS payload is unique to the CS, and the MAC CPS is not required to understand the format of or parse any information from the CS payload.

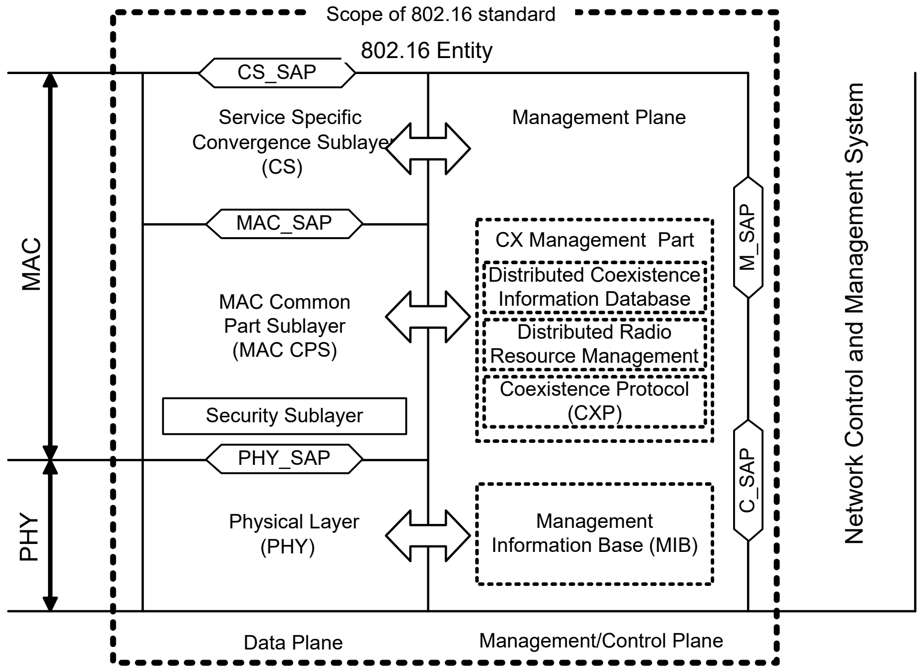

Figure 1-1—IEEE 802.16 protocol layering, showing SAPs

The MAC CPS provides the core MAC functionality of system access, bandwidth allocation, connection establishment, and connection maintenance. It receives data from the various CSs, through the MAC SAP, classified to particular MAC connections. An example of MAC CPS service definition is given in Annex C. Quality of service (QoS) is applied to the transmission and scheduling of data over the PHY.

The MAC also contains a separate security sublayer providing authentication, secure key exchange, and encryption.

Data, PHY control, and statistics are transferred between the MAC CPS and the PHY via the PHY SAP (which is implementation specific).

The PHY definition includes multiple specifications, each appropriate to a particular frequency range and application. The various PHY specifications supported are discussed in Clause 8. The Management/Control Plane may also include the “CX Management part” of WirelessMAN-CX composed of the “Distributed Coexistence Information Database,” “Distributed Radio Resource Management,” and “Coexistence Protocol (CXP).” All these parts are supported at the MAC level.

The IEEE 802.16 devices can include Subscriber Stations (SS) or Mobile Stations (MS), or Base Stations (BS). As the IEEE 802.16 devices may be part of a larger network and therefore would require interfacing with entities for management and control purposes, a Network Control and Management System (NCMS) abstraction has been introduced in this standard as a “black box” containing these entities. The NCMS abstraction allows the PHY/MAC layers specified in IEEE Std 802.16 to be independent of the network architecture, the transport network, and the protocols used at the backend and therefore allows greater flexibility. NCMS logically exists at BS side and SS/MS side of the radio interface, termed NCMS(BS) and NCMS(SS/MS), respectively. Any necessary inter-BS coordination is handled through the NCMS(BS).

This specification includes a Control SAP (C-SAP) and Management SAP (M-SAP) that expose control plane and management plane functions to upper layers. The C_SAP and M-SAP interfaces are described in Clause 15 The NCMS uses the C-SAP and M-SAP to interface with the IEEE 802.16 entity. In order to provide correct MAC operation, NCMS shall be present within each SS/MS. The NCMS is a layer independent entity that may be viewed as a management entity or control entity. General system management entities can perform functions through NCMS and standard management protocols can be implemented in the NCMS.

1.4.1 Management reference model

Figure 1-2 shows a management reference model of BWA networks. It consists of a network management system (NMS), managed nodes, and a Network Control System. Managed nodes, such as BS, MS and SS, collect and store the managed objects in the format of WirelessMAN Interface MIB (e.g., wmanIfMib) and Device MIB (e.g., wmanDevMib) that are made available to NMSs via management protocols, such as Simple Network Management Protocol (SNMP). A Network Control System contains the service flow and the associated QoS information that have to be populated to BS when a SS or MS enters into a BS network.

The management information between SS/MS and BS will be carried over the secondary management connection for managed SS or MS. If the secondary management connection does not exist, the SNMP messages, or other management protocol messages, may go through another interface in the customer premise or on a transport connection over the air interface..

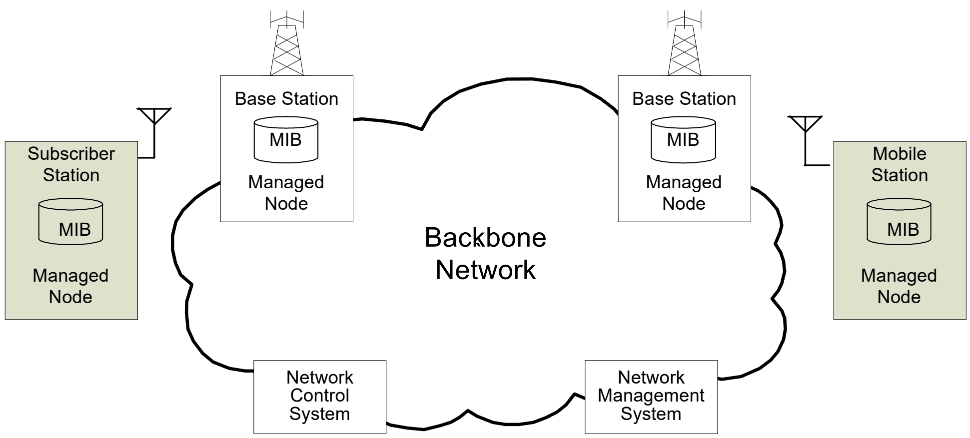

Figure 1-2—BWA WirelessMAN network management reference model

1.4.2 Handover (HO) process

The HO process in which an MS migrates from the air-interface provided by one BS to the air-interface provided by another BS is defined in 6.3.20.2.

1.4.3 IEEE 802.16 entity

An IEEE 802.16 entity is defined as the logical entity in an SS/MS or BS that comprises the PHY and MAC layers of the Data Plane and the Management/Control Plane.

1.6 Multihop relay

Multihop relay (MR) is an optional deployment that may be used to provide additional coverage or performance advantage in an access network. In MR networks, the BS may be replaced by a multihop relay BS (MR-BS) and one or more relay stations (RS).

Traffic and signaling between the SS and MR-BS are relayed by the RS thereby extending the coverage and performance of the system in areas where RSs are deployed. Each RS is under the supervision of an MR-BS. In a more than two hop system, traffic and signaling between an access RS and MR-BS may also be relayed through intermediate RSs. The RS may be fixed in location (i.e., attached to a building) or, in the case of an access RS, it may be mobile (i.e., traveling with a transportation vehicle). The SS may also communicate directly with the MR-BS.

The various MR features defined throughout this standard permit a multihop relay system to be configured in several modes.

The protocols (including the mobility features) on the access link remain unchanged. New functionality has been specified on the relay link to support the MR features.

Two different modes (centralized and distributed scheduling) are specified for controlling the allocation of bandwidths for an SS or an RS. In centralized scheduling mode, the bandwidth allocation for an RS's subordinate stations is determined at the MR-BS; conversely in distributed scheduling mode, the bandwidth allocation of an RS's subordinate stations is determined by the RS, in cooperation with the MR-BS.

Two different types of RS are defined, namely transparent and non-transparent. A non-transparent RS can operate in both centralized and distributed scheduling mode, while a transparent RS can only operate in centralized scheduling mode.

A transparent RS communicates with the superordinate station and subordinate station(s) using the same carrier frequency. A non-transparent RS may communicate with the superordinate station and subordinate station(s) using the same or different carrier frequencies.

The MAC layer includes extensions to signaling to support functions such as network entry (of an RS, and of an SS through an RS), bandwidth request, forwarding of PDUs, connection management, and handover.

Two different security modes are defined (see Clause 7). The first one, referred to as the centralized security mode, is based on key management between an MR-BS and an SS. The second security mode, referred to as the distributed security mode, incorporates authentication and key management between an MR-BS and a non-transparent access RS and between the access-RS and an SS.

An RS may be configured to operate either in normal CID allocation mode, where primary management, secondary, and basic CIDs are allocated by the MR-BS or in local CID allocation mode where the primary management and basic CID are allocated by the RS. The network management of RS shall use secondary management connection and shall follow the management reference model as defined in 1.4.1.

The PHY includes extensions to the OFDMA-PHY layer (see 8.4) for transmission of PHY PDUs across the relay link between the MR-BS and the RS.

1.7 Support for machine-to-machine (M2M) communications

The M2M communication is referred to as the information exchange between devices through a base station, or between a device and a server in the core network through a base station that may be carried out without any human interaction.

M2M communications is a very distinct capability that enables the implementation of the “Internet of things.”

Some of the typical use cases that the M2M communication enables are secured access and surveillance, tracking and tracing, public safety, payment, healthcare, remote maintenance and control, metering, consumer devices, and retailing.

In order to enable a range of machine-to-machine applications in which the device communications require wide area wireless coverage in licensed bands, and are automated rather than human-initiated or human-controlled for purposes such as observation and control, some MAC protocols and PHY specifications have been changed for enhancement. MAC enhancements and minimal PHY modifications include support of lower power consumption at the device, support by the base station of significantly larger numbers of devices, efficient support of small burst transmission, and improved device authentication.

1.8 Support for high reliability networks

A high reliability (HR) network implements features that enable increased robustness and alternate radio path establishment in a degraded network, in the case of failure of one or more infrastructure nodes or network connectivity.

In order to support high reliability in WirelessMAN-OFDMA, multi-mode operation of base station as a relay and mobile station as a relay, direct communication between MSs, forwarding of MS traffic to the network and another MS by other MS, standalone network, local forwarding bypassing backhaul links, path management against single point of failures by providing alternative radio and backhaul paths, and enhanced multicast-based service among a group of mobile stations are supported.

Those distinct functionalities in HR Networks support the mission critical application, including Public Safety, Avionics, Airport Surface, and Smart Grid.

1.9 Support for multi-tier networks

Multi-tier networks utilize base stations of a variety of power level tiers, each of which represents a different range of operating power levels, in order to improve network capacity and efficiently manage radio resources, in comparison to networks using only base stations of a uniform power level tier. In such multi-tier networks, coordination techniques among base stations across multiple tiers and among base stations in the same tier are important to achieve system capacity enhancements. Interference mitigation techniques across tiers is also critical to achieving user throughout enhancements.

Multi-tier network operation is specified in this standard to support efficient cooperation among base stations in multi-tier networks in order to enhance interference mitigation, mobility management, and base station power management. Associated management protocol among base stations and between base stations and mobile stations enables efficient cooperation and coordination. Multi-tier network operation is supported by a specific set of MAC management messages, without physical layer customization of mobile stations. This standard addresses two tiers of network, with higher-power base stations (BSs) that are capable of signaling to lower-power stations, known as small base stations (SBSs).

2. Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ATM Forum Specification af-uni-0010.002, ATM User-Network Interface Specification, Version 3.1, Sept. 1994.[1]

ATM Forum Specification af-sig-0061.000, ATM User-Network Interface (UNI) Signalling Specification, Version 4.0, July 1996.

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FIPS 46-3, Data Encryption Standard (DES), Oct. 1999.[3] This reference is withdrawn.

FIPS 74, Guidelines for Implementing and Using the NBS Data Encryption Standard, Apr. 1981. This reference is withdrawn.

FIPS 81, DES Modes of Operation, Dec. 1980. This reference is withdrawn.

FIPS 180-1, Secure Hash Standard (SHS), Apr. 1995. This reference is withdrawn.

FIPS 186-2, Digital Signature Standard (DSS), Jan. 2000. This reference is withdrawn.

FIPS 197, Advanced Encryption Standard (AES).

IEEE Std 802®, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture.[4, 5]

IEEE Std 802.1D™, IEEE Standard for Local and metropolitan Area Networks: Media Access Control (MAC) Bridges.[6]

IEEE Std 802.1Q™, IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks.

IEEE Std 802.3™, IEEE Standard for Ethernet.

IEEE Std 802.16.1™-2012, IEEE Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems.

IEEE Std 802.16.2™, IEEE Recommended Practice for Local and metropolitan area networks—Coexistence of Fixed Broadband Wireless Access Systems.

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[1]ATM Forum publications are available from the ATM Forum (http://www.atmforum.com/).
[2]ETSI publications are available from the European Telecommunications Standards Institute (http://www.etsi.org/).
[3]FIPS publications are available from the National Technical Information Service (NTIS) (http://www.ntis.gov/).
[4]IEEE and 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.
[5]IEEE publications are available from The Institute of Electrical and Electronics Engineers, Inc. (http://standards.ieee.org/).
[6]IEEE standards referred to in Clause 2 are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

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IETF RFC 1042, "A Standard for the Transmission of IP Datagrams over IEEE 802 Networks," Postel, J., and Reynolds, J., Feb. 1988.

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IETF RFC 2131, "Dynamic Host Configuration Protocol," Droms, R., Mar. 1997.

IETF RFC 2349, "TFTP Timeout Interval and Transfer Size Options," Malkin, G., and Harkin, A., May 1998.

IETF RFC 2373, "IP Version 6 Addressing Architecture," Hinden, R., and Deering, S., July 1998. (http://www.ietf.org/rfc/rfc2373.txt)

IETF RFC 2459, "Internet X.509 Public Key Infrastructure Certificate and CRL Profile," Housley, R., Ford, W., Polk, W., and Solo, D., Jan. 1999.

IETF RFC 2460, "Internet Protocol, Version 6 (IPv6) Specification," Deering, S., and Hinden, R., Dec. 1998.

IETF RFC 2462, "IPv6 Stateless Address Autoconfiguration," Thomson, S., and Narten, T., Dec. 1998. (http://www.ietf.org/rfc/rfc2462.txt)

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IETF RFC 2758, "Definitions of Managed Objects for Service Level Agreements Performance Monitoring," White, K., Feb. 2000.

IETF RFC 2789, "Mail Monitoring MIB," Freed, N., and Kille, S., Mar. 2000. (http://www.ietf.org/rfc/rfc2789.txt)

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IETF RFC 3012, "Mobile IPv4 Challenge/Response Extensions," Perkins, C., and Calhoun, P., Nov. 2000. (http://www.ietf.org/rfc/rfc3012.txt)

[7]IETF publications are available from the Internet Engineering Task Force (http://www.ietf.org/).

IETF RFC 3095, “RObust Header Compression (ROHC): Framework and four profiles: RTP, UDP, ESP, and uncompressed,” Bormann, C., et al., July 2001. (http://www.ietf.org/rfc/rfc3095.txt)

IETF RFC 3280, “Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile,” Housley, R., Polk, W., Ford, W., and Solo, D., Apr. 2002. (http://www.ietf.org/rfc/rfc3280.txt)

IETF RFC 3315, “Dynamic Host Configuration Protocol for IPv6 (DHCPv6),” Droms, R., et al., July 2003. (http://www.ietf.org/rfc/rfc3315.txt)

IETF RFC 3415, “View-based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP),” Dec. 2002.

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IETF RFC 3545, “Enhanced Compressed RTP (CRTP) for Links with High Delay, Packet Loss and Reordering,” Koren, T., Casner, S., Geevarghese, J., Thompson, B., and Ruddy, P., July 2003. (http://www.ietf.org/rfc/rfc3545.txt)

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IETF RFC 3759, “RObust Header Compression (ROHC): Terminology and Channel Mapping Examples,” Jonsson, L-E, Apr. 2004. (http://www.ietf.org/rfc/rfc3759.txt)

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ISO/IEC 8825, Information technology—Open Systems Interconnection—Specification of the Basic Encoding Rules for Abstract Syntax Notation One (ASN.1), May 1999.

ITU Radio Regulations, Volume 1, Article 5, 2008.[9]

[8]ISO/IEC publications are available from the ISO Central Secretariat (http://www.iso.ch/). ISO/IEC publications are also available in the United States from the American National Standards Institute (http://www.ansi.org/).

[9]ITU publications are available from the International Telecommunications Union (http://www.itu.int/).

ITU-T Recommendation X.25—Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit, Oct. 1996.

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WiMAX Forum Mobile System Profile Release 1.5—Common Part.

WiMAX Forum Mobile System Profile Release 1.5—FDD Specific Part.

WiMAX Forum Mobile System Profile Release 1.5—TDD Specific Part.

[10]NIST publications are available from the National Institute of Standards and Technology (http://csrc.nist.gov/).
[11]WiMAX publications are available from the WiMAX Forum (http://www.wimaxforum.org/).

3. Definitions

For the purposes of this standard, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[12]

AAI-only ABS: A base station that supports the WirelessMAN-Advanced Air Interface specified by IEEE Std 802.16.1-2012, but does not support the OFDMA air interface specified in IEEE Std 802.16.

acceptable interference: An interference caused by an interference signal that does not degrade the current selection of modulation and coding at a receiver.

acceptable interference threshold: A value (in dBm) of a signal level, below which an interference signal causes acceptable interference.

access link: A radio link between an MR-BS or RS and an MS, or between an MR-BS or RS and a subordinate RS during network entry.

access RS: A relay station that serves as an access station.

access station: A station that provides a point of access into the network for an MS or RS. An access station can be a base station (BS), relay station (RS), or multihop relay BS (MR-BS).

active base station: A BS that is informed of the mobile station (MS) capabilities, security parameters, service flows, and full medium access control layer (MAC) context information.

adaptive antenna system (AAS): An array of antennas and associated signal processing that together is able to change its antenna radiation pattern dynamically to adjust to noise environment, interference and multipath.

adaptive modulation: A system's ability to communicate with another system using multiple burst profiles and a system's ability to subsequently communicate with multiple systems using different burst profiles.

adjacent subcarrier allocation: A variation of PUSC permutation wherein the subcarriers are located adjacent to each other.

adjacent subcarrier permutation: A permutation scheme in which symbol data within a subchannel is assigned to adjacent subcarriers and wherein the pilot and data subcarriers are assigned fixed positions in the frequency domain within an OFDMA symbol.

affected HR-BS: An HR-BS that is experiencing a failure of its backhaul connection to the backbone network. *See also*: **high reliability base station (HR-BS).**

alternative channel (ALTCH): A physical (frequency) channel determined by the base station as being a suitable alternative physical channel for use if its current physical channel becomes unavailable.

alternative subframe (ALTSF): A subframe that can be used by the base station of a system because it is unoccupied.

anchor base station: A base station, used with macro diversity handover or fast base station switching, supporting mobile station registration, synchronization, ranging, and downlink monitoring.

[12] *IEEE Standards Dictionary Online* is available at http://dictionary.ieee.org/.

Authenticator: Entity in the network control and management system (NCMS) incorporating AAA client functionality and facilitating authentication of a supplicant.

automatic repeat request (ARQ) block: A distinct unit of data that is carried on an ARQ-enabled connection.

backbone network: A communication mechanism by which two or more base stations (BSs) communicate to each other. It may also include communication with other networks. The method of communication for backbone networks is outside the scope of IEEE Std 802.16.

band AMC: A permutation scheme in which the entire channel is split into groups of contiguous subcarriers.

bandwidth stealing: The use, by a subscriber station (SS), of a portion of the bandwidth allocated in response to a bandwidth request (BR) for a connection to send a BR or data for any of its connections.

NOTE—See also 6.3.6.[13]

base station (BS): A generalized equipment set providing connectivity, management, and control of the subscriber station (SS). *See also:* **active base station (BS)**, **anchor base station (BS), neighbor base station (BS)**, **serving base station (BS)**, **target base station (BS)**.

base station (BS) receive/transmit transition gap (RTG): A gap between the last sample of the uplink (UL) burst and the first sample of the subsequent downlink (DL) burst at the antenna port of the BS in a time division duplex (TDD) transceiver. This gap allows time for the BS to switch from receive (Rx) to transmit (Tx) mode. During this gap, the BS is not transmitting modulated data but simply allowing the BS transmitter carrier to ramp up and the Tx/Rx antenna switch to actuate. Not applicable for frequency division duplex (FDD) systems.

base station (BS) transmit/receive transition gap (TTG): A gap between the last sample of the downlink (DL) burst and the first sample of the subsequent uplink (UL) burst at the antenna port of the BS in a time division duplex (TDD) transceiver. This gap allows time for the BS to switch from transmit (Tx) to receive (Rx) mode. During this gap, the BS is not transmitting modulated data but simply allowing the BS transmitter carrier to ramp down, the Tx/Rx antenna switch to actuate, and the BS receiver section to activate. Not applicable for frequency division duplex (FDD) systems.

basic connection: Connection that is established during subscriber station (SS) initial ranging and used to transport delay-intolerant medium access control layer (MAC) management messages.

broadband: Having instantaneous bandwidths greater than around 1 MHz and supporting data rates greater than about 1.5 Mb/s.

broadband wireless access (BWA): Wireless access in which the connection(s) capabilities are broadband.

broadcast connection: The management connection used by the base station (BS) to send medium access control layer (MAC) management messages on a downlink (DL) to all subscriber stations (SSs). The broadcast connection is identified by a well-known connection identifier (CID). A fragmentable broadcast connection is a connection that allows fragmentation of broadcast MAC management messages.

NOTE—See Table 10-5.

BS power controller: BS power controller is a network element that performs BS power management services in the network control and management system (NCMS).

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[13]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement this standard.

burst profile: Set of parameters that describe the uplink (UL) or downlink (DL) transmission properties associated with an interval usage code. Each profile contains parameters such as modulation type, forward error correction (FEC) type, preamble length, guard times, etc. *See also:* **interval usage code**.

bursty system: A system that comprises non-SSU units and transmits data in short uneven intervals.

candidate channel: A frequency channel within the frequency band that may be used by a system.

centralized scheduling: A mode of operation applicable to multihop relay where a multihop relay BS (MR-BS) determines the bandwidth allocations and generates the corresponding MAPs [or dictates the information used by relay stations (RSs) to generate their MAPs] for all access and relay links in the MR-cell.

channel identifier (ChID): An identifier used to distinguish between multiple uplink (UL) channels, all of which are associated with the same downlink (DL) channel.

coexistence: A state of acceptable co-channel and/or adjacent channel operation of two or more radio systems (possibly using different wireless access technologies) within the same geographical area.

coexistence community: A coexistence community is composed of those systems that have resolved their interference and coexist within it.

Coexistence Control Channel (CXCC): A logical channel composed of a periodic sequence of time slots, which may be used for sensing, synchronization, cumulated interference measurement and broadcast of the coordinated coexistence related information. CXCC is used for WirelessMAN-CX and may be used for WirelessMAN-UCP.

Coexistence frame (CX-Frame): A pre-defined sequence of IEEE 802.16 DL and UL subframes that, in conjunction with associated operational rules, is used for facilitating coexistence between systems.

Coexistence Messaging Interval (CMI): A unique repetitive sequence of intervals defined in CXCC and claimed by a system. It is used for broadcasting system's main radio parameters to other systems in its Coexistence Community using always the same predefined PHY parameters.

coexistence messaging mechanism: The messaging mechanism defined in WirelessMAN-CX to exchange information specifically between wireless systems with the same PHY profiles.

Coexistence Protocol (CXP): An intersystem protocol for improving coexistence through the exchange of information, using communication over-the-air or back-haul. Messages for intersystem communication over-the-air and primitives for communication over the backhaul are provided.

coexistence signaling: The signaling mechanism defined in WirelessMAN-CX to exchange information between wireless systems with or without the same PHY profiles.

Coexistence Signaling Interval (CSI): A predefined time slot not associated with the CXCC, used for coexistence signaling purposes between systems that may have different PHYs. This technique uses power keyed energy symbols and RSSI detection, by a BS to contact its coexistence neighbor BS through one or more coexistence neighbor SSs in the common coverage area.

Coexistence Signaling Interval Number (CSIN): The allocation of CSI according to the time order within CX-Frame. The range of CSIN is from 0 to 3 while 0-3 is referring to OCSI1/OCSI2/OCSI3/ICSI, respectively.

cognitive radio (CR): A system that is aware of its operational environment and internal state, and has the capability to make decisions about its radio operating behavior. An active cognitive radio can share information regarding its spectral/temporal/spatial characteristics with other similar systems and/or dynamically and autonomously adjust its radio operating parameters depending on the results of its actions and environmental usage patterns. This definition reflects the CR functionality in IEEE Std 802.16.

Common subframe: That part at the beginning of the MAC Frame within the CX-Frame where all the systems of a coexistence neighborhood may operate in parallel. The operation of non-Master systems during these subframes may require limitations on the transmit power.

community: A group of systems that coordinate to resolve their interference.

concatenation: The act of combining multiple medium access control layer (MAC) protocol data units (PDUs) into a single physical layer (PHY) service data unit (SDU).

connection: A unidirectional mapping between base station (BS) and subscriber station (SS) medium access control layer (MAC) peers. Connections are identified by a connection identifier (CID). The MAC defines two kinds of connections: management connections and transport connections. *See also:* **connection identifier (CID)**.

connection identifier (CID): A 16-bit value that identifies a transport connection or an uplink (UL)/ downlink (DL) pair of associated management connections [i.e., belonging to the same subscriber station (SS)] to equivalent peers in the medium access control layer (MAC) of the base station (BS) and SS. The CID address space is common (i.e., shared) between UL and DL and partitioned among the different types of connections. Security associations (SAs) also exist between keying material and CIDs. *See also:* **connection**.

NOTE—Table 10-5 specifies how the CID address space is partitioned among the different types of connections.

Coordinated Coexistence Mechanism: A coexistence mechanism relying on rules of behavior based on a common Coexistence Frame (CX-Frame) and a Coexistence Control Channel (CXCC).

Credit Token-Based Coexistence Protocol (CT-CXP): Over-the-air or backhaul-based mechanisms enabling dynamic subframe sharing between systems.

DC subcarrier: In an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal, the subcarrier whose frequency would be equal to the radio frequency (RF) center frequency of the station.

destination base station (BS): The BS that responds to an intersystem communication request.

destructive interference: Interference that disables a particular PHY receiver from receiving using any combination of its modulation and coding methods.

detection threshold: A value (in dBm) of a signal level, used for the purpose of initiating an action.

distributed scheduling: A mode of operation applicable to multihop relay where the MR-BS and each RS in the MR-cell (with or without information from the MR-BS) determine the bandwidth allocations and generate the corresponding MAPs for the access link to/from their subordinate SSs and/or relay links to/ from their subordinate RSs.

diversity set: A list of active base stations (BSs) to the mobile station (MS). The diversity set is managed by the MS and BSs and is applicable to macro diversity handover (MDHO) and fast BS switching (FBSS).

DL access zone: A portion of the DL subframe in the MR-BS/RS frame used for MR-BS/RS to MS or RS (except TTR RS in TDD mode) transmission. The DL access zone may consist of the entire downlink subframe, depending on the method used to separate the transmissions on the access and relay links.

DL relay zone: A portion of the DL subframe in the MR-BS/RS frame used for MR-BS/RS to RS transmission. A frame may have no DL relay zone, depending on the method used to separate the transmissions on the access and relay links.

downlink (DL): The direction from the base station (BS) to the subscriber station (SS).

downlink burst transition gap (DLBTG): The gap included on the trailing edge of each allocated downlink (DL) burst so that ramp-down can occur and delay-spread can clear receivers.

downlink channel descriptor (DCD): A medium access control layer (MAC) message that describes the physical layer (PHY) characteristics of a downlink (DL) channel.

downlink interval usage code (DIUC): An interval usage code specific to a downlink (DL). *See also:* interval usage code.

downlink map (DL-MAP): A medium access control layer (MAC) message that defines burst start times for both time division multiplex and time division multiple access (TDMA) by a subscriber station (SS) on the downlink (DL).

Dynamic Channel Selection (DCS): The ability of a system to switch to a different physical (frequency) operating channel based on channel measurements avoiding interference in license-exempt bands of operation. DCS is distinct from DFS (Dynamic Frequency Selection) because DCS is not used for interference avoidance to regulatory protected devices, such as radar systems, but to other non-SSUs in the band.

dynamic frequency selection (DFS): The ability of a system to switch to different physical radio frequency (RF) channels based on channel measurement criteria to conform to particular regulatory requirements.

dynamic service: The set of messages and protocols that allow the base station (BS) and subscriber station (SS) to add, modify, or delete the characteristics of a service flow.

fast base station switching (FBSS): Base station (BS) switching that utilizes a fast switching mechanism to improve link quality. The mobile station (MS) is only transmitting/receiving data to/from one of the active BS (anchor BS) at any given frame. The anchor BS can change from frame to frame depending on the BS selection scheme.

fixed wireless access: Wireless access application in which the locations of the base station (BS) and subscriber station (SS) are fixed in location during operation.

frame: A structured data sequence of fixed duration used by some physical layer (PHY) specifications. A frame may contain both an uplink (UL) subframe and a downlink (DL) subframe.

frequency assignment (FA): A logical assignment of downlink (DL) center frequency and channel bandwidth programmed to the base station (BS).

frequency assignment (FA) index: A network-specific logical FA index assignment. FA index assignment is used in combination with operator-specific configuration information provided to the mobile station (MS) in a method outside the scope of IEEE Std 802.16.

frequency division duplex (FDD): A duplex scheme in which uplink (UL) and downlink (DL) transmissions use different frequencies but are typically simultaneous.

frequency offset index: An index number identifying a particular subcarrier in an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal, which is related to its subcarrier index. Frequency offset indices may be positive or negative.

group key encryption key (GKEK): A random number generated by the base station (BS) or a network entity [e.g., an authentication and service authorization (ASA) server] used to encrypt the group traffic encryption keys (GTEKs) sent in broadcast messages by the BS to mobile stations (MSs) in the same multicast group.

handover (HO): The process in which a mobile station (MS) migrates from the air-interface provided by one base station (BS) to the air-interface provided by another BS. A break-before-make HO is where service with the target BS starts after a disconnection of service with the previous serving BS. A make-before-break HO is where service with the target BS starts before disconnection of the service with the previous serving BS.

harmful interference: An interference caused by an interference signal that seriously degrades, obstructs, or repeatedly interrupts the radio communication.

high reliability base station (HR-BS): A base station that is a subset of base station (BS) features and functions and additionally supports the WirelessMAN-High Reliability Air Interface. *See also*: **base station (BS).**

high reliability mobile station (HR-MS): A subscriber station capable of performing the WirelessMAN-OFDMA subset of mobile station (MS) features and functions and additionally implementing the WirelessMAN-High Reliability Air Interface. *See also*: **mobile station (MS).**

high reliability network (HR-Network): A network compliant with High Reliability Air Interface System.

high reliability relay station (HR-RS): A relay station that is a subset of relay station (RS) features and functions and additionally supports the WirelessMAN-High Reliability Air Interface.

high reliability station (HR-station): An HR-MS, HR-BS, or HR-RS.

infrastructure station: An MR-BS, RS, HR-BS, or HR-RS. *See also:* **multihop relay base station (MR-BS)**, **relay station (RS)**, **high reliability base station (HR-BS)**, **high reliability relay station (HR-RS)**.

Initialization Coexistence Signaling Interval (ICSI): The periodically appointed CSI specially used by an Initializing Base Station (IBS) to contact its neighbor OBS. When the IBS gets the OCSI allocation and starts the operating stage, it will cease from using the ICSI.

NOTE—See Table 10-5.

initial ranging connection: A management connection used by the subscriber station (SS) and the base station (BS) during the initial ranging process. The initial ranging connection is identified by a well-known connection identifier (CID). This CID is defined as a constant value within the protocol since an SS has no addressing information available until the initial ranging process is complete.

Interference Evaluation Burst (IEB): A short regular data transmission during an interference-free slot. This transmission is scheduled using CXP messages. The time position of this interval is associated with an IEB identifier.

intermediate RS: A relay station that is located on a path between an MR-BS and an access RS.

interval usage code: A code identifying a particular burst profile that can be used by a downlink (DL) or uplink (UL) transmission interval.

licensing regime: Specific service rules defined by a regulatory body for a given band and possibly region of operation.

Location Based Services (LBS): Services that are based on location data of the MS and/or BS in a network of IEEE 802.16 devices. Examples in location sensitized applications, emergency call origination tracking, equipment tracking, etc.

machine-to-machine (M2M) communication: Information exchange between user devices through a Base Station, or between a device and a server in the core network through a Base Station, that may be carried out without any human interaction.

M2M feature: A unique characteristic of an M2M application.

macro diversity handover (MDHO): The process in which an mobile station (MS) migrates from the air-interface provided by one or more base stations (BSs) to the air-interface provided by one or more other BSs. This process is accomplished in the downlink (DL) by having two or more BSs transmitting the same medium access control layer (MAC) or physical layer (PHY) protocol data unit (PDU) to the MS so that diversity combining can be performed by the MS. In the uplink (UL), it is accomplished by having two or more BSs receiving (demodulating, decoding) the same PDU from the MS so that diversity combining of the received PDU can be performed among the BSs.

management connection: A connection used for transporting medium access control layer (MAC) management messages or standards-based messages required by the MAC. *For MAC management messages, see also:* **basic connection**, **primary management connection**, **broadcast connection, initial ranging connection**. *For standards-based messages required by the MAC, see also:* **secondary management connection**.

NOTE—Table 6-56 specifies which MAC management message is transmitted on which of the management connections.

managenent tunnel CID (MT-CID): An identifier taken from the connection identifier (CID) space managed by an MR-BS that uniquely identifies a management tunnel connection between the MR-BS and an access RS.

Master subframe: The part of the MAC frame that is used by a specific system (Master system) of a coexistence community to operate with reduced interference from its neighboring systems.

Master system: A specific system that operates during the Master subframe. Systems of a coexistence community equally share the role of Master system on a rotating basis.

minislot: A unit of uplink (UL) bandwidth allocation equivalent to n physical slots (PSs), where $n = 2^m$ and m is an integer ranging from 0 through 7.

mobile station (MS): A station in the mobile service intended to be used while in motion or during halts at unspecified points. An MS is always a subscriber station (SS) unless specifically excepted otherwise in IEEE Std 802.16.

MR-BS frame: Frame structure for DL transmission/UL reception by MR-BS.

M2M ASN: An Access Service Network that supports M2M service.

M2M device: An MS that is capable of providing M2M communication.

M2M device group: A group of M2M devices that share one or more downlink multicast service flows.

M2M feature: A unique characteristic of an M2M application.

multicast polling group: A group of zero or more subscriber stations (SSs) that are assigned a multicast address for the purposes of polling.

multihop relay base station (MR-BS): A generalized equipment set providing connectivity, management, and control of relay stations and subscriber stations. *See also:* **base station (BS)**, **relay station (RS)**.

multiple input multiple output (MIMO): A system employing at least two transmit (Tx) antennas and at least two receive (Rx) antennas to improve the system capacity, coverage, or throughput.

neighbor base station (BS): For any mobile station (MS), a BS (other than the serving BS) whose downlink (DL) transmission can be received by the MS.

non-transparent RS: A relay station that transmits DL frame-start preamble, FCH, MAP message(s) and channel descriptor (DCD/UCD) messages.

Operation Coexistence Signaling Interval (OCSI): All the CSIs other than ICSI, periodically reallocated to OBSs.

Operator ID: Operator ID is an identifier of the network provider. The Operator ID is contained in the Base Station ID.

orderly power-down procedure: The procedure that the mobile station (MS) performs when powering down, for example, as directed by user input or as prompted by a automatic power-down mechanism.

packing: The act of combining multiple service data units (SDUs) from a higher layer into a single medium access control layer (MAC) protocol data unit (PDU).

Paging Controller: A unit that belongs to the idle mode services in the network control and management system (NCMS). The paging controller retains the MS state and operational parameters and/or administers paging activity for the MS while in idle mode.

payload header suppression (PHS): The process of suppressing the repetitive portion of payload headers at the sender and restoring the headers at the receiver.

Payload Header Suppression field (PHSF): A string of bytes representing the header portion of a protocol data unit (PDU) in which one or more bytes are to be suppressed (i.e., a snapshot of the uncompressed PDU header inclusive of suppressed and unsuppressed bytes).

payload header suppression index (PHSI): An 8-bit value that references the payload header suppression (PHS) rule.

payload header suppression mask (PHSM): A bit mask indicating which bytes in the Payload Header Suppression field (PHSF) to suppress and which bytes to not suppress.

payload header suppression size (PHSS): The length of the suppressed field in bytes. This value is equivalent to the number of bytes in the Payload Header Suppression field (PHSF) and also the number of valid bits in the payload header suppression mask (PHSM).

payload header suppression valid (PHSV): A flag that tells the sending entity to verify all bytes that are to be suppressed.

physical slot (PS): A unit of time, dependent on the physical layer (PHY) specification, for allocating bandwidth.

point-to-point (PtP): A mode of operation whereby a link exists between two network entities.

primary management connection: A connection that is established during initial subscriber station (SS) ranging and used to transport delay-tolerant medium access control layer (MAC) management messages.

Primary service: See ITU Radio Regulations, sections 5.2 to 5.31.

Primary (Spectrum) users: Users of radio services that have a regulatory PRIMARY status in a band. In a given frequency allocation there may be SSU, non-SSU, or both SSU and non-SSU, assigned as primary users.

Privacy Key Management (PKM) Protocol: A client/server model between the base station (BS) and subscriber station (SS) that is used to secure distribution of keying material.

protocol data unit (PDU): The data unit exchanged between peer entities of the same protocol layer. On the downward direction, it is the data unit generated for the next lower layer. On the upward direction, it is the data unit received from the previous lower layer (see Figure 3-1).

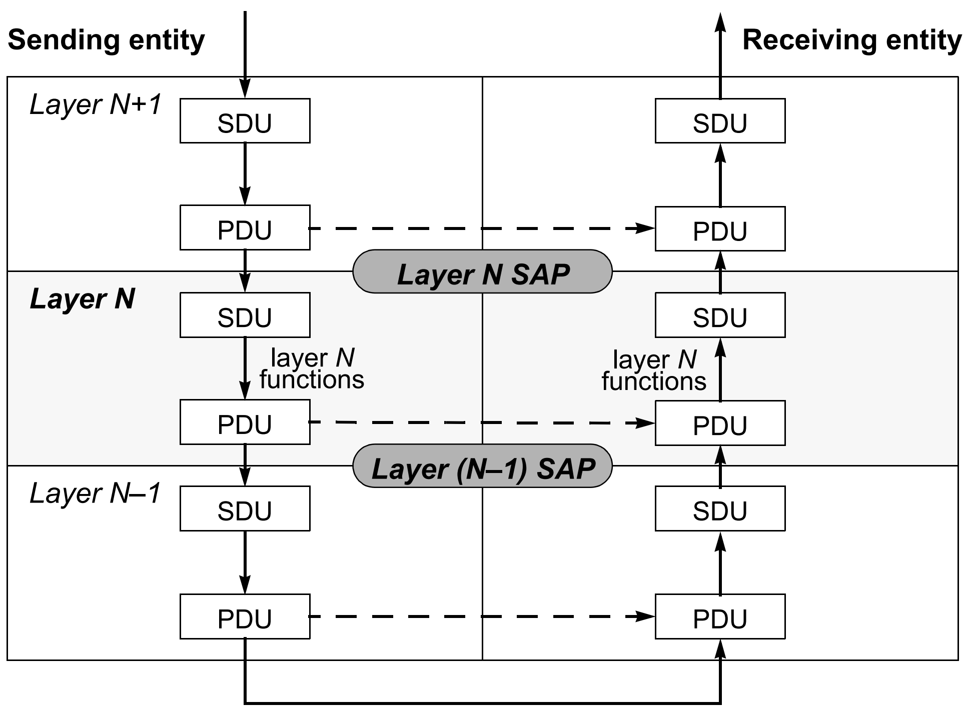


Figure 3-1—PDU and SDU in a protocol stack

quality of service (QoS) parameter set: A parameter set associated with a service flow identifier (SFID). The contained traffic parameters define scheduling behavior of uplink (UL) or downlink (DL) flows associated with transport connections.

NOTE—See 6.3.14.1.

radio frequency (RF) center frequency: The center of the frequency band in which a base station (BS) or subscriber station (SS) is intended to transmit.

radio path redundancy: The ability to provide alternative paths between base stations, relay stations, and subscriber stations.

random temporary key (RTK): The temporary key sent over-the-air, to be cross-checked with the key contained in the request primitive (15.6.5.2) received by the BS that originally sent it over-the-air. RTK is used to obstruct the coexistence requests from unauthenticated terminals.

regulatory threshold: A value (in dBm) of a signal level, as defined by the regulatory rules, above which the receiver has to initiate an action.

relay link (R-link): A radio link between an MR-BS and an RS or between a pair of RSs. This can be a relay uplink or downlink.

relay station (RS): A generalized equipment set, dependent on a multihop relay base station (MR-BS) providing connectivity, to other RSs or subscriber stations (SS). An RS may also provide management and control of subordinate RSs or SSs. The air interface between an RS and an SS is identical to the air interface between a BS and an SS. *See also:* multihop relay base station (MR-BS), base station (BS), subscriber station (SS).

relay zone: A portion of a frame used for the relay link.

round-trip delay (RTD): The round-trip delay time between communicating stations (i.e., such as between an RS and its superordinate station).

RS frame: Frame structure for DL/UL transmission/reception by RS.

RS receive/transmit transition gap (RSRTG): The minimum receive-to-transmit turnaround gap required at an RS. RSRTG is measured from the time of the last sample of the received burst to the first sample of the transmitted burst at the antenna port of the RS.

RS transmit/receive transition gap (RSTTG): The minimum transmit-to-receive turnaround gap required at an RS. RSTTG is measured from the time of the last sample of the transmitted burst to the first sample of the received burst at the antenna port of the RS.

scanning interval: A time period intended for the mobile station (MS) to monitor neighbor base stations (BSs) to determine the suitability of the BSs as targets for handover (HO).

scheduling RS: A relay station that serves as a scheduling station; i.e., a non-transparent RS with unique BSID and operating in distributed scheduling mode.

scheduling station: In centralized scheduling mode, the scheduling station is always the MR-BS. In distributed scheduling mode, the scheduling station of a given MS/RS is the first station along the route to the MR-BS that transmits MAPs; i.e., either a non-transparent RS or the MR-BS itself.

secondary management connection: A connection that may be established during subscriber station (SS) registration that is used to transport standards-based [e.g, Simple Network Management Protocol (SNMP), Dynamic Host Configuration Protocol (DHCP)] messages.

security association (SA): The set of security information that a base station (BS) and one or more of its client subscriber stations (SSs) share in order to support secure communications. This shared information includes traffic encryption keys (TEKs) and cipher block chaining (CBC) initialization vectors (IVs).

security association identifier (SAID): An identifier shared between the base station (BS) and subscriber station (SS) that uniquely identifies a security association (SA). The SAID is unique within MS. The uniqueness of this identifier shall be guaranteed by {MS MAC Address, SAID} pair.

security zone (SZ): A group consisting of one or more RSs and the MR-BS that share key material for the protection of MAC management messages produced and processed by members of the group.

security zone key (SZK): A group key shared by the MR-BS and a group of RSs within the same security zone. The SZK is a head of key hierarchy used to satisfy the security requirements such as integrity protection for MAC management messages within a defined security zone.

service access point (SAP): The point in a protocol stack where the services of a lower layer are available to its next higher layer.

service data unit (SDU): The data unit exchanged between two adjacent protocol layers. On the downward direction, it is the data unit received from the previous higher layer. On the upward direction, it is the data unit sent to the next higher layer.

NOTE—See Figure 3-1.

service flow (SF): A unidirectional flow of medium access control layer (MAC) service data units (SDUs) on a connection that is provided a particular quality of service (QoS).

service flow identifier (SFID): A 32-bit quantity that uniquely identifies a service flow to the subscriber station (SS).

serving base station (BS): For any mobile station (MS), the BS with which the MS has most recently completed registration at initial network-entry or during a handover (HO).

Shared subframe: The MAC Frame where all the systems of a coexistence community may operate in parallel. The operation during this frame may require limitations on the transmit power.

Slave subframe: That part of the MAC frame coinciding with the Master subframe in which all systems (other than the Master) of the coexistence community have restricted operation.

Slave system: A specific system that operates during the Slave subframe. This system shall not create interference to the Master systems that operate during its Master subframe.

small BS (SBS): A BS operating in a multi-tier network, typically at a lower-power tier than a BS that is not an SBS, with additional functionality related to Idle Mode, BS power management, and/or CSG support.

source base station (BS): The BS that initiates an intersystem communication procedure.

specific spectrum user (SSU): A service specifically identified in regulation as requiring protection from harmful interference. These systems are given a priority from a regulatory point of view within a given frequency band.

STC layer: OFDMA Space Time Coding information-flow fed to the STC encoder as an input. The number of STC layers in a system with vertical encoding is one, while in horizontal encoding, it depends on the number of encoding/modulation paths. This term may be used interchangeably with the word *layer* when used in the context of OFDMA STC.

STC stream: OFDMA Space Time Coding information path encoded by the STC encoder that is passed to subcarrier mapping and sent through one antenna, or passed on to the beamformer. The number of STC streams in both vertical and horizontal encoding systems is the same as the number of output paths of the STC encoder. This term may be used interchangeably with the word *stream* when used in the context of OFDMA STC.

STR RS: A non-transparent relay station capable of performing STR relaying.

subcarrier index: An index number identifying a particular used subcarrier in an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal. Subcarrier indices are greater than or equal to zero.

subscriber station (SS): A generalized equipment set providing connectivity between subscriber equipment and a base station (BS).

subscriber station receive/transmit gap (SSRTG): The minimum receive-to-transmit turnaround gap. SSRTG is measured from the time of the last sample of the received burst to the first sample of the transmitted burst at the antenna port of the SS.

subscriber station transmit/receive gap (SSTTG): The minimum transmit-to-receive turnaround gap. SSTTG is measured from the time of the last sample of the transmitted burst to the first sample of the received burst at the antenna port of the SS.

system: A base station (BS) and its subscriber stations (SSs).

target base station (BS): The BS with which a mobile station (MS) intends to be registered at the end of a handover (HO).

time division duplex (TDD): A duplex scheme where uplink (UL) and downlink (DL) transmissions occur at different times but may share the same frequency.

time division multiple access (TDMA) burst: A contiguous portion of the uplink (UL) or downlink (DL) using physical layer (PHY) parameters, determined by the downlink interval usage code (DIUC) or uplink interval usage code (UIUC), that remain constant for the duration of the burst. TDMA bursts are separated by preambles and are separated by gaps in transmission if subsequent bursts are from different transmitters.

time division multiplexing (TDM) burst: A contiguous portion of a TDM data stream using physical layer (PHY) parameters, determined by the downlink interval usage code (DIUC), that remain constant for the duration of the burst. TDM bursts are not separated by gaps or preambles.

transparent RS: A relay station that does not transmit DL frame-start preamble, FCH, MAP message(s) or channel descriptor (DCD/UCD) messages.

transparent zone: A portion of the DL subframe in the MR-BS/RS frame for an RS operating in the transparent mode used for MR-BS/RS to MS transmission. A DL subframe may, or may not, have a transparent zone.

transport connection: A connection used to transport user data. It does not include any traffic over the basic, primary, or secondary management connections. A fragmentable transport connection is a connection that allows fragmentation of service data units (SDUs).

transport connection identifier (CID): A unique identifier taken from the CID address space that uniquely identifies the transport connection. All user data traffic is carried on transport connections, even for service flows that implement connectionless protocols, such as Internet Protocol (IP). An active or admitted service flow [identified by a service flow identifier (SFID)] maps to a Transport CID assigned by the base station (BS).

TTR RS: A non-transparent relay station that performs TTR relaying.

tunnel CID (T-CID): An identifier taken from the connection identifier (CID) space that uniquely identifies a transport tunnel connection.

turbo decoding: Iterative decoding, using soft inputs and soft outputs.

type/length/value (TLV): A formatting scheme that adds a tag to each transmitted parameter containing the parameter type (and implicitly its encoding rules) and the length of the encoded parameter.

U Interface: The management and control interface that exists between the SS and the BS over the air interface.

UL access zone: A portion of the UL subframe in the MR-BS/RS frame used for MS or RS (except TTR RS in TDD mode) to MR-BS/RS transmission. A frame may have no UL access zone, or the UL access zone may consist of the entire uplink subframe, depending on the method used to separate the transmissions on the access and relay links.

UL relay zone: A portion of the UL subframe in the MR-BS/RS frame used for RS to MR-BS/RS transmission. A frame may have no UL relay zone, or the UL relay zone may consist of the entire uplink subframe, depending on the method used to separate the transmissions on the access and relay links.

Uncoordinated Coexistence Mechanism: A mechanism by which a radio system attempts to achieve coexistence without coordination with other spectrum users.

uplink (UL): The direction from a subscriber station (SS) to the base station (BS).

uplink channel descriptor (UCD): A medium access control layer (MAC) message that describes the physical layer (PHY) characteristics of an uplink (UL).

uplink interval usage code (UIUC): An interval usage code specific to an uplink (UL).

uplink map (UL-MAP): A set of information that defines the entire access for a scheduling interval.

user data: Protocol data units (PDUs) of any protocol above a service-specific convergence sublayer (CS) received over the CS service access point (SAP).

wireless access: End-user radio connection(s) to core networks.

WirelessMAN-CX: The designation used to describe the realization that adds coordinated coexistence mechanisms to systems operating below 11 GHz in license-exempt bands.

WirelessMAN-UCP: The designation used to describe the realization that adds uncoordinated coexistence mechanisms to systems operating below 11 GHz in license-exempt bands.

4. Abbreviations and acronyms

3-DES	triple data encryption standard
AAS	adaptive antenna system
AC	authentication control
ACLR	Adjacent Channel Leakage Ratio
ACM	account management
ACS	Adaptive Channel Selection
ADPD	Advertisement Discovery Policy Descriptor
AES	advanced encryption standard
AGC	automatic gain control
AK	authorization key
AKID	authorization key identifier
ALTCH	alternative channel
AMC	adaptive modulation and coding
AMS	advanced mobile station (specified in IEEE Std 802.16.1-2012)
ARQ	automatic repeat request
ASA	authentication and service authorization
ASR	anchor switch reporting
ATDD	adaptive time division duplexing
ATM	asynchronous transfer mode
BCC	block convolutional code
BE	best effort
BER	bit error ratio
BPSK	binary phase shift keying
BR	bandwidth request
BS	base station
BSD	base station descriptor
BSIS	Base Station Identification Server
BSN	block sequence number
BTC	block turbo code
BW	bandwidth (abbreviation used only in equations, tables, and figures)
BWA	broadband wireless access
BWAA	bandwidth allocation/access
C/I	carrier-to-interference ratio
C/N	carrier-to-noise ratio
CA	certification authority
CBC	cipher block chaining
CBC-MAC	cipher block chaining message authentication code
CC	confirmation code
CCA	Clear Channel Assessment
CCD	Candidate Channel Determination
CCH	control subchannel
CCI	co-channel interference
CCM	CTR mode with CBC-MAC
CCMFA	Candidate Channel and Master Frame Assessment

CCS	common channel signaling
CCV	clock comparison value
CDMA	code division multiple access
ChCtrFr	channel center frequency
ChID	channel identifier
CID	connection identifier
CINR	carrier-to-interference-and-noise ratio
CIR	channel impulse response
CLP	cell loss priority
CMAC	cipher-based message authentication code
CMI	Coexistence Messaging Interval
CoNBR	coexistence neighbor
CP	cyclic prefix
CPS	common part sublayer
CQI	channel quality information
CQICH	channel quality information channel
CR	cognitive radio
CRC	cyclic redundancy check
CS	convergence sublayer
CSCF	centralized scheduling configuration
CSCH	centralized scheduling
CSG	closed subscriber group
CSI	Coexistence Signaling Interval
CSIN	Coexistence Signaling Interval Number
CSIT	channel state information at the transmitter
CT	cooperative transmission
CTC	convolutional turbo code
CT-CX	credit token-based coexistence
CTG	CSI Transmission GAP
CTR	counter mode encryption
CW	contention window
CX	Coexistence
CX_CMI_D	Coexistence Message Interval Downlink
CX_CMI_U	Coexistence Message Interval Uplink
CXCBI	Coordinated Coexistence Contention-Based Interval
CX-CBP	Coordinated Coexistence Contention-Based Protocol
CXCC	Coexistence Control Channel
CXCW	coexistence contention window
CXP	Coexistence Protocol
CXSBI	Coordinated Scheduled-Based Interval
DCS	Dynamic Channel Selection
DAMA	demand assigned multiple access
DARS	digital audio radio satellite
dBi	decibels of gain relative to the 0 dB gain of a free-space isotropic radiator
dBm	decibels relative to 1 mW
DCD	downlink channel descriptor

DES	data encryption standard. This reference is withdrawn.
DFS	dynamic frequency selection
DHCP	Dynamic Host Configuration Protocol
DID	deregistration identifier (specified in IEEE Std 802.16.1-2012)
DIUC	downlink interval usage code
DL	downlink
DLFP	downlink frame prefix
DSA	dynamic service addition
DSC	dynamic service change
DSCH	distributed scheduling
DSCP	differentiated services codepoint
DSD	dynamic service deletion
DSx	dynamic service addition, change, or deletion
D-TDOA	Downlink Time Difference Of Arrival
EAP	extensible authentication protocol
EC	encryption control
ECB	electronic code book
ECRTP	a IP-header-compression CS PDU format (IETF RFC 3545)
EDE	encrypt-decrypt-encrypt
EESS	earth exploratory satellite system
EIK	EAP Integrity Key
EIRP	effective isotropic radiated power
EKS	encryption key sequence
EOF	End of Frame (of the CSI message)
EQP	extended quite period
EVM	error vector magnitude
FA	frequency assignment
FBIS	forwarding between infrastructure stations
FBSS	fast base station switching
FC	fragmentation control
FCZ	forwarding control zone
FCAPS	Fault Management, Configuration Management, Account Management, Performance Management, Security Management
FCC	Federal Communications Commission
FCH	frame control header
FDD	frequency division duplex or duplexing
FEC	forward error correction
FFSH	fast-feedback allocation subheader
FFT	fast Fourier transform
FHDC	frequency hopping diversity coding
FPC	fast power control
FRS	fixed relay station
FSH	fragmentation subheader
FSN	fragment sequence number
FSS	fixed satellite service
FUSC	full usage of subchannels

GPCS	Generic Packet Convergence Sublayer
GF	galois field
GKEK	group key encryption key
GMSH	grant management subheader
GPS	global positioning system
GS	guard symbol
GTEK	group traffic encryption key
HARQ	hybrid ARQ
HCS	header check sequence
HEC	header error check
H-FDD	half-duplex frequency division duplex
HMAC	hashed message authentication code
HO	handover
HR	handover ranging
HR	high reliability
HT	header type
HUMAN	high-speed unlicensed metropolitan area network
I	inphase
IANA	Internet Assigned Numbers Authority
IBS	initializing base station
ICSI	Initialization Coexistence Signaling Interval
IE	information elemen
IEB	Interference Evaluation Burst
IEBBSn	Nth Interference Evaluation Burst of a BS
IEBSSn	Nth Interference Evaluation Burst over all the SS associated with a BS
IFFT	inverse fast Fourier transform
IM	interference management
IMM	idle mode management
INR	interference-to-noise ratio
IP	Internet Protocol
IR	initial ranging
IS	infrastructure station
IV	initialization vector
IWF	interworking function
KEK	key encryption key
LAN	local area network
LBS	location based services
LBT	listen-before-talk
LBT-TXOP	Transmission Opportunity depending on LBT result
LDPC	low-density parity check
LE	license-exempt
LFSR	linear feedback shift register
LLC	logical link control
LOS	line-of-sight
LSB	least significant bit
M2M	machine-to-machine

M2MCID	M2M multicast connection identifier
MAC	medium access control layer
MAK	MBS authorization key
MAN	metropolitan area network
MBS	multicast and broadcast service
MCID	multicast CID (see Table 8-282)
MCS	modulation coding scheme
MDHO	macro diversity handover
MDS	multipoint distribution service
MGTEK	MBS group traffic encryption key
MIB	management information base
MIC	message integrity check
MIH	media independent handover
MIHF	MIH Function
MIMO	multiple input multiple output
MMDS	multichannel multipoint distribution service
MPEG	moving pictures experts group
MR-BS	multihop relay base station
MRS	mobile relay station
MS	mobile station
MSB	most significant bit
MSK	master session key
NCFG	network configuration
NCMS	network control and management system
NCMS(BS)	network control and management system at the BS side (network side)
NCMS(SS/MS)	network control and management system at the SS/MS side
NEM	network entry management
NENT	network entry
NLOS	non-line-of-sight
NNI	network-to-network interface (or network node interface)
NRM	network reference model
nrtPS	non-real-time polling service
NSP	network service provider
NTI	Network Time Intervals
NTI_S	Network Time Interval Slots
NTP	Network Time Protocol
NURBC	Neighborhood Update Request BroadCast
OBS	operating base station
OCSI	Operation Coexistence Signaling Interval
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiple access
OID	object identifier
PAK	primary authorization key
PAPR	peak to average power ratio
PBR	piggyback request
PDU	protocol data unit

PER	packet error ratio
PHS	payload header suppression
PHSF	Payload Header Suppression field
PHSI	payload header suppression index
PHSM	payload header suppression mask
PHSS	payload header suppression size
PHSV	payload header suppression valid
PHY	physical layer
PKM	privacy key management
PLD	PayLoaD (of the CSI message)
PM	poll-me bit
PMD	physical medium dependent
PMK	pairwise master key
PMP	point-to-multipoint
PN	packet number
PPDR	public protection and disaster relief
PPP	Point-to-Point Protocol
PRBS	pseudo-random binary sequence
PS	physical slot
PSC	power saving class
PTI	payload type indicator
PtP	point to point
PUSC	partial usage of subchannels
PUSC-ASCA	partial usage of subchannels – adjacent subcarrier allocation
PVC	permanent virtual circuit
Q	quadrature
QAM	quadrature amplitude modulation
QoS	quality of service
QP	quiet period
QPSK	quadrature phase-shift keying
R-ACK	relay ACK
RAIS	Radio Application Identification Server
RCG	Receive CSI GAP
R-DL	relay downlink
REQ	request
R-FCH	relay zone frame control header
RLAN	Radio Local Area Network
R-MAP	relay zone MAP
RNG	ranging
ROHC	an IP-header-compression CS PDU format [IETF RFC 3095 (updated by RFC 4815 [B44])]
RRA	radio resource agent
RRC	radio resource controller
RRM	radio resource management
R-RTI	relay receive/transmit transition interval
RRU	renting resource unit

RS	Reed-Solomon
RS	relay station
RSP	response
RSS	receive signal strength
RSSI	receive signal strength indicator
RTD	round-trip delay
RTG	receive/transmit transition gap
RTK	random temporary key
rtPS	real-time polling service
R-TTI	relay transmit/receive transition interval
R-UL	relay uplink
Rx	receive (abbreviation not used as verb)
RxDS	receiver delay spread clearing interval
R-Zone	relay zone
SA	security association
SAID	security association identifier
SAP	Service Access Point
SAR	synthetic aperture radar
SC	single carrier
SDMA	spatial division multiple access
SDU	service data unit
SF	service flow
SFID	service flow identifier
SFM	service flow management
SHA	secure hash algorithm
SI	slip indicator
SIQ	service information query
SM	spatial multiplexing
SN	sequence number
SNMP	Simple Network Management Protocol
SNR	signal-to-noise ratio
SOF	Start of Frame (of CSI message)
SPOF	single point of failure
SS	subscriber station
SSID	subscriber station identification (MAC address)
SSM	subscriber station management
SSTG	subscriber station transition gap
SSU	specific spectrum user
SSURF	Subscriber Station Uplink Radio Frequency
STC	space time coding
STID	Station Identifier (specified in IEEE Std 802.16.1-2012)
STR	simultaneous transmit and receive relaying
STTD	space time transmit diversity
SVC	switched virtual circuit
TCM	trellis coded modulation
TCP	Transmission Control Protocol

TCS	transmission convergence sublayer
TDD	time division duplex or duplexing
TDM	time division multiplexing
TDMA	time division multiple access
TDOA	time difference of arrival
TDU	tunnel data unit
TEK	traffic encryption key
TFTP	Trivial File Transfer Protocol
TLV	type/length/value
TPC	Transmit Power Control
TTG	transmit/receive transition gap
TTR	time-division transmit and receive relaying
TUSC	tile usage of subchannels
Tx	transmit (abbreviation not used as verb)
UCD	uplink channel descriptor
UCP	Uncoordinated Coexistence Protocol
UDP	User Datagram Protocol
UEP	unequal error protection
UGS	unsolicited grant service
UIUC	uplink interval usage code
UL	uplink
UNI	user-to-network interface (or user-network interface)
U-NII	unlicensed national information infrastructure
UTC	coordinated universal time
U-TDOA	uplink time difference of arrival
UW	unique word
VC	virtual channel
VCI	virtual channel identifier
VLAN	virtual local area network
VP	virtual path
VPI	virtual path identifier
WirelessHUMAN	Wireless High-speed Unlicensed Metropolitan Area Networks
WirelessMAN	Wireless Metropolitan Area Networks
WirelessMAN-CX	Wireless Metropolitan Access Network Coexistence
WirelessMAN-UCP	Wireless Metropolitan Access Network Uncoordinated Coexistence Protocol
WLAN	wireless local area network
XOR	exclusive-or

5. Service-specific CS

6. MAC common part sublayer

6.1 Data/Control plane

6.1.1 Addressing and connections

6.1.1.1 Point-to-multipoint (PMP)

Each air interface in an SS shall have a 48-bit universal MAC address, as defined in IEEE Std 802®. This address uniquely defines the air interface of the SS. It is used during the initial ranging process to establish the appropriate connections for an SS. It is also used as part of the authentication process by which the BS and SS each verify the identity of the other. The definition and usage of the MAC address defined above for the SS and the BS shall be applicable for the RS and the MR-BS, respectively.

Connections are identified by a 16-bit CID. At SS initialization, two pairs of management connections, basic connections (UL and DL) and primary management connections (UL and DL), shall be established between the SS and the BS, and a third pair of management connections (secondary management, DL and UL) may be optionally generated. The three pairs of management connections reflect the fact that there are inherently three different levels of QoS for management traffic between an SS and the BS. The basic connection is used by the BS MAC and SS MAC to exchange short, time-urgent MAC management messages. The primary management connection is used by the BS MAC and SS MAC to exchange longer, more delay-tolerant MAC management messages. Table 6-55 specifies which MAC management messages are transferred on which of these two connections. In addition, it also specifies which MAC management messages are transported on the broadcast connection. Finally, the secondary management connection is used by the BS and SS to transfer delay-tolerant, standards-based [Dynamic Host Configuration Protocol (DHCP), Trivial File Transfer Protocol (TFTP), SNMP, etc.] messages. Messages carried on the secondary management connection may be packed and/or fragmented. For the OFDM, and OFDMA PHYs, management messages shall have CRC. Use of the secondary management connection is required only for managed SS. The identification, establishment, and usage of the connection defined above for the SS and the BS shall be applicable for the RS and the MR-BS, respectively. In addition, the multicast management connection is used by the MR-BS to transfer MAC management messages to a group of RSs.

The CIDs for these connections shall be assigned in the RNG-RSP, REG-RSP, RS_Config-CMD (RS only), or MOB_BSHO-REQ/RSP for pre-allocation in handover. When CID pre-allocation is used during HO, a primary management CID may be derived based on Basic CID without assignment in the messages (see 6.3.20.2.11). The message dialogs provide three CID values. The same CID value is assigned to both members (UL and DL) of each connection pair.

For bearer services, the BS and the SS may initiate the set-up of service flows based upon the provisioning information. The registration of an SS, or the modification of the services contracted at an SS, stimulates the higher layers of the BS and/or the SS to initiate the setup of the service flows. When admitted or active, service flows are uniquely associated with transport connections. MAC management messages shall never be transferred over transport connections. Bearer or data services shall never be transferred on the basic, primary, or secondary management connections.

Bearer connection CID reassignments during handover or network reentry shall be sent using the REG-RSP encodings TLV in the RNG-RSP message, the REG-RSP message, or reassigned autonomously without explicit assignment in any message (see 6.3.20.2.11).

Requests for transmission are based on these CIDs, since the allowable bandwidth may differ for different connections, even within the same service type. For example, an SS unit serving multiple tenants in an office building would make requests on behalf of all of them, though the contractual service limits and other connection parameters may be different for each of them.

Many higher layer sessions may operate over the same wireless CID. For example, many users within a company may be communicating with Transmission Control Protocol (TCP)/IP to different destinations, but since they all operate within the same overall service parameters, all of their traffic is pooled for request/grant purposes. Since the original local area network (LAN) source and destination addresses are encapsulated in the payload portion of the transmission, there is no problem in identifying different user sessions.

The type of service and other current parameters of a service are implicit in the CID; they may be accessed by a lookup indexed by the CID.

6.1.1.2 Multihop relay

Addressing and connections as perceived by an SS served by an RS or MR-BS are defined in the same manner as in 6.1.1.1. This subclause specifies the additional addressing and connection definitions that apply to multihop relay systems. A non-transparent RS shall be assigned a Base Station ID. The format of the Base Station ID is defined in 6.3.2.3.2.

Connections may span multiple hops and may pass through one or more intermediate RSs. These connections shall be identified by the connection ID (CID) as specified in 6.1.1.1 and the CIDs shall be unique within an MR cell. All the CID connection types specified in PMP mode shall be supported between the MR-BS and MS.

An additional type of connection called a tunnel connection may be established between the MR-BS and an access RS, or between the MR-BS and a superordinate station of an RS group (see 6.1.7). Tunnel connections shall be used for transporting relay MAC PDUs from one or more connections between the MR-BS and an access RS and may pass through one or more intermediate RSs. It is not required that all connections shall pass through a tunnel connection. MAC PDUs from connections that do not pass through a tunnel are forwarded based on the CID of the connection. There shall be two types of tunnel connections. Management tunnel connections, identified using the MT-CID, shall be used exclusively for transporting MAC PDUs from management (basic, primary, or secondary) connections. Transport tunnel connections, identified using the T-CID, shall be used exclusively for transporting MAC PDUs from transport connections. The MR-BS shall allocate the T-CID and MT-CID using the DSA messages. MT-CID is bidirectional and T-CID is unidirectional.

6.1.1.2.1 Addressing scheme for relaying

In the procedure of network entry and initialization for a new RS, the MR-BS may pre-allocate a range of management CIDs to an RS. The operation for pre-allocation of these CIDs is described in 6.3.9.18.2.One or more BS in an area of the network may be grouped into an M2M zone and identified by an M2M GROUP ZONE ID. A BS may belong to at most one M2M group zone. The BS may broadcast the M2M GROUP ZONE ID of the zone to which it belongs in the DCD message.

The M2M multicast connection ID (M2MCID) uniquely identifies a downlink multicast service flow shared by a group of M2M devices within an M2M zone. Implicitly, it is also used to identify the group of M2M devices that share the downlink multicast service flow. An M2M device may share more than one downlink multicast service flow each identified by an M2MCID. All M2MCIDs that are assigned to an M2M device belong to the same M2M group zone.

The M2MCID is assigned to a service flow of an M2M device during the DSA procedure and released during the DSD procedure or an explicit network exit (e.g., power down location update). The assigned M2MCID shall be retained by an M2M device even in idle mode unless the M2M device exits from the network or the network explicitly deletes the service flow associated with the M2MCID. The M2MCID may be reassigned during normal operation mode and idle mode. During normal operation, the M2MCID may be changed and deleted by DSC and DSD procedures respectively.

During idle mode, the M2MCID may be changed by a location update procedure or during network reentry through the RNG-RSP message. The BS may trigger the group location update via paging message. In normal operation, the BS may update the M2MCID for a M2M device group using the MAC Group Management Control (MGMC) message.

When the M2M device performs the timer-based location update, if the BS needs to update the M2MCID of M2M device, the BS may send a RNG-RSP message with an M2MCID Update TLV, which contains a new M2MCID value in response to the RNG-REQ message.

A BS may use the MOB_PAG-ADV message to indicate the update of the M2MCID and its new value to all the M2M devices in a group. When an idle mode M2M device that belongs to the M2M device group (identified by its M2MCID) receives a paging message containing an M2MCID TLV identifying one of its service flows and an Action Code TLV with value set to 0b11, this M2M device shall update the M2MCID based on the value indicated by M2MCID reassignment TLV (see 11.17.5).

After receiving the updated M2MCID value, the M2M device shall send an acknowledgment (ACK) to the BS.

If the BS does not receive an acknowledgment from some of the M2M devices, it may trigger location update in the next paging cycle of those M2M devices by sending MOB_PAG-ADV message containing MS MAC Address hash and it may send a RNG-RSP message with an M2MCID Update TLV containing the new M2MCID to each of them during the location update procedure.

The BS may use the M2M Group MAC Control (MGMC) message with the M2MCIDs to send the information to multiple M2M devices. The M2M device shall respond to acknowledge this message with M2M ACK MAC Control (MAMC) message.

The information of the neighboring M2M Group Zones may be advertised by BSs of a given M2M Group Zone in MOB_NBR-ADV message. Neighboring M2M Group Zones implies the M2M Group Zones to which the neighboring BSs belong are different from the M2M Group Zone to which the serving BS belongs.

The MOB_NBR-ADV message contains M2M_GROUP_ZONE_ID of the neighboring M2M Group Zones along with the mappings of M2MCID from the M2M Group Zone of the serving BS to one or more neighboring M2M Group Zones. When an M2M device changes its preferred or serving BS to a BS that belongs to a different M2M Group Zone than the current serving BS, it may have the M2MCID mapping information for the M2M Group Zone of that BS, if it has already received the MOB_NBR-ADV.

The MOB_NBR-ADV message including M2M Group Zone information should be transmitted by the BSs that are situated at the M2M Group Zone boundaries.

6.1.1.3 MAC header formats

The MAC header formats are defined in Table 6-1 except for the MAC header formats for DL-MAP and UL-MAP MAC messages for channel bandwidth less than 1.25 MHz in which case the MAC header formats are defined in subclause 6.1.1.3.1.1.

There is one defined DL MAC header, which is the Generic MAC header, which begins each DL MAC PDU containing either MAC management messages or CS data. There are two defined UL MAC header formats. The first is the Generic MAC header that begins each MAC PDU containing either MAC management messages or CS data, where the header type (HT) is set to 0 as shown in Table 6-2. The second is the MAC header format without payload where HT is set to 1 as shown in Table 6-2. For the latter format, the header is not followed by any MAC PDU payload and CRC.

Table 6-1—MAC header formats

Syntax	Size (bit)	Notes
MAC Header() {	—	—
HT	1	See below for context-dependent definitions.
EC	1	If HT = 1, EC = 0
if (HT == 0) {	—	—
Type	6	—
ESF	1	—
CI	1	—
EKS	2	—
Reserved	1	Shall be set to zero
LEN	11	—
}	—	—
else {	—	—
Type	3	—
BR	19	—
}	—	—
CID	16	—
HCS	8	—
}	—	—

Table 6-2—MAC header HT and EC fields encoding

HT	EC[a]	MAC PDU type	Reference figure	Reference table
0	0	Generic MAC header for DL and UL. MAC PDU with data payload, no encryption, with a 6-bit type field, see Table 6-4 for its type field encodings.	Figure 6-1	Table 6-3
0	1	Generic MAC header for DL and UL. MAC PDU with data payload, with encryption with a 6-bit type field, see Table 6-4 for its type field encodings.	Figure 6-1	Table 6-3
1	0	DL: DL M2M MAC signaling header type I. MAC PDU without data payload, with a 3-bit type field, see Table 6-30 for type encoding definitions.	Figure 6-5, Figure 6-8, Figure 6-9– Figure 6-14	Table 6-6, Table 6-7, Table 6-8– Table 6-13 Table 6-30, Table 6-31

Table 6-2—MAC header HT and EC fields encoding *(continued)*

HT	EC[a]	MAC PDU type	Reference figure	Reference table
1	1	DL: Compressed/Reduced Private DL-MAP[b] UL: MAC signaling header type II. MAC PDU without data payload, with 1-bit type field, see Table 6-7 for type encoding definitions.	Figure 6-6– Figure 6-17	Table 6-7, Table 6-15

[a]Headers with HT = 1 shall not be encrypted. Thus the EC field is used to distinguish between feedback MAC header (UL)/Compress MAP (DL), and all other type headers.

[b]Compressed DL-MAP and Reduced Private MAP do not use MAC headers as defined in 6.1.1.3; however, the first two bits of these maps replace the HT/EC fields and are always set to 0b11 to identify them as such (see 8.3.6.6, 8.3.6.7, 8.4.5.6, and 8.4.5.8). If the most significant bit of the Type field is set to 0, it indicates the presence of a compressed/reduced private DL-MAP. If the most significant bit of the Type field is set to 1, it indicates the presence of a SUB-DL-UL-MAP.

6.1.1.3.1 Generic MAC header

The Generic MAC header is illustrated in Figure 6-1.

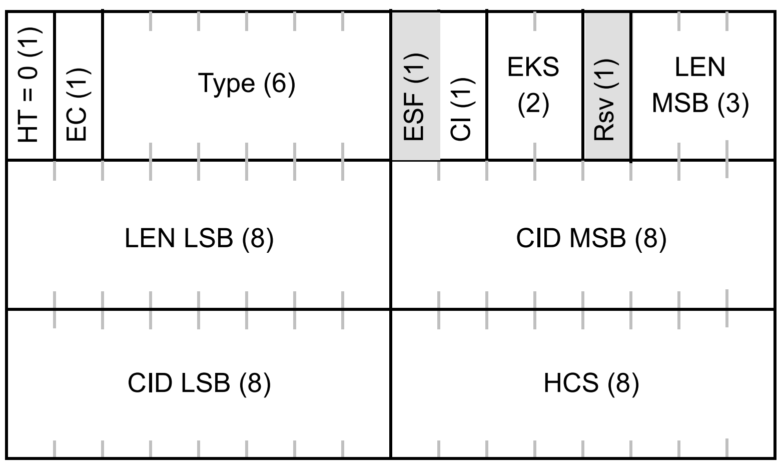


Figure 6-1—Generic MAC header format

The fields of the Generic MAC header are defined in Table 6-3. Every header is encoded, starting with the HT and encryption control (EC) fields. The coding of these fields is such that the first byte of a MAC header shall never have the value of 0xFX, where “X” means “do not care.” This prevents false detection on the stuff byte used in the transmission convergence sublayer (TCS).

The ESF bit in the Generic MAC header indicates that the extended subheader is present. Using this field, a number of additional subheaders can be used within a PDU. The extended subheader shall always appear immediately after the Generic MAC header and before all other subheaders. Contrary to the other subheaders, extended subheaders are not considered part of the MAC PDU payload and, hence are not encrypted. When an entity transmits a MAC PDU without a payload, it shall set the EC bit in the Generic MAC header to 0, even if the connection on which it transmits the MAC PDU is associated with data encryption. When an entity receives a MAC PDU that does not contain a payload, it shall process this MAC PDU if the EC bit is set to 0, and should discard this MAC PDU if the EC bit is set to 1.

Table 6-3—Generic MAC header fields

Name	Length (bit)	Description
HT	1	Header type. Shall be set to zero.
EC	1	Encryption control. 0 = Payload is not encrypted or payload is not included. 1 = Payload is encrypted.
Type	6	This field indicates the subheaders and special payload types present in the message payload.
ESF	1	Extended Subheader field. If ESF = 0, the extended subheader is absent. If ESF = 1, the extended subheader is present and shall follow the Generic MAC header immediately. (See 6.3.2.2.7.) The ESF is applicable both in the DL and in the UL.
CI	1	CRC indicator. 1 = CRC is included in the PDU by appending it to the PDU payload after encryption, if any. 0 = No CRC is included.
EKS	2	Encryption key sequence. The index of the traffic encryption key (TEK) and initialization vector (IV) used to encrypt the payload. This field is only meaningful if the EC field is set to 1.
RSV	1	*Reserved*
LEN	11	Length. The length in bytes of the MAC PDU including the MAC header and the CRC if present.
CID	16	Connection identifier.
HCS	8	Header check sequence. An 8-bit field used to detect errors in the header. The transmitter shall calculate the HCS value for the first five bytes of the cell header, and insert the result into the HCS field (the last byte of the MAC header). It shall be the remainder of the division (Modulo 2) by the generator polynomial $g(D = D^8 + D^2 + D + 1$ of the polynomial D^8 multiplied by the content of the header excluding the HCS field. (Example: [HT EC Type] = 0x80, BR = 0xAAAA, CID = 0x0F0F; HCS would then be set to 0xD5).

146 The definition of the Type field is indicated in Table 6-4.

Table 6-4—Type encodings

Type bit	Value
#5 most significant bit (MSB)	*Reserved*
#4	ARQ feedback payload 1 = present, 0 = absent
#3	Extended type Indicates whether the present packing subheader (PSH) or fragmentation subheader (FSH) is extended for non-ARQ-enabled connections 1 = Extended 0 = Not extended For ARQ-enabled connections, this bit shall be set to 1.
#2	Fragmentation subheader (FSH) 1 = present, 0 = absent

Table 6-4—Type encodings *(continued)*

Type bit	Value
#1	Packing subheader (PSH) 1 = present, 0 = absent
#0 least significant bit (LSB)	DL: Fast-feedback allocation subheader (FFSH) UL: Grant management subheader (GMSH) 1 = present, 0 = absent

If the ARQ Feedback Payload bit in the MAC Type field (see Table 6-4) is set, the ARQ Feedback Payload shall be transported. If packing is used, it shall be transported as the first packed payload. See 6.3.3.4.3. Note that this bit does not address the ARQ Feedback payload contained inside an ARQ Feedback message.

MAC PDUs sent on a relay link through a tunnel shall be constructed into a relay MAC PDU of the form illustrated in Figure 6-2. Each relay MAC PDU shall begin with a fixed length relay MAC header (see 6.1.1.3.2). The relay MAC header shall be followed by zero or more extended subheaders and the payload. The payload shall consist of zero or more subheaders and zero or more MAC PDUs as defined in Figure 6-1. In the case of management tunnel, the payload may consist of zero or more subheaders and one MT_Transfer MAC message. A relay MAC PDU may contain a CRC as described in 6.3.3.5.2. Implementation of CRC capability is mandatory for MR systems and the presence of a CRC is indicated in the relay MAC header. When a relay MAC PDU contains a CRC, the CRCs of individual MAC PDUs within the payload shall be omitted but the CI bit setting and LEN values are retained. If omitted, the egress station of the tunnel shall calculate the CRCs and attach them to the individual MAC PDUs if the CI bit of the MAC PDU header within the relay MAC PDU is set.

6.1.1.3.1.1 Generic MAC header format for DL-MAP and UL-MAP MAC messages when the channel bandwidth is less than 1.25 MHz

The header of the DL-MAP MAC message shall be of the format defined in Figure 6-2. The DL-MAP is always the first burst in the DLSF so it can be identified as DL-MAP by its position in the burst. Therefore only LEN and HCS fields are transmitted. The modified GMAC header consists of 1 byte length field and 1 byte for HCS field.

LEN (8)	HCS (8)

Figure 6-2—Modified DL-MAP header for channel bandwidths less than 1.25 MHz

The header of the UL-MAP MAC message shall be of the format defined in Figure 6-3. The UL-MAP, if present, is the first data burst in the DLSF after DL-MAP, but it may not always be present in a frame in which case, the first burst may carry data traffic. Conflict will be avoided by setting HT = 1 to identify the burst as UL-MAP.

HT (1)	LEN (8)	HCS (8)

Figure 6-3—Modified UL-MAP header for channel bandwidths less than 1.25 MHz

6.1.1.3.2 Relay MAC header format

The header of the relay MAC PDU shall be of the format defined in Table 6-5 and further illustrated in Figure 6-4.

Table 6-5—Description of relay MAC header fields

Name	Length (bits)	Description
HT	1	Shall be set to zero.
EC/AC	1	Encryption control if CID in the relay MAC header is T-CID. 0 = Payload is not encrypted 1 = Payload, except subheaders inserted on the relay link, is encrypted. Authentication control if CID in the relay MAC header is MT-CID. 0 = Payload starting with MAC header defined in Table 6-1. 1 = Payload starting with MT_Transfer message defined in Table 6-222.
RMI	1	Relay Mode Indicator Shall be set to 1.
ASH	1	Allocation subheader 1=present; 0=absent
GMSH	1	UL: grant management subheader (GMSH) 1 = present, 0 = absent DL: *Reserved;* shall be set to 0.
FSH	1	Fragmentation subheader (FSH) 1=present; 0=absent
PSH	1	Packing subheader (PSH) 1=present; 0=absent
QSH	1	QoS subheader (QSH) 1=present; 0=absent
ESF	1	Extended subheader field If ESF=0, the extended subheader is absent. If ESF=1, the extended subheader is present and immediately follows the relay MAC header. The ESF is applicable in both the DL and UL.
CI	1	CRC indicator. 1 = CRC is included in the relay MAC PDU by appending it to the relay MAC PDU payload after encryption, if any. 0 = No CRC is included.
EKS	2	Encryption key sequence. The index of the traffic encryption key (TEK) of the access RS operating in distributed security mode and initialization vector (IV) used to encrypt the payload. This field is only meaningful if the EC/AC field is set to 1; otherwise, it shall be set to zero.
LEN	12	Length. The length in bytes of the relay MAC PDU including the relay MAC header and the CRC if present.
CID	16	T-CID or MT-CID.
HCS	8	Header Check Sequence.

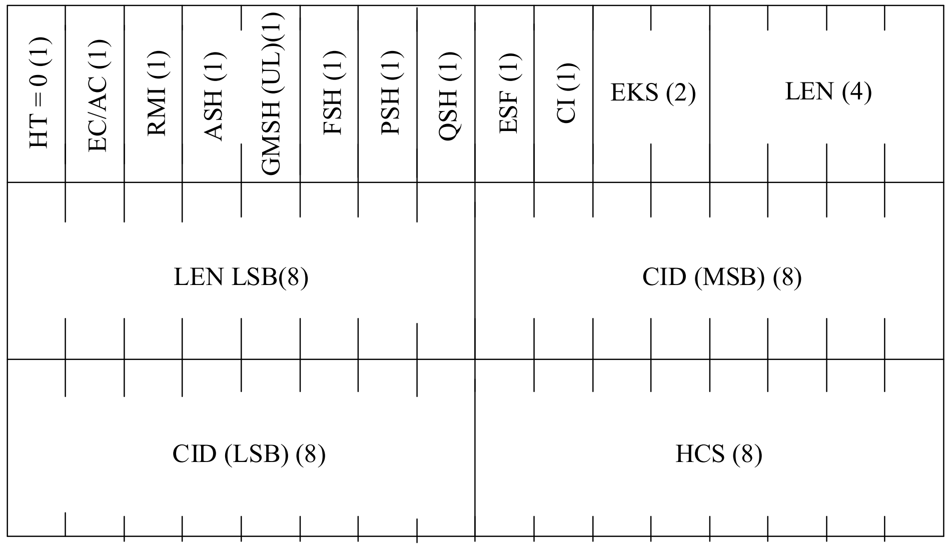


Figure 6-4—Header format of relay MAC PDU with payload

6.1.1.3.3 MAC header without payload

This MAC header format is applicable to UL only. The MAC header is not followed by any MAC PDU payload and CRC.

6.1.1.3.3.1 MAC signaling header type I

For this MAC header format, there is no payload following the MAC header. The MAC signaling header type I is illustrated in Figure 6-5. Table 6-6 describes the encoding of the 3-bit Type field following the EC field.

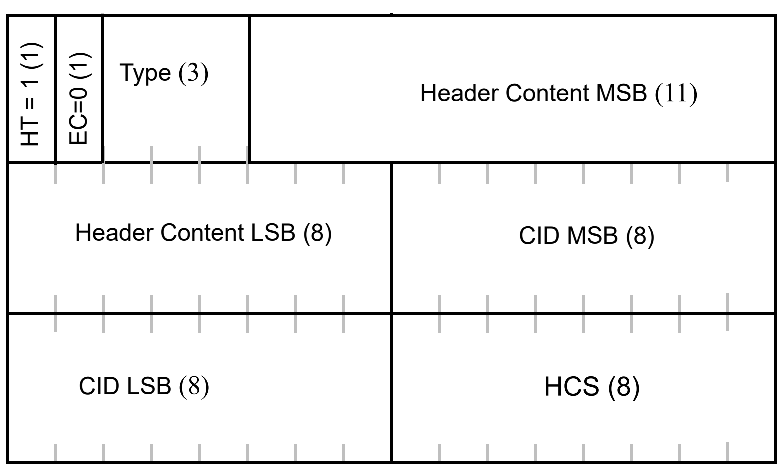


Figure 6-5—MAC signaling header type I format

Table 6-6—Type field encodings for MAC signaling header type I

Type field (3 bits)	MAC header type (with HT/EC = 0b10)	Reference figure	Reference table
000	BR incremental	Figure 6-8	Table 6-7
001	BR aggregate	Figure 6-8	Table 6-7
010	PHY channel report	Figure 6-12	Table 6-11
011	BR with UL Tx power report	Figure 6-9	Table 6-8
100	BR and CINR report	Figure 6-10	Table 6-9
101	BR with UL sleep control	Figure 6-13	Table 6-12
110	SN Report	Figure 6-14	Table 6-13
111	CQICH allocation request	Figure 6-11	Table 6-10

6.1.1.3.3.2 MAC signaling header type II

This type of MAC header is UL-specific. There is no payload following the MAC header. The MAC signaling header type II is illustrated in Figure 6-6. Table 6-7 describes the encoding of the 1-bit type field following the EC field. The description of DL MAC header format with HT/EC = 0b11, defined as the Compressed DL-MAP, is not part of this subclause. The detailed description can be found in 8.4.5.6.1.

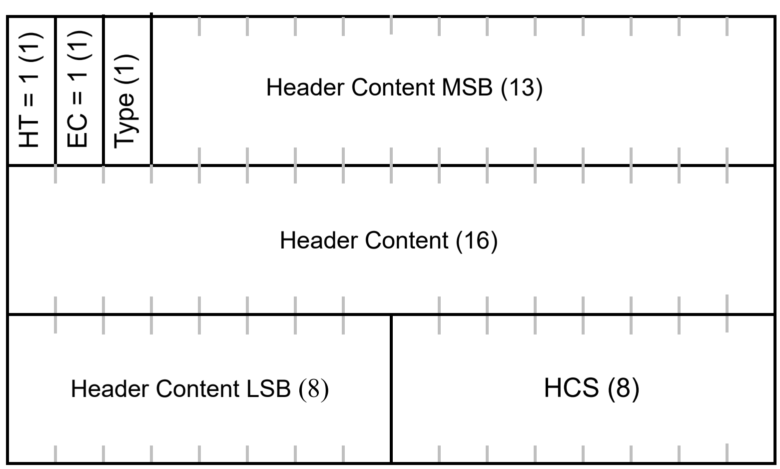


Figure 6-6—MAC signaling header type II format

6.1.1.3.4 DL MAC header without payload

This MAC header format is applicable to DL only. The MAC header is not followed by any MAC PDU payload and CRC.

6.1.1.4 MAC subheaders and special payloads

Five types of subheaders may be present in a MAC PDU with Generic MAC header; four per-PDU subheader types and one per-SDU subheader type. The per-PDU subheaders (i.e., extended subheaders,

Table 6-7—Type field encodings for MAC signaling header type II

Type field	MAC header type (with HT/EC = 0b11)	Reference figure	Reference table
0	Feedback header, with another 4-bit type field; see Table 6-16 for its type encodings.	Figure 6-16, Figure 6-17	Table 6-15
1	Extended relay MAC Signaling Header Type II Extended M2M device MAC Signaling Header Type II (M2M)	Figure 6-20	Table 6-18 Table 6-28

FSH, FFSH, and GMSH) may be inserted in the MAC PDUs immediately following the Generic MAC header. If both the FSH and GMSH are indicated, the GMSH shall come first. In the DL, the FFSH shall always appear as the last per-PDU subheader. The ESF bit in the Generic MAC header indicates that one or more extended subheaders are present in the PDU. The extended subheaders shall always appear immediately after the Generic MAC header and before all other subheaders. All extended subheaders are not encrypted. (See 6.3.2.2.7.)

The only per-SDU subheader is the PSH. It may be inserted before each MAC SDU if so indicated by the Type field. The PSH and FSH are mutually exclusive and shall not both be present within the same MAC PDU.

When present, per-PDU subheaders shall always precede the first per-SDU subheader.

6.1.1.4.1 Downlink operation

6.1.1.4.1.1 BS operation

To change the location of a HARQ region associated with a particular Persistent Region ID, the BS transmits the Persistent HARQ DL MAP IE with a new HARQ Region definition (OFDMA Symbol offset, Subchannel offset, Number of OFDMA symbols, Number of subchannels) and sets the Persistent Region ID field of the Persistent HARQ DL MAP IE to the associated Persistent Region ID. The BS should set the allocation period to the same value for all persistent allocations associated with a particular Persistent Region ID.

6.1.1.4.1.2 MS operation

If the MS receives a persistent HARQ DL MAP IE, which includes its RCID and has the Persistent Flag set to 1, the MS shall store the Persistent Region ID field and the HARQ region definition. The MS shall determine its resource allocation using the slot offset field and the HARQ region definition. Upon receiving a subsequent Persistent HARQ DL MAP IE in a frame corresponding to the period of the persistent allocation, which has the Persistent Region ID field set to the stored Persistent Region ID, the MS shall store the new HARQ region definition and determine its resource allocation using the slot offset field and the new HARQ region definition. If the MS successfully decodes the DL-MAP and there is no Persistent HARQ DL MAP IE containing its assigned Persistent Region ID, then the MS shall use the stored location for the Persistent Region ID for its persistent allocation.

6.1.1.4.2 Uplink operation

6.1.1.4.2.1 BS operation

To change the location of a HARQ region associated with a particular Persistent Region ID, the BS transmits the Persistent HARQ UL MAP IE with a new HARQ Region definition. For uplink operation, the HARQ region is identified by the start of the UL subframe or allocation start indication information (if included).

Additionally, the BS sets the Persistent Region ID field of the Persistent HARQ UL MAP IE to the associated Persistent Region ID. The BS should set the allocation period to the same value for all persistent allocations associated with a particular Persistent Region ID.

6.1.1.4.2.2 MS operation

If the MS receives a persistent HARQ UL MAP IE, which includes its RCID and has the Persistent Flag set to 1, the MS shall store the Persistent Region ID and the HARQ region definition. The MS shall determine its resource allocation using the slot offset field and the HARQ region definition. Upon receiving a subsequent Persistent HARQ UL MAP IE in a distance in time which is multiple of the period of the persistent allocation, which has same Persistent Region ID value, the MS shall store the new HARQ region definition and determine its resource allocation using the slot offset field and the new HARQ region definition. If the MS successfully decodes the UL-MAP and there is no Persistent HARQ UL MAP IE containing its assigned Persistent Region ID, then the MS shall use the stored location for the Persistent Region ID for its persistent allocation.

6.1.1.5 Explicit path management for relay

After MR-BS discovers the topology between a newly attached MS or RS and itself, or detects a topology update due to events such as mobility, MR-BS may remove an old path, establish a new path and inform the new path information to all the RSs on the path.

When connections are established or removed, MR-BS may distribute the mapping information between the connection and the path to all the RSs on the path. The connection could be a regular connection established for an MS or a connection established for an RS (e.g., basic/primary management CID and tunnel connection). The path management procedures are specified below.

6.1.1.5.1 Path establishment, removal and update

After RS is operational, the MR-BS shall send a DSA-REQ message to distribute the path information to all the RSs on the path. The explicit path information and a uniquely assigned path ID shall be included. The CIDs to be routed on this path and their associated service flow parameters may also be included for path/ CID binding operation.

If the MR-BS decides to remove an existing path (e.g., after an MRS handover), it shall send a DSD-REQ message with the path ID. The RSs receiving the DSD-REQ message shall remove all the information related to the path.

Upon receiving the DSA/DSD-REQ, the RS performs the operation as requested in the message, and then sends the request to its subordinate RS using the primary management CID of the subordinate RS that is obtained from the explicit path information included in the DSA/DSD-REQ message, or derived from the path information obtained from previous operation. Such process is repeated until the last RS on the path (i.e., the access RS) is reached. If an intermediate RS fails to process the request, it sends a DSA/DSD-RSP directly to MR-BS with the associated confirmation code. After receiving the DSA/DSD-REQ, the access RS then sends a DSA/DSD-RSP directly back to MR-BS.

The MR-BS may aggregate multiple path management commands into one DSA/DSD-REQ message to save bandwidth. When the paths of different path management commands in the same message divaricates in an RS, the RS separates the path establishment or removal commands into different messages and transmits them to the appropriate next-hop RSs.

6.1.1.5.2 CID to path binding

A routing table that contains the mapping between a CID and one given path needs to be updated when a new tunnel (identified by a Tunnel CID) is generated between the MR-BS and an access RS, or when a new connection (identified by an individual CID) is established for an RS or MS and the new connection is not put into a tunnel. The MR-BS selects a path to carry the traffic for the new connection, and informs all the RSs on the path of the binding between the path ID and the supported CIDs by sending a DSA-REQ message to all the RSs on the specified path. Such DSA-REQ message contains the CIDs of the connections that will be routed through the specified path, the path ID and optionally the service flow parameters for the connection. If the connection is a tunnel connection, the service flow parameters are the aggregate service flow parameters for all the connections put into the tunnel.

For multicast there may be more than one path bound to a single multicast CID.

When an RS on the path receives such a DSA-REQ message, it retrieves the CIDs and path ID information and builds up the routing table that will be used to route the traffic in the future for the specified CIDs. If the SFID and the QoS requirement are also present for certain connection, the RS saves them for scheduling the traffic for the specified CID. This process is repeated until the last RS along the path is reached. The last access RS then replies with the DSA-RSP.

If the MR-BS decides to cancel an existing binding between a path and one or more CID (e.g., after MS or MRS handover to another RS, or MS deregistration, or service flow deletion), it sends a DSD-REQ message with the path ID and the affected CIDs to the associated RSs. The RSs receiving such DSD-REQ shall remove the record of the correspondent mapping.

The processing of DSA/DSD-REQ by the RSs on the path is the same as that defined in 6.1.1.5.1.

The MR-BS may aggregate multiple CID to path binding commands in one DSA/DSD-REQ message to save bandwidth. In addition, when a path is established for one or more connections, the CID to path binding/unbinding procedure can be conducted together with the path establishment procedure by sending a single DSA-REQ or DSD-REQ to save bandwidth.

6.1.1.5.3 Temporary path establishment and CID to path binding during initial network entry

When an access RS does not use tunneling, a new path is determined by the MR-BS during MS/RS network entry, relay path management for forwarding the management messages of other MS/RS network entry procedures can be conducted as defined below.

- When an SS/RS performs initial ranging, it shall follow the steps indicated by the type of system in 6.3.10.3.1.1.
- When an RS receives RNG-RSP message with RS basic CID with path information, it shall bind basic CID and primary CID contained in the message with the path ID and start a timer T65 associated with the path ID. The RNG-RSP and the SBC-RSP messages shall be forwarded to the access RS by following the same mechanism defined for the DSA message in 6.1.1.5.2. If the RS is the endpoint of the path, replace RS basic CID with ranging CID, and forward to the MS or RS originating RNG-REQ.
- If T65 expires before the RS receiving DSA-REQ, the RS shall remove the association between the path ID and basic CID and primary CID. Otherwise, the RS shall stop T65 when receiving DSA-REQ with the same path ID.

6.1.1.6 Relaying support for combined ranging and initial topology discovery

A combined initial ranging and initial topology discovery procedure can be conducted as defined below:

— When an SS/RS performs initial ranging, it shall follow the steps indicated by the type of system in 6.3.10.3.1.1.
— When an MR-BS receives an initial RNG-REQ from an SS/RS, it determines that the SS/RS sending the RNG-REQ directly attaches to MR-BS and is just one hop away.
— When an MR-BS receives a RNG-REQ message with the CID set to the basic CID of an RS, it shall verify its validity after replacing the basic CID with the ranging CID. Since the MR-BS is already aware of the topology between the selected access RS and itself, by using the same mechanism as defined in this section, it establishes the topology between the SS/RS and itself.

6.1.1.7 R-link monitoring and reporting procedure for relay path management

Computation at the MR-BS of the end-to-end route quality metric for the multihop path between the MR-BS and an RS in its cell may, optionally, be enabled. Optionally, the stability of link quality may be considered as a metric for multihop path selection. A route quality metric may be derived at the MR-BS based on link measurements obtained from a CQI fast-feedback channel (CQICH) and/or from a REP-RSP message carrying an R-link TLV.

In the case of RSs operating in centralized scheduling mode, MR-BS may allocate CQICH to an RS in its cell for reporting CQI on DL transmissions originating at RS's superordinate RS or MR-BS. Allocation of CQICH for RSs is performed in the relay zone.

In the case of scheduling RS, MR-BS and each RS in an MR cell may allocate CQICH to a subordinate RS. Allocation of CQICH for an RS is performed in the relay zone.

To report R-UL, R-DL and R-Link neighbor measurements, REP-RSP messages with R-Link TLV may optionally be used. An MR-BS may send a REP-REQ message to an RS in its cell requesting RSSI mean and standard deviation or CINR mean and standard deviation measurements. The RS may respond with a REP-RSP message containing R-Link TLV and requested measurements. MR-BS may use the reported measurements for route quality calculations, and optionally for computing the stability of a route.

6.1.1.7.1 Access-link monitoring and reporting procedure for MS path management

Computation at the MR-BS of the overall quality metric for the multihop path between the MR-BS and an MS in its cell may, optionally, be enabled. To enable routing metric computation at the MR-BS, R-link metrics shall be reported to the MR-BS in the REP-RSP message containing R-Link TLV, and access link metrics may optionally be reported to the MR-BS in the REP-RSP message containing Access-Link TLV. The REP-RSP message may be sent to the MR-BS in response to the REP-REQ message or by sending an unsolicited REP-RSP message. Access-link measurements at an MS may optionally be triggered by sending a MOB_SCN-RSP message (6.3.2.3.44) to the MS.

To enable DL CQI reporting, MR-BS may allocate CQICH to MSs in its cell. CQICH is allocated in the access zone on the access link hop, and may optionally be allocated in the relay zone on subsequent hops. Therefore, an RS may send to MR-BS CQI received from an MS in the access zone through a corresponding CQICH in the relay zone. A fast feedback region for reporting MS CQI values in the relay zone to the MR-BS may be allocated by sending, in a unicast manner, a FAST-FEEDBACK allocation IE (8.4.5.4.10) to an RS. Fast feedback slot assignments in this region shall be the same as those in the CQI fast feedback region in the RS access zone.

6.1.1.8 Path management for multicast services

The MR-BS may initiate a multicast distribution tree for the MBS. Alternatively, an MS may initiate a MBS, by sending a DSA-REQ message with the MBS service request to the MR-BS. The procedures for establishing a multicast distribution tree are as follows.

When an MR-BS initiates a MBS or receives a DSA-REQ message with the MBS request from an MS, it checks whether the requested MBS has been created. If not, the MR-BS creates a multicast distribution tree for this MBS and allocates a multicast CID (MCID) to it. The MR-BS also determines the path(s) to carry this multicast service flow. The MR-BS creates the mapping between the determined path and the MCID. The MR-BS informs all the RSs on the path of the binding between the path ID and MCID by sending a DSA-REQ message along path as specified in 6.1.1.5. Each RS along the path stores the path ID and MCID binding information for forwarding multicast data with the MCID. The MR-BS adds this path to the multicast distribution tree and records the number and identification information of the MSs using the path for multicast communications. A multicast distribution tree may consist of multiple paths.

If the multicast distribution tree has been created and an MCID has been allocated to this MBS, the MR-BS determines the path to carry this multicast service flow. If the path is not in the multicast distribution tree, the MR-BS creates the binding between the determined path and the MCID. The MR-BS distributes the path and MCID binding information to all the RSs along the path. The MR-BS adds this path to the multicast distribution tree and records the number and identification information of the MSs using the path for multicast communications. If the path is already in the multicast distribution tree, the MR-BS simply updates the number and identification information of the MSs using the path for the MBS in the multicast tree.

A path may be removed from a multicast distribution tree by the MR-BS. When an MS needs to leave the multicast service, the MS sends a DSD-REQ to the MR-BS to request removing it from the multicast service flow. The MR-BS first updates the number and identification information of the MSs that are receiving the MBS along the path to this requesting MS. The MR-BS determines whether the path can be removed from the tree MCID. If no more MSs use this path for the MBS, the path may be removed from the multicast distribution tree. Otherwise, the path shall not be removed from the multicast distribution tree. If the path is removed from the tree-MCID then the MR-BS removes the binding between the path and the MCID by sending a DSD-REQ along path as specified in 6.1.1.5.

When the parameters for a multicast service flow change, an MR-BS or MS may also send a DSC-REQ message to update these changes. All the RSs in the multicast distribution tree of the MBS are informed of these changes. This is achieved by MR-BS sending a DSC-REQ message to all of the RSs along all the paths in the multicast distribution tree as specified in 6.1.1.5.

6.1.1.9 Neighbor path metric for relay

An end-to-end metric of the path between an RS and its MR-BS may be reported in the MR_NBR-INFO message. The end-to-end metric is carried in the form of a TLV described in 11.4.

6.1.2 Relay station neighborhood discovery

In order to perform RS neighborhood discovery, the RS may obtain its neighbor information using MR_NBR-INFO message (6.3.2.3.61). Then, it shall scan the preamble or, if present, the R-amble transmitted by the existing MR-BS(s) or RS(s), and send the measurement report to the MR-BS using the RS _NBR-MEAS-REP message (6.3.2.3.64).

As not every RS will transmit its own preamble and the existing RSs in an MR network need to perform measurement over the preamble, the MR-BS may instruct the RSs to perform complete neighborhood discovery/measurement, as described further in this subclause.

The neighborhood discovery/measurement can be used in different stages of operation, during initial network entry, during periodic intervals or whenever an MR-BS requires this information. There are two methods to carry out neighborhood measurements:

a) Repeatable R-amble transmission and monitoring scheme

b) Preplanned R-amble transmission and monitoring scheme

6.1.2.1 Repeatable R-amble transmission and monitoring scheme

The transmission and monitoring frames for the R-amble are specified by the MR-BS in the RS_Config-CMD message (6.3.2.3.63). Each RS finds the R-amble sequences from the parameters provided in the RS_Config-CMD message. More details are provided in 8.4.6.1.1.4. The measurement results shall be sent to the MR-BS by using the RS_NBR_MEAS-REP message (6.3.2.3.64) or using any other appropriate measurement report messages, periodically or as requested by the MR-BS.

6.1.2.2 Preplanned R-amble transmission and monitoring scheme

In this scheme, the MR-BS first sends the RS_Config-CMD message to the RSs that will be involved in the neighborhood measurement mechanism, and the message is either broadcast, multicast or unicast to these RSs. The 8 LSB bits of frame number shall be set to synchronize the starting time to the RSs. If the RSs involved in this mechanism are in a different MR-cell, each of the Start Frame Numbers sent by each MR-BSs shall be synchronized to the same frame time. The Prefix shall be set to “00” and attach the transmit/receive pattern for each iteration. The pattern is indicated by Amble Index, which are the indexes instructed in the RS_Config-CMD message.

Second, the stations follow the instruction to transmit/receive the R-amble at the designated frames in each iteration.

Third, the RSs report their RSSI or CINR measurement results with corresponding amble index by RS_NBR_MEAS-REP to MR-BS.

The preplanned R-amble transmission opportunities are identified by Monitoring Duration and Interleaving Interval for each iteration. An example is given in Figure 6-7, where the Duration = 2, Interleaving Interval = 3 and the Iteration = 2. When the Iteration is more than one, the pattern for each iteration shall be carried in this message. After the last iteration, the RSs shall report the measurement results by RS_NBR_MEAS-REP message defined in 6.3.2.3.64.

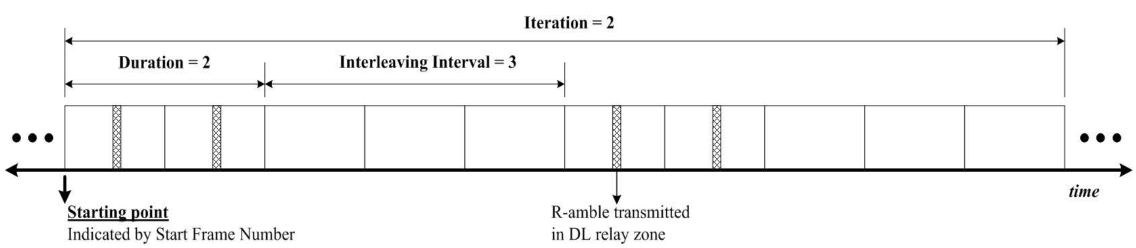


Figure 6-7—R-amble transmission pattern as per the preplanned scheme instructed by MR-BS

6.1.3 Interference measurement in MR systems

This subclause describes a measurement and reporting procedure with supported messaging mechanism to estimate the interference level in MR network.

6.1.3.1 Interference prediction by RS neighborhood measurement

In order to predict the interference or SINR of the radio links for different MR network topology and radio resource reuse pattern, the following prediction method may be considered based on the RSSI reported by RS_NBR_MEAS-REP message (see 6.3.2.3.64):

a) Prediction of the interference plus noise power received by station #i: The interference plus noise may be the summation of (1) the thermal noise plus background interference power received by station #i and (2) the signal power not intended to be received by station #i but transmitted by the same radio resource.

b) Prediction of the received SINR of station #i: The SINR may be the following ratio:

   1) The total signal power destined to station # i to

   2) The interference plus noise power obtained in step a)

6.1.3.2 Optional interference detection and measurement by RS sounding

As an option, the path loss and interference between multiple RSs and the MR-BS can be estimated using the UL sounding mechanism (8.4.6.2.7). In order to predict the interferences between different RS cells, the MR-BS needs to collect the interference measurements from the related RSs and possibly from their associated MSs. The interference can be estimated by having one or multiple RSs or MSs transmit UL sounding signals at specific sounding zones and having the other related RSs and BSs measure the related CINR or RSSI of the received sounding signals. An MR-BS may construct a multicast group within its MR-cell that uses a multicast CID to represent the group of the RSs that participate in the interference measurement. Alternatively multiple unicast messages can be sent. This group is called RS_interference_measurement group and shall be setup before any measurement of UL sounding signals by the group. The interference measurement procedure is controlled by the MR-BS for intra-MR-cell interference measurement. For interference measurement performed across clusters of MR-cells, a network control entity is required to coordinate the measurement activities across the MR-cells.

The interference measurement operation within an MR cell is as follows: the MR-BS sends an REP-REQ message to its RS_interference_measurement group. The REP-REQ carries the reporting period, start frame number and the type of measurement reports (either CINR or RSSI). MR-BS sends UL_Sounding_Command_IE to RS_interference_measurement_group as a multicast burst. The MR-BS shall also transmit PAPR_Safety_and_Sounding_Zone_Allocation_IE. When an RS receives such an REP-REQ, it expects to hear the PAPR_Safety_and_Sounding_Zone_Allocation_IE (8.4.5.4.2) starting from the start frame number until the time indicated in the TLV of report period in the REP-REQ message. If an RS specified by the multicast CID in PAPR_Safety_and_Sounding_Zone_Allocation_IE, and indicated by CID in the UL_Sounding_Command_IE, the RS shall transmit the sounding signal at the specified symbol and subcarriers as instructed by the MR-BS. Otherwise, the RSs belonging to the RS_interference_measurement_group shall measure the sounding signals if they are not scheduled to transmit sounding signals in the same symbol. The scheduling of RS PAPR_Safety_and_Sounding_Zone_Allocation_IEs by MR-BS is implementation specific.

The sounding signal sent from different RSs and different MSs can be multiplexed in the same sounding zone. This can be done when the MR-BS or RS serving the MS sends to the MS a separate UL_Sounding_Command_IE with instruction of the sounding signal that may be sent by the MS. The measurement and reporting procedure of the MS UL sounding signal by the RSs in the RS_interference_measurement_group remains the same as the RS sounding procedure. The average measurement results are reported. After an MR-BS receives the REP-RSP from all the RSs in its RS_interference_measurement_group, it shall forward it to the network control entity.

When interference across different MR-cells needs to be estimated, the above UL sounding procedure shall be conducted with the coordination of a network control entity that controls multiple BSs. In this case the network control entity shall coordinate the multiple BSs to send PAPR_Safety_and_Sounding_Zone_Allocation_IE and UL_Sounding_Command_IE to their respective RS_interference_measurement_groups and MSs for conducting UL sounding measurement across MR-cells. When the RS sounding signal is to be sent by an RS in one of the MR-cells, the same PAPR_Safety_and_Sounding_Zone_Allocation_IE and UL_Sounding_Command_IE shall be duplicated and sent in the other MR cells, so the RSs in these other cells shall conduct measurement on the UL sounding signal.

6.1.4 RS broadcast message relaying

For a non-transparent RS operating in centralized scheduling mode, the MR-BS shall generate and send RS_Access-MAP message to the RS over the basic connection of the RS. When the RS receives the RS_Access-MAP message, RS shall compose FCH and possibly the associated MAPs such as DL/UL-MAP message, Compressed DL/UL-MAP, SUB-DL-UL-MAPs message and HARQ MAP message, etc., based on the RS_Access-MAP message. In case of more than two hops, the MR-BS shall generate and send RS-Relay-MAP message to RS over the basic connection of the RS. When RS receives RS-Relay-MAP message, RS shall compose R-FCH and R-MAP based on the RS_Relay-MAP message.

Upon receiving the DCD/UCD message with RS primary CID, as shown in Figure 6-8, or RS multicast management CID, the RS shall acknowledge the reception of DCD or UCD messages over primary management connection by sending an acknowledgment header (see 6.3.2.1.3.2.2.3) or MR Generic-ACK message (see 6.3.2.3.79). The Transaction ID of the MR Acknowledgment header or 8 LSB of the transaction ID of the MR_Generic-ACK message shall be set to the Configuration Change Count of the DCD or UCD message. There shall be one MR Acknowledgment header or MR_Generic-ACK message per DCD/UCD message. The MR-BS may retransmit the DCD/UCD message if an acknowledgment header or message is not received at the expiration of T61 timer.

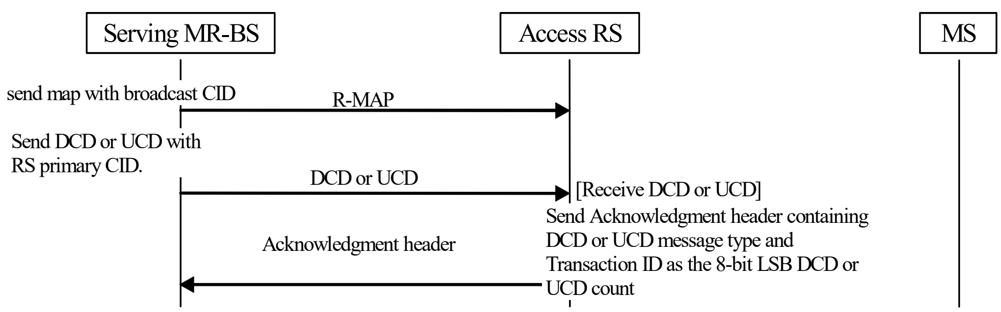


Figure 6-8—Relaying DCD/UCD procedure

For a centralized scheduling mode RS, as shown in Figure 6-9, after receiving an acknowledgment header from the RS corresponding to reception of the DCD/UCD, the MR-BS shall periodically allocate unsolicited bandwidth to the RS to enable it to broadcast the DCD/UCD message over the access link by using an RS_BW-Alloc_IE in the RS-Access-MAP message. To enable the RS to send the DCD/UCD message with fragmentable broadcast CID, if the RS_BW-Alloc_IE is lost, the RS shall request bandwidth by using an RS BR header after the timer T69 expires. For a scheduling RS, the RS shall autonomously broadcast DCD/UCD with fragmentable broadcast CID.

When the DCD and UCD messages are generated by the MR-BS, the MR-BS shall send DCD and UCD messages to either one RS with its primary management CID or multiple RSs with RS multicast management CID. In RS grouping, the superordinate station of the group shall use the multicast CID of the RS group to send RS RS_Access-MAP message.

In MR networks, each RS would be assigned to different DCD/UCD messages with the same configuration change count. In this case, each DCD/UCD message may be separated into the common part and the specific

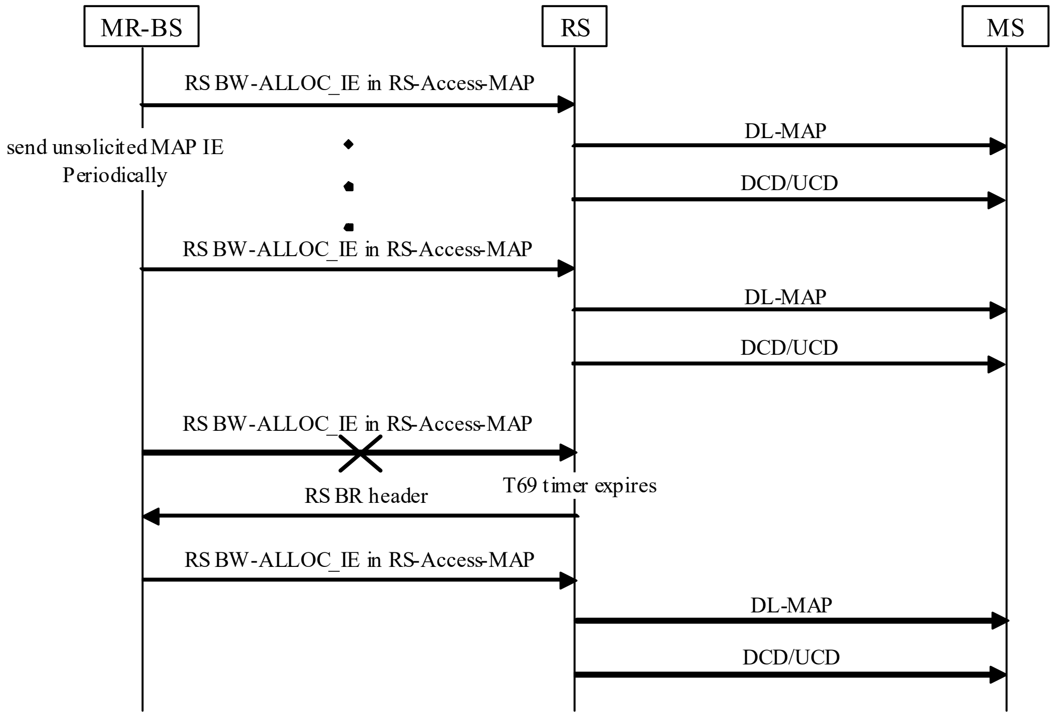


Figure 6-9—DCD/UCD broadcasting procedure with an RS operating in centralized scheduling mode

part before fragmentation. The common part shall be packed with multicast management CID, and the receiving RS shall buffer the common part until receiving the specific part that shall be packed as a new DCD/UCD message with the RS primary management CID. In the specific part, the message type field, reserved field and configuration change count field shall be the same as the associated common part. The receiving RS shall restructure the common part and the associated specific part to a complete DCD/UCD message, and then broadcast the message with Fragmentable Broadcast CID.

6.1.5 RS de-registration

In MR networks, an RS may end its service and be removed from the networks. During the RS de-registration process, all subordinate MSs of the RS shall be transferred to another RS or MR-BS prior to RS deregistration. An RS may transmit DREG-REQ to an MR-BS so that it initiates the de-registration procedure and requests handover of all its subordinate MSs. Upon receiving DREG-REQ, the MR-BS decides whether it allows the RS de-registration. If the request is accepted, the MR-BS may transmit DREG-CMD to inform the acceptance and start BS-initiated handover process for the requested MSs. After handover procedures between the MR-BS and the RS's subordinate MSs are completed, the MR-BS informs the RS that handover is completed by transmitting DREG-CMD. Upon receiving DREG-CMD, the RS starts deregistration process. The MR-BS may initiate the de-registration process by transmitting an unsolicited DREG-CMD message.

If the MR-BS rejects the request (Action Code = 0x06), the MR-BS informs the RS rejection of the request by transmitting DREG-CMD. Upon receiving DREG-CMD with rejection information, the RS continues normal operation. After REQ-duration expires, the RS retransmits DREG-REQ to the MR-BS.

6.1.6 MR location information

In order to assist RS neighborhood discovery, MR-BS may send an MR_LOC-REQ message to the RS. Upon receiving the MR_LOC-REQ message, the RS shall report its location information by sending an MR_LOC-RSP message to the MR-BS. If the MR_LOC-REQ message containing the report type field 0b01, RS shall periodically send an MR_LOC-RSP message to the serving MR-BS every time interval defined by "Report period."

In order to obtain the location information of neighbor stations, an RS may send an MR_LOC-REQ message to the MR-BS. Upon receiving the MR_LOC-REQ message, MR-BS shall report the location information of neighboring stations by sending an MR_LOC-RSP message to the RS.

The message sequence charts (Figure 6-10, Figure 6-11, and Figure 6-12) describe the RS location request and report that shall be followed by compliant RSs and MR-BSs.

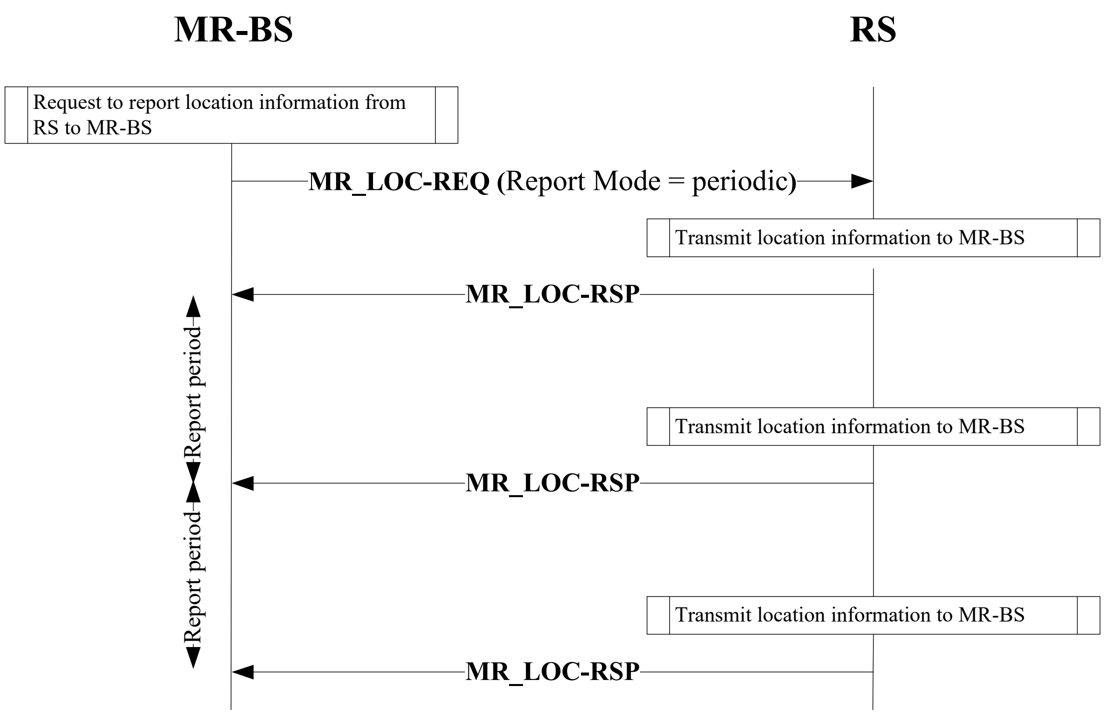


Figure 6-10—Relay location report (part 1)

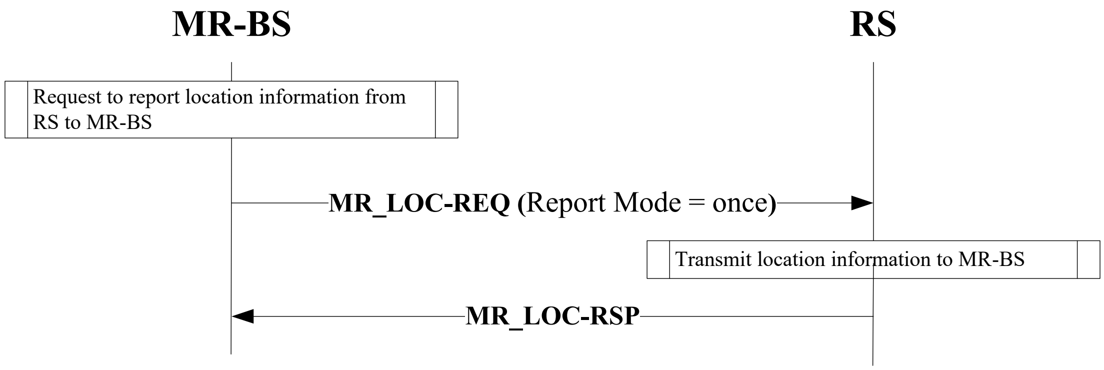


Figure 6-11—Relay location report (part 2)

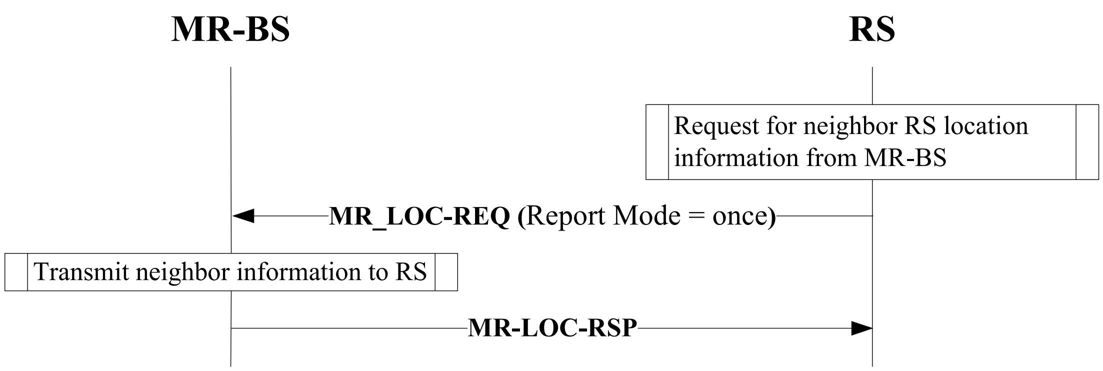


Figure 6-12—Relay location report (part 3)

6.1.7 RS grouping

The RS grouping method may be used to enable the following operation scenarios:

- — The operation of an RS in a location where no segment allocation is possible due to interference from all other segments
- — The operation of MSs in a region served by multiple short-range RS without incurring high handover signaling disadvantages
- — The operation of mobile RSs with dynamic adjustments of coordinated transmission and reception
- — Macro-diversity within an MR cell applied to individual SSs and individual connections

The grouping of RS and the coordinated operation of RS in a group is determined and controlled by its superordinated station or MR-BS.

- — The members of the group are assigned a multicast CID as the RS group ID. The multicast CID is the same for all members in the group. Thus, an RS can be managed individually or as a group using the basic CID and this multicast CID. These IDs are unique within the associated MR-BS. The association of an RS to an RS group is configured using RS_Config-CMD message (see 6.3.2.3.63).

The multicast CID of the RS group is used for messages that are addressed to all the members of the RS group, and the basic CID is used for the individual members of the RS group. When the MS performs network entry into an RS group, the MS network entry procedure outlined in 6.3.10.3.1.1 shall be followed. When the MS moves within the RS group, the MS movement procedure outlined in 6.1.7.1 shall be followed. For a transparent (or non-transparent) RS group all the other procedures follow the procedures for the transparent (or non-transparent) RS. For example, if the RS group is non-transparent, the MAPs for the individual RSs shall be received by the RSs according to the associated procedure defined for a non-transparent RS using the multicast CID of the RS group (see 6.1.4).

— The RS group has a superordinate station (non-transparent RS or MR-BS) that is the superordinate station of all RSs in the group. All the RSs in the RS group shall either transmit the same preamble, FCH and MAPs or they all do not transmit any preamble, FCH or MAPs. The MR-BS or the superordinate station carries out resource control and scheduling for the RS group. The non-transparent RS group transmitting with a preamble different from superordinate station's preamble may be assigned a BSID parameter value. The RS group shall serve only MSs. The radio resources may be shared by the RSs members of the RS group for data burst transmission. The RSs members of the non-transparent RS group shall transmit with the same EIRP parameter value, decided by the MR-BS.

— Removal of an RS from the group: During normal operation of the RS group, each RS continues to monitor the radio environment (e.g., the interference). One example is that for an RS that is located at the edge of the group coverage area, it could detect strong segment interference from other nearby RS(s) or RS groups. When this happens, the MR-BS can reconfigure the RS(s) operate in a different RS operational mode using the TLV described in 11.25.1. For RS grouping, DL/UL reciprocity relied on by SS in the open loop power control may not hold. In this case, the SS power control correction term in Equation (8-148) may be used to set SS UL TX power to an appropriate level. Computation of the correction term is implementation specific.

— Addition of an RS to an existing group or forming a new group: An RS, at network entry, can a) operate on its own, i.e., it is assigned a dedicated preamble index (implying the segment), b) form a new group or c) join an existing group. The RS may perform measurements such as radio signals from the neighbor stations (the RSs or the MR-BS), and then report to the MR-BS the preferred preamble index selected by the RS (implying the segment). The MR-BS replies by either confirming the preamble sequence index selected by the RS or assigning a different one, indicating whether it should transmit the preamble, and at the same time, providing the corresponding RS group ID. The MR-BS may assign one of the members as the designated RS based on the measured signal qualities at the members. The designated RS may be responsible for certain procedures such as measurement reporting as specified elsewhere in this standard.

— For communication with RS groups, tunnel-based or CID based forwarding can be applied. If the MS/SS is served by an RS group, the tunnel connections shall be established between the MR-BS and the superordinate station of the RS group i.e., the superordinate station is considered as the access station for the tunnel connection that is the end-of-tunnel in DL and beginning-of-tunnel in UL.

— Data forwarding within RS group: For DL, the members of an RS group may be configured to forward traffic data for only specific subordinate terminal stations. This may be done on a per-connection basis. In this way, by specifying scheduling times, two RSs belonging to the same RS group may transmit to two different MSs/SSs at the same time. In addition, transmissions may be scheduled such that multiple RSs in the RS group may transmit to the same MS to exploit macro-diversity. This scheduling may be achieved for RSs operating in centralized scheduling mode by keeping CID list associated with each RS. Each RS would look for the data bound to its subordinated stations or data coming from the subordinate stations in the uplink and forward in the assigned times indicated in the MAP. The list may be updated by the RS_Member_List_Update message defined in 6.3.2.3.77 or DL_Transmit_Reference_IE defined in 6.3.2.3.80. If the MR-BS does not receive MR_Generic-ACK message from all RS group members designated in the RS_Member_List_Update message after the Frame Action Number, DL_Transmit_Reference IE should be used to encode the forwarding rules for the RS group members. The RS group members shall follow the forwarding rules encoded in DL_Transmit_Reference IE, if present, instead of its original forwarding rules to forward the data to the MS. If the RS_Member_List_Update message is not provided by the superordinate station to the RSs members of the RS group, then all RSs members of the group shall transmit according to the MAPs received, without using the per CID transmission. Data forwarding may also follow the procedure defined in 6.3.15.7 for DL HARQ for RS groups.

— For the UL, the UL signaling can be designed such that several member RSs may receive data from multiple MS at the same time. Data forwarding may also follow the procedure defined in 6.3.15.7 for UL HARQ for RS groups. This scheduling may be achieved for RSs operating in centralized scheduling mode by keeping an MS list or CID list associated with each RS and forwarding those messages in a specified resource unit (time and frequency). When the MS is same and the resources are the same, it is equivalent to macro-diversity. When the resources are same but the MSs are different, it is equivalent to parallel transmission occurring at different locations.
— Each time a handover occurs or a new terminal joins an RS group, the list of CIDs for the RSs in the group may be updated.

6.1.7.1 MS movement among access stations that share the same BSID

The stations that share the same BSID (i.e., the non-transparent RSs that transmit the same preamble, FCH or MAPs or transparent RSs that have the same BSID), shall perform measurement of MS signal quality to assist MS movement among stations.

The stations shall measure the signal quality (RSSI, CINR), Timing Adjustment (TA), power and Frequency Adjustment (FA) for each active MS served by these stations to support MS mobility among these stations. All RSs shall use an MR_RNG-REP message to provide MR-BS/superordinate RS with the selected report metrics (RSSI and/or CINR, TA, FA and power adjustment) for each active MS when needed.

Two modes of operation are described in 6.1.7.1.1 and 6.1.7.1.2. The mode of operation and related reporting parameters are configured in RS_Config-CMD in 6.3.2.3.63.

An MR-BS/superordinate RS may select a new designated RS based on the measurement results and use RNG-RSP to adjust the timing and the power level of the MS, in order to fulfill the handover procedure. An MR-BS/superordinate RS may use the RS_Member_List_Update management message to notify the RSs of the changes regarding data forwarding status for the specified MSs.

6.1.7.1.1 Mode 1

For this mode of operation, only those RSs that are marked as designated RSs shall automatically report the measurement results to MR-BS/superordinate RS in an event-triggered or periodic way, for the basic CID of MSs provided in the RS_Member_List_Update.

For event-triggered reporting, the designated RS shall send an MR_RNG-REP message to report its measurement results if the selected triggering condition is met. The trigger condition could be RSSI, CINR, or TA and is specified in RS_Config-CMD message. For periodic reporting, the designated RS shall send an MR_RNG-REP message every REP_INT that is specified in RS_Config-CMD message and the MR-BS/superordinate RS shall periodically allocate uplink resource for the designated RS to report the latest measurement result for each active MS.

In Mode 1, non-designated RSs shall report their measurement results only if the RS_MOB_MEAS-REQ message is received. The MR-BS/superordinate RS shall send RS_MOB_MEAS-REQ message to request all or part of RSs in the same RS group to report their measurement results for a specific MS. The MR-BS/superordinate RS shall allocate uplink resource for the selected non-designated RSs to send their MR_RNG-REP messages at the frame specified in RS_MOB_MEAS-REQ.

6.1.7.1.2 Mode 2

For this mode of operation, an RS may report the measurement results to an MR-BS/superordinate RS using an MR_RNG-REP message in an event-triggered way as indicated below.

If the MR-BS/superordinate RS provides the thresholds values for triggering, the RS shall send the measurement report to MR-BS/superordinate RS in the following instances:

— When the measured RSSI/CINR crosses above RSSI/CINR_T_ADD[i] (i=0,...,NRSSI-1/NCINR-1).
— When the measured RSSI/CINR crosses below the RSSI/CINR_T_DEL[i] (i=0,...,NRSSI-1/NCINR-1).
— When the current measured TA exceeds TA_DIFF and the RS has the CID of the MS included in the RS_Member_List_Update message.

If the MR-BS/superordinate RS does not provide the threshold values for adding/removing an MS, the RS uses its own threshold values to decide when to report the measurement to MR-BS/superordinate RS.

6.1.8 Support of multicast operation for M2M applications

A BS may provide a multicast service for group of M2M devices that share a downlink multicast service flow. The BS shall initiate the establishment of a service flow using the DSA procedures. During the establishment of the service flow, the service flow is assigned an M2MCID, which uniquely identifies the service flow. The M2M device shall retain these identifiers in idle mode (see 6.3.1). The BS shall provide the mapping between the service flow and the M2MCID during the DSA signaling and may modify this mapping using the DSC procedures or by using M2MCID Update TLV during network reentry.

6.1.8.1 M2M multicast operation in idle mode

A BS may provide a multicast service for M2M devices in idle mode with or without requiring network reentry of the M2M devices. Before a BS sends DL multicast data, the BS shall transmit the paging message including the multicast traffic indication to the M2M devices during the paging listening intervals of the M2M devices. If an M2M device receives the paging message indicating multicast traffic reception without network reentry during its paging listening interval and the paging message does not include the Multicast transmission start time TLV, the M2M device shall start receiving the DL multicast data without the idle mode termination.

The Multicast transmission start time TLV may be included in the paging message in order to indicate when the DL multicast data is sent by the BS. The value of Multicast transmission start time TLV shall be less than the start time of the next paging listening interval of the M2M devices receiving the MOB_PAG-ADV message. The M2M device may power down until the frame indicated by the Multicast transmission start time TLV in the MOB_PAG-ADV message.

When the multicast data transmission ends, the BS shall notify the end of multicast data transmission to the group of M2M devices by sending the MOB_MTE-IND message. Upon receiving the MOB_MTE-IND message, the M2M devices may enter the paging unavailable interval as specified in 6.3.22.4.

In order to receive the M2M multicast data during idle mode M2M devices in idle mode shall use M2M Multicast Traffic Reception timer. If Multicast transmission start time TLV is included in the MOB_PAG-ADV message indicating the multicast traffic reception (Action code = 0b10), M2M devices receiving the MOB_PAG-ADV message shall start the Multicast Traffic Reception timer at the frame indicated by the Multicast transmission start time TLV. Otherwise, the M2M device shall start the Multicast Traffic Reception timer when the M2M device receives the MOB_PAG-ADV. The M2M device shall reset this timer whenever the multicast data is received and stop the timer when it receives the MOB_MTE-IND message. If the M2M Multicast Traffic Reception timer expires, the M2M device shall enter the paging unavailable interval as specified in 6.3.22.4.

6.1.9 Abnormal power down

When an abnormal or involuntary power down has occurred, an M2M device may attempt to report the abnormal power down event.

6.1.9.1 Abnormal power down reporting in normal operation

If the M2M device is in normal operation with uplink bandwidth already allocated and available, then it may use the available bandwidth to send an M2M Abnormal Power Down Report header (as defined in 6.3.2.1.3.2.3.1).

If the M2M device does not have available UL bandwidth, then it may use the procedure defined in 6.3.6 to request bandwidth. Upon receiving bandwidth allocation it may send the M2M Abnormal Power Down Report header.

The M2M device may start its Abnormal Power Down Confirmation timer at the transmission of the M2M Abnormal Power Down Report header in order to wait for Abnormal Power Down Confirmation signaling header. If the M2M device has not received the M2M Abnormal Power Down Confirmation header until the Abnormal Power Down Confirmation timer expires, it may restart the abnormal power down reporting procedure.

6.1.9.2 Abnormal power down reporting in idle mode

When an abnormal power down occurs, an M2M device in idle mode that has been configured to report abnormal power down events and that has a valid security association with the preferred BS shall select a ranging opportunity within a backoff window starting at the next frame. The M2M device shall set the back-off window size as large as possible, yet such that it is guaranteed to complete the abnormal power down reporting procedure before its power is depleted. The M2M shall select the ranging opportunity, t, where $t = 1, \ldots, b$, within the backoff window according to the following cumulative distribution function:

$$F(t) = \frac{N^{t/b} - 1}{N - 1}$$

where b is the backoff window size and N is the value of the configurable system parameter Abnormal Power Down Ranging Opportunity Selection parameter (see Table 10-1). At the selected ranging opportunity, the M2M device shall transmit the Abnormal Power Down Ranging Code, which is also a configurable system parameter (see Table 10-1).

The BS, upon receiving the ranging code, may include a CDMA Allocation IE in the next frame identifying the M2M device and provide an allocation sufficiently large to allow the M2M device to transmit a RNG-REQ message including a Ranging Purpose Indication TLV and the CMAC/HMAC Tuple. Upon receiving this allocation, the M2M device shall transmit a RNG-REQ message including a Ranging Purpose Indication TLV with bits 5–7 set to 001 (power outage) and a valid HMAC/CMAC Tuple. The M2M device shall not repeat sending of a ranging code if it does not receive an allocation from the BS.

If the target BS evaluates the HMAC/CMAC Tuple as valid and can supply a corresponding authenticating HMAC/CMAC Tuple, then the target BS may reply with a RNG-RSP message including the Location Update Response TLV and HMAC/CMAC Tuple completing the abnormal power down reporting process.

6.1.10 M2M Short Data Burst transmission

If an M2M device receives a bandwidth allocation that is sufficient for piggybacking M2M Short Data Burst contents in a RNG-REQ message during network reentry, it may send the RNG-REQ message with a piggybacked M2M Short Data Burst with SFID for Short Data Burst.

If the data is received successfully, the BS shall send a RNG-RSP message with an M2M Short Data Burst Confirmation TLV. This concludes the Short Data Burst transaction.

If an M2M device receives a bandwidth allocation that is not sufficient for piggybacking M2M Short Data Burst contents, it may include an M2M Bandwidth Request combined with the related SFID in a RNG-REQ message during network reentry. If the allocation allows for it, it may additionally include the Bandwidth Request Size in the RNG-REQ message. If the BS receives the RNG-REQ message with an M2M Bandwidth Request, the BS shall include M2M Bandwidth Request ACK in the RNG-RSP message. If the BS accepts the bandwidth request, the BS shall allocate UL bandwidth to the M2M device after network reentry completion.

To transmit short data DL bursts, the BS may include an M2M Short Data Burst TLV in a RNG-RSP message when the action code of MOB_PAG-ADV indicates location update.

For DL short data burst transmission, the BS should send a Basic CID and a Temp CID Timer in a RNG-RSP message. When the M2M device successfully receives a RNG-RSP message with an M2M Short Data Burst, a Basic CID, and the Temp CID Timer, it shall set T3 timer (see Table 10-1) and wait for bandwidth allocation on the Basic CID. If UL bandwidth is allocated before expiration of T3 timer, the M2M device transmits a RNG-REQ message containing an M2M Short Data Burst Confirmation TLV. If T3 timer expires, the M2M device shall perform bandwidth request procedure to transmit a RNG-REQ message containing an M2M Short Data Burst Confirmation TLV.

6.2 Procedures for uncoordinated coexistence

This subclause describes enhancements in support of operation in license-exempt bands. First, general concepts are described, after which details of support for uncoordinated coexistence mechanisms are presented. The mechanisms detailed are as follows:

— Coexistence with *specific spectrum users* (SSUs) (6.2.1.2), often termed Dynamic Frequency Selection (DFS) (ITU-R F.1499 [B51], ETSI EN 301 893 [B17]).
— Coexistence with *non-specific spectrum users (non-SSUs)* (6.2.1.3). Dynamic Channel Selection (DCS) (6.2.1.3.2) is a realization.
— Uncoordinated Coexistence Protocol (UCP) (6.2.1.3).

Mechanisms are related to bands containing SSUs and those containing non-SSUs. It shall be left to regulation to mandate such mechanisms for a particular band.

6.2.1 Uncoordinated coexistence mechanisms

6.2.1.1 Overview

This subclause details a number of uncoordinated coexistence mechanisms. Whether these features are mandatory or optional is governed by adherence to profiles described in 12.8.1.

The mechanism overviewed in 6.2.1.2 is intended to protect *specific spectrum user*s (SSUs) where regulation mandates. Subclause 6.2.1.3 provides a general uncoordinated coexistence mechanism suitable, for example, in bands where no mandatory coexistence behavior is required.

In bands containing both SSUs and non-SSUs, it can be expected that a combination of schemes presented in 6.2.1 will be required to provide mandatory protection for the SSUs and as well as a means of coexistence with non-SSUs.

Subclause 6.2.1.3 provides a UCP to provide a further mechanism to allow operation in license-exempt bands for non-SSUs.

Upon system startup, the BS shall choose a suitable channel in which to operate. Channel selection shall depend upon the requirements for operation in a given band. If the band contains SSUs, the BS shall use a protocol termed in this subclause "DFS" to attempt to find a channel free of SSUs; this protocol is described in 6.2.1.2. If the band contains only non-SSUs (IEEE 802.16 or non-IEEE 802.16), the BS uses the DCS protocol to find the best channel for operation; this protocol is described in 6.2.1.3. In certain regulatory regimes where SSUs are not present, it may be sufficient for the choice of channel to be able to be performed manually with coordination between operators as needed. If the band contains both SSUs and non-SSUs (IEEE 802.16 or non-IEEE 802.16) then both DFS and DCS protocols are used together. The DFS protocol is used to avoid interference to SSUs by vacating the channels on which SSUs are detected, and additionally DCS is used to select the best channel of the set of channels in the band that are cleared for operation by DFS.

The BS shall continue to perform DFS and DCS operation, as required, selecting the most appropriate channels based on the prevailing conditions and reacting to reported measurements from the SSs. For the case where SSUs are detected on a channel then the DFS protocol shall attempt to select an alternative channel. For the non-SSU (IEEE 802.16 or non-IEEE 802.16) detection of the BS shall use the DCS protocol in order to select an alternative channel, previously checked to be clear of SSUs. For improved coexistence with other uncoordinated IEEE 802.16 systems, the BS shall claim a Master frame (15.4.1.2) sequence as described in 6.2.1.3.3 and shall use the described mechanism to share the channel with up to two other IEEE 802.16 systems on a minimally interfering basis.

This clause describes the use of a UCP. The UCP is designed to use passive cognitive radio techniques to allow co-channel coexistence between multiple IEEE 802.16 systems.

6.2.1.2 Uncoordinated coexistence with specific spectrum users (SSUs)

6.2.1.2.1 Overview

Procedures are defined in this subclause that may be used when the IEEE 802.16 system is sharing a frequency band with another system or service to reduce interference to and from other systems, to facilitate coexistence of systems, or to address other reasons. These procedures generally involve mechanisms to facilitate the detection of other users and to avoid and prevent harmful interference into other users. Within these procedures for certain sharing scenarios, regulatory requirements specify that DFS (as defined by ITU-R M.1652 [B52]) shall be used to facilitate sharing with SSUs identified by regulation. A specific spectrum user is a user from a service specifically identified by regulation as requiring protection from harmful interference. When DFS is mandated by regulatory requirements, it shall be implemented according to this specification.

Further, the use of a channel selection algorithm may be required, which results in uniform channel spreading across a minimum number of channels. This specification is intended to be compliant with regulatory requirements such as ECC/DEC/(04)08 [B11]. The timing and threshold parameters used for DFS are specified by each regulatory administration.

The procedures specified in this subclause provide for the following:

- Testing channels for other users including SSUs (6.2.1.2.2)
- Discontinuing operations after detecting other users including SSUs (6.2.1.2.3)

- Detecting other users including SSUs (6.2.1.2.4)
- Scheduling for channel testing (6.2.1.2.5)
- Requesting and reporting of measurements (6.2.1.2.6)
- Selecting and advertising a new channel (6.2.1.2.7)

6.2.1.2.2 Testing channels for other users (including specific spectrum users)

A BS or SS implementing these procedures shall not use a channel that it knows contains other users or has not been tested recently for the presence of other users. A BS shall test for the presence of other users based on timing parameters and values that may be set locally or, in the case of DFS and the detection of specific spectrum users, may be defined in regulation. Timing parameters include the following:

- **Startup Test Period** before operating in a new channel if the channel has not been tested for other users for at least **Startup Test Period** during the last **Startup Test Valid.**
- **Startup Test Period** before operating in a new channel if a channel was previously determined to contain other users during the last **Startup Test Valid.**
- **Operating Test Period** (where the period is only accumulated during testing) of each **Operating Test Cycle** while operating in a channel. Testing may occur in quiet periods or during normal operation.

An SS may start operating in a new channel without following the above start-up testing procedures if

- The SS moves to the channel as a result of the receipt of a Channel Switch Announcement from the BS.
- The SS is initializing with a BS that is not currently advertising, using the Channel Switch Announcement, that it is about to move to a new channel.

A BS may start operating in a new channel without following the above start-up testing procedures if it has learned from another device by means outside the scope of this standard that it is usable.

6.2.1.2.3 Discontinuing operations after detecting specific spectrum users

If a BS or an SS is operating in a channel and detects SSUs, it shall discontinue any transmission of the following:

- MAC PDUs carrying data within **Max Data Operations Period**.
- MAC PDUs carrying MAC management messages within **Management Operations Period.**

The values of the above parameters may be set locally or, in the case of DFS, may be defined in regulation.

The detection of a *specific spectrum user* shall mean the channel is unusable for a **Channel Exclusion Period.** The channel is marked as an Excluded Channel for a period defined by regulation.

6.2.1.2.4 Detecting specific spectrum users

Each BS and SS shall use a method to detect SSUs operating in a channel that satisfies the regulatory requirements, where applicable. The particular method used to perform detection is outside the scope of this standard.

6.2.1.2.5 Scheduling for channel testing

A BS may measure one or more channels itself and may request any SS to measure one or more channels on its behalf, either in a quiet period or during normal operation.

To request the SSs to measure one channel, the BS shall include in the DL-MAP a Channel Measurement IE as specified in 8.3.6.2.3. The BS that requests the SSs to perform a measurement shall not transmit MAC PDUs to any SS during the measurement interval. If the channel measured is the operational channel, the BS shall not schedule any UL transmissions from SSs to take place during the measurement period.

Upon receiving a DL-MAP with the Channel Measurement IE, an SS shall start to measure the indicated channel no later than **Max. Channel Switch Time** after the start of the measurement period. An SS may stop the measurement no sooner than **Max. Channel Switch Time** before the expected start of the next frame or the next scheduled UL transmission (of any SS). If the channel to be measured is the operating channel, Max. Channel Switch Time shall be equal to the value of the receive/transmit transition gap (RTG), as specified in Table 8-301, or, in the case of DFS Max. Channel Switch Time, may be defined in regulation.

6.2.1.2.6 Requesting and reporting of measurements

The SS shall, for each measured channel, keep track of the following information:

— Frame Number of the frame during which the first measurement was made
— Accumulated time measured
— Existence of a specific spectrum user on the channel
— Whether a IEEE 802.16 system using the same PHY system was detected on the measured channel
— Whether unknown transmissions [such as radio local area network (RLAN) transmissions] were detected on the channel

The BS may request a measurement report by sending a REP-REQ message. This is typically done after the aggregated measurement time for one or more channels exceeds the regulatory required measurement time. Upon receiving a REP-REQ the SS shall reply with a REP-RSP message and reset its measurement counters for each channel on which it reported.

If the SS detects a SSU on the channel where it is operating during a measurement interval or during normal operation, it shall immediately cease to send any user data if so mandated by regulatory requirements and send at the earliest possible opportunity an unsolicited REP-RSP. The BS shall provide transmission opportunities for sending an unsolicited REP-RSP frequently enough to meet regulatory requirements, where applicable. The SS may also send, in an unsolicited fashion, a REP-RSP when other user interference is detected above a threshold value.

6.2.1.2.7 Selecting and advertising a new channel

A BS may decide to stop operating in a channel at any time. The algorithm used to decide to stop operating in a channel is outside the scope of this standard, but shall satisfy any regulatory requirements.

A BS may use a variety of information, including information learned during SS initialization and information gathered from measurements undertaken by the BS and the SSs, to assist in the selection of the new channel. The algorithm to choose a new channel is not standardized but, in the case of DFS, shall satisfy any regulatory requirements, including uniform spreading rules and channel testing rules. If a BS would like to move to a new channel, a channel supported by all SSs in the sector should be selected.

A BS shall inform its associated SSs of the new channel using the Channel Nr in the DCD message. The new channel shall be used starting from the frame with the number given by the Channel Switch Frame Number in the DCD message. The BS shall not schedule any transmissions during the last Max. Channel Switch Time before the channel change is to take place.

The Uplink Burst Profiles used on the old channel defined shall be considered valid also for the new channel, i.e., the BS need not define new Uplink Burst Profiles when changing channels. When operating in license-exempt bands, the BS shall not send the Frequency (Type = 3) parameter as a part of UCD message.

6.2.1.3 Uncoordinated coexistence with non-specific spectrum users (non-SSUs)

6.2.1.3.1 Overview

This subclause considers uncoordinated coexistence mechanisms for use in bands where non-SSUs are present. The important distinction for coexistence with non-SSUs, when compared with SSUs (6.2.1.2), is that there are less stringent, if any, regulatory demands placed on the coexistence solution. Aspects where requirements may be relaxed include monitoring resource requirements and accompanying detection times, probability of detection requirements, or time to vacate the operating channel. When a non-SSU is detected it is not mandated that the operating channel be vacated, it may be possible to use a more robust modulation scheme, or use an AAS beamforming approach to focus energy and reduce interference; however, to meet with some guidelines on coexistence in license-exempt bands then channel changing to a less interfered channel may be a preferred option. One realization of uncoordinated coexistence with non-SSUs is termed *Dynamic Channel Selection* (DCS).

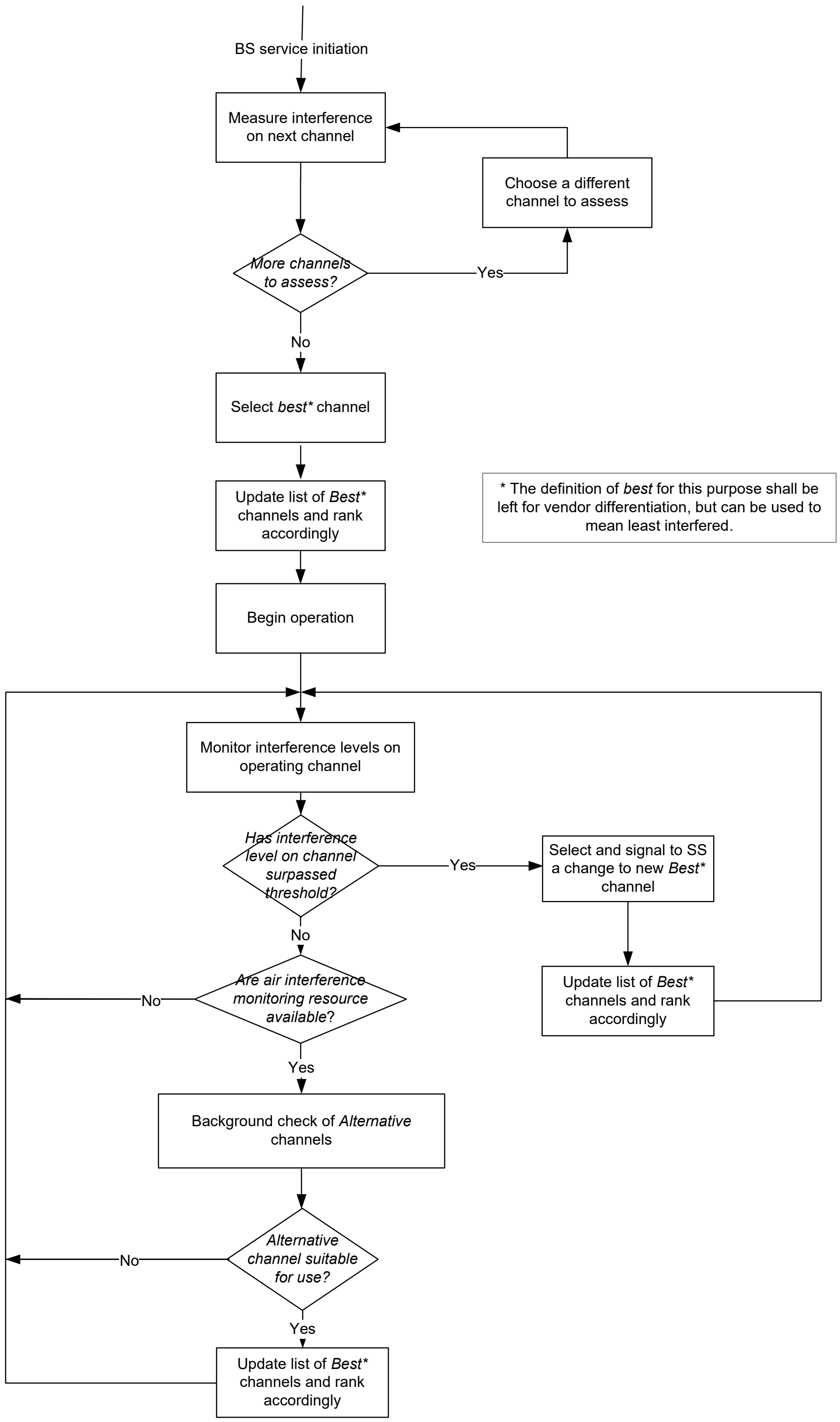
6.2.1.3.2 Dynamic Channel Selection (DCS)

Dynamic Channel Selection (DCS) is an uncoordinated coexistence mechanism that provides the ability for a system to switch to a different physical frequency channel, based on channel conditions, and thereby avoid interference in license-exempt bands. DCS can be used as a means of finding a least interfered channel at system startup or can be used during normal system operation to provide constant interference monitoring capabilities and, with the ability to monitor other channels, provide a list of *alternative channels* for informed switchover to a different, less interfered, channel. An illustrative example is given in Figure 6-13 for possible behavior at the BS, while Figure 6-14 illustrates the behavior at the SS. DCS may be used when the interference is caused by other IEEE 802.16 systems or by non-IEEE 802.16 systems (e.g., IEEE 802.11 systems).

Quiet periods for measurement are scheduled by the BS via the DL-MAP and the UL-MAP for the BS and SS respectively, with measurements provided, for example, by an OFDM Periodic Channel Measurement IE (see 8.3.6.2.10) and OFDMA Periodic Channel Measurement IE (see 8.4.5.3.34). These mechanisms are supported with the REP-REQ/REP-RSP (6.3.2.3.33) MAC messages to provide reports of incident interference. Once a channel is deemed unusable due to prevailing interference that has surpassed the *acceptable threshold* or degraded the BER sufficiently, the BS may choose to move to a new channel. This new channel may be unmeasured or a member of an *alternative* list of available channels previously measured by the BS or SSs. The number of *alternative channels* that can be monitored depends on the spare channel capacity available. Also the “freshness” of a channel (in terms of when the channel was last measured and how accurate the measurement is likely to be) may also depend on available resources to accomplish this task. The previously interfered channel that was vacated may be monitored for usability after some defined period. Figure 6-13 and Figure 6-14 provide an example of how DCS can be used to provide resource management and alternative operating channels.

An example of a DCS solution is provided in Figure 6-15 in which interference detection results in a channel change. Figure 6-15 indicates the events that occur following interference detection at the BS. The DCS algorithm has a choice to either vacate the channel or overcome the interference by using a more robust modulation scheme. The Channel Measurement IE, containing a reference to the ChCtrFr*,* is used to make the channel change. A similar procedure is followed for interference detection at the SS, illustrated in Figure 6-16; however, in this case, the REP-RSP message, sent by the SS in an unsolicited manner, initializes the response by the BS.

The mechanism given in 6.2.1.2 may be used to maintain a list of available *alternative channels* for use in the event interference is detected on a channel that needs vacating due to high levels of interference.



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944 **Figure 6-13—Flowchart showing generic operation at the BS in bands with non-SSUs only**

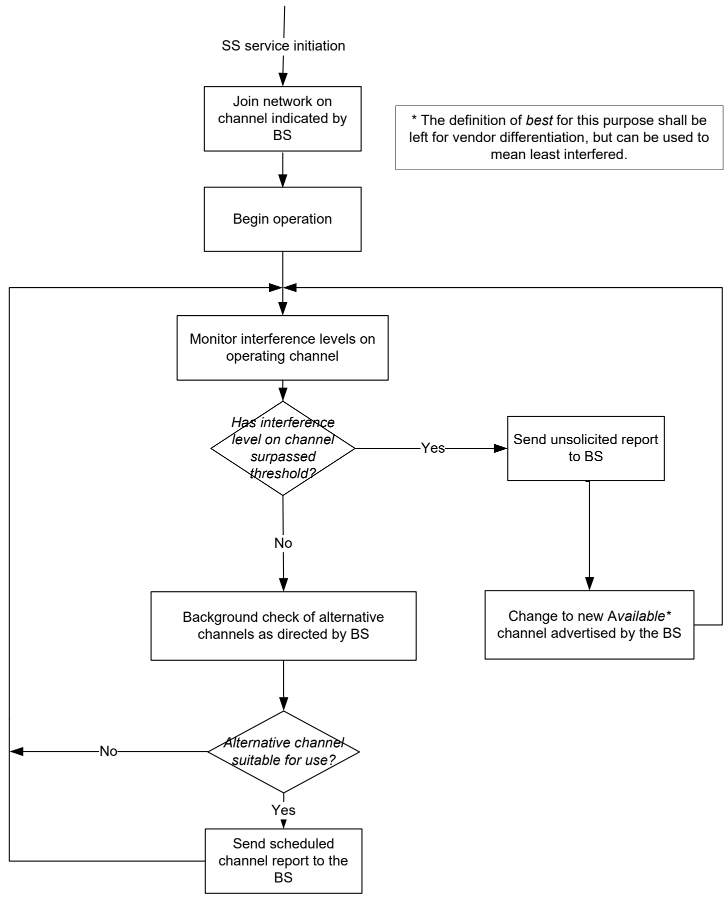

Figure 6-14—Flowchart showing generic operation at the SS in bands with non-SSUs only

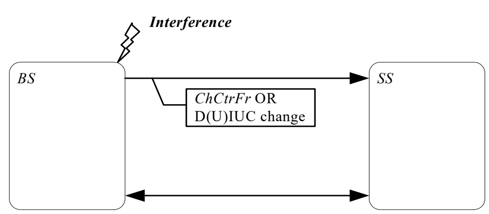

Figure 6-15—Interference reporting and remedial action at the BS

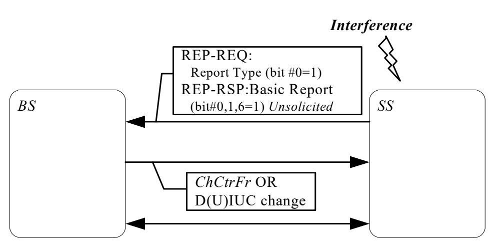

Figure 6-16—Interference reporting and remedial action at the SS

6.2.1.3.3 Frame structure and frame allocation

Co-channel coexistence between multiple IEEE 802.16 systems is achievable by the sharing of frames, whereby advantage is derived from the synchronous behavior of IEEE 802.16. This sharing is reliant upon a known frame allocation and network synchronization. The mechanism for co-channel coexistence at the frame level is related to the band of operation, but all BS shall follow the procedures in 15.2. Situations exist where frames may be assigned to IEEE 802.16 systems by administrative means within the context of a 4-frame structure. This administrative provisioning eliminates the need to support a discovery protocol, and an a priori knowledge of frame allocation patterns. Such situations occur, for example, in bands where a regulatory requirement demands device registration together with information on device location. It is therefore possible to make use of this location information and make informed decisions on which systems should be assigned to which frames. Administrative provisioning shall therefore be used if sufficient information is available, otherwise a discovery protocol or standardized frame structure shall be used.

The frame structure based on the CX-Frame is described in 15.4. The systems compliant with UCP shall not use Slave subframes.

When all systems attempting to coexist on the same channel are IEEE 802.16 systems, the end result after all three systems have entered the channel is a four frame sequence of frame usage as shown in Figure 6-17. This is a simplified version of Figure 15-19.

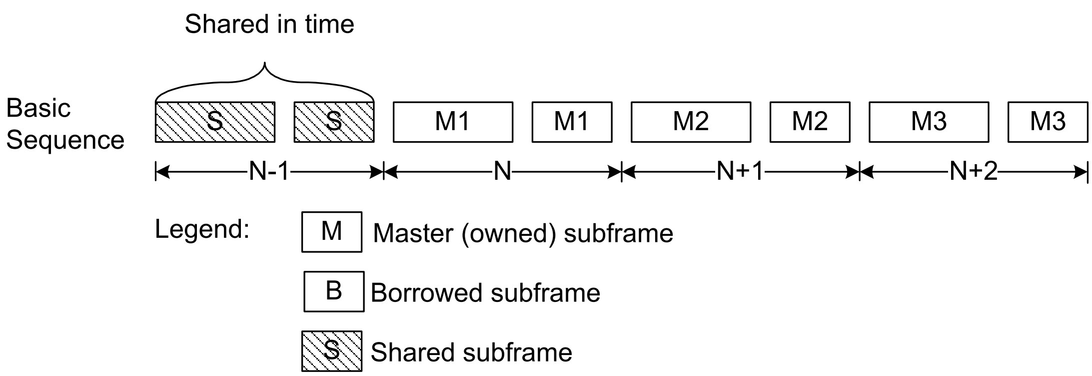

Figure 6-17—Basic four frame repetitive sequence

Initially when the channel has no occupants, the first system to operate on the channel shall claim a slot within the repetitive sequence as Master. While a system may be administratively allowed to borrow unused slots a system shall claim no more than a single slot as Master. It does not matter which slot the first system claims although it is highly recommended that all BSs on the given channel belonging to the same network operator claim the same slot as this will reduce the need for operator coordination. Operator coordination is necessary when there are conflicts that are not resolved automatically. If there are two operators on the same channel, operating in the same geographic location, and the equipment of the first has randomly chosen a different Master allocation in each cell, then it becomes much more difficult for the equipment of the second operator to automatically select non-interfering allocations. Any unresolved cases of interference should be resolved through operator coordination.

The result of the first system claiming slot 1 of the repetitive sequence is shown in Figure 6-18.

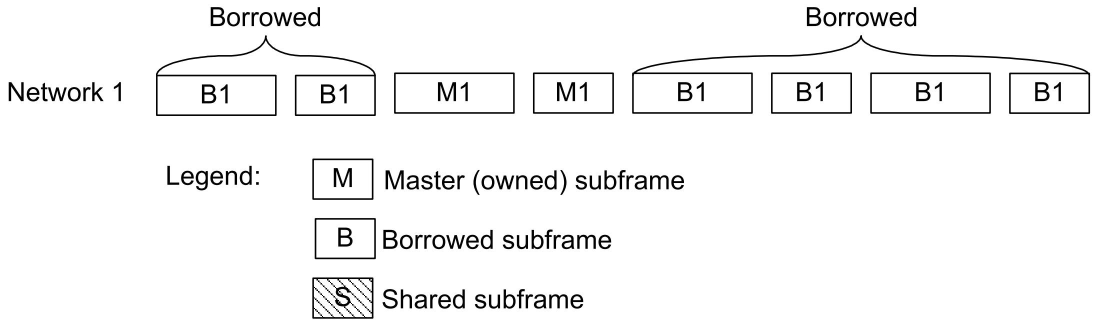

Figure 6-18—First IEEE 802.16 system claiming slot 1

The result after a second system has claimed slot 2 is shown in Figure 6-19.

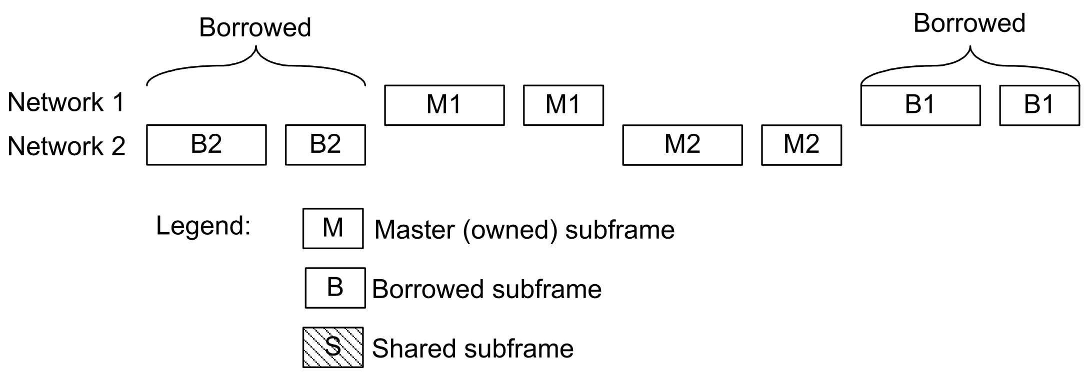

Figure 6-19—Second IEEE 802.16 system claiming slot 2

The result after a third system has claimed slot 3 is shown in Figure 6-20. This creates the basic 4-frame sequence originally described.

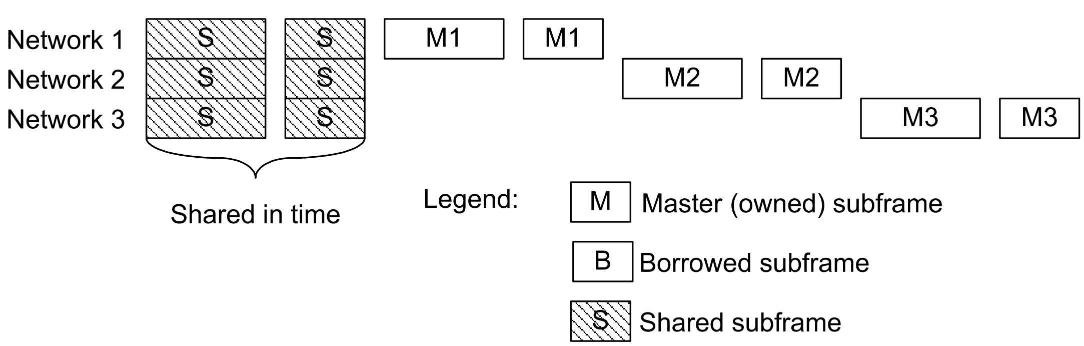

Figure 6-20—Third IEEE 802.16 system claiming slot 3

7. Security sublayer

8. Physical layer (PHY)

8.1 802.16t PHY specification

8.1.1 Overview

8.1.2 Framing

This PHY specification operates in a framed format (6.3.7). Within each frame are a DL subframe and an UL subframe. The DL subframe begins with information necessary for frame synchronization and control. In the TDD case, the DL subframe comes first, followed by the UL subframe. In the FDD case, UL transmissions occur concurrently with the DL frame.

Each SS shall attempt to receive all portions of the DL except for those bursts whose burst profile is either not implemented by the SS or is less robust than the SS's current operational DL burst profile. Half-duplex SSs shall not attempt to listen to portions of the DL coincident with their allocated UL transmission, if any, adjusted by their Tx time advance.

8.1.2.1 Supported frame durations

Table 8-1 indicates the supported frame durations.

Table 8-1—Frame durations and frame duration codes

Frame duration code (4 bits)	Frame duration (T_f)	Units
0x01	0.5	ms
0x02	1	ms
0x03	2	ms
0x04–0x0F	*Reserved*	

8.1.3 Tx spectral mask

The transmitted spectral density of the transmitted signal shall fall within the spectral mask as shown Figure 8-1 and Table 8-2. The measurements shall be made using 100 kHz resolution bandwidth and a 30 kHz video bandwidth. The 0 dBr level is the maximum power allowed by the relevant regulatory body.

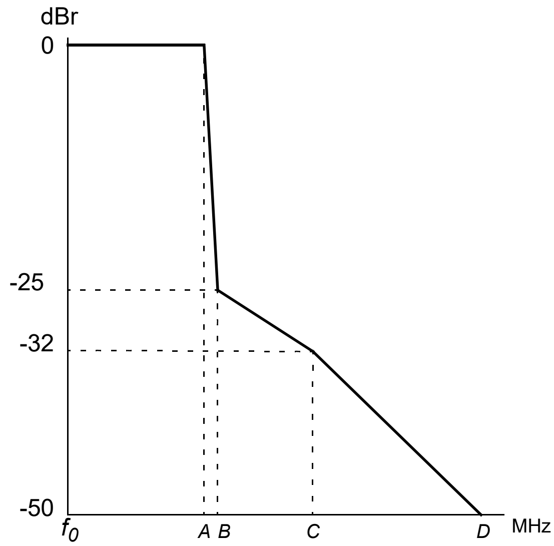

Figure 8-1—Tx spectral mask (see Table 8-2)

Table 8-2—Tx spectral mask parameters

Channelization (MHz)	A	B	C	D
20	9.5	10.9	19.5	29.5
10	4.75	5.45	9.75	14.75

9. Configuration

10. Parameters and constants

10.1 Global values

The BS and SS shall meet the requirements contained in Table 10-1.

Table 10-1—Parameters and constants

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	DCD Interval	Time between transmission of DCD messages.	—	—	10 s
BS	UCD Interval	Time between transmission of UCD messages.	—	—	10 s
BS	UCD Transition Interval	The time the BS shall wait after repeating a UCD message with an incremented Configuration Change Count before issuing a UL-MAP message referring to Uplink_Burst_Profiles defined in that UCD message.	20 ms following the last fragment of the message	—	—
BS	DCD Transition Interval	The time the BS shall wait after repeating a DCD message with an incremented Configuration Change Count before issuing a DL-MAP message referring to Downlink_Burst_Profiles defined in that DCD message.	20 ms following the last fragment of the message	—	—
BS	Max MAP Pending	Maximum validity of map.	—	—	End of next frame
BS	Initial Ranging Interval	Time between Initial Ranging regions assigned by the BS.	—	—	2 s

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	CLK-CMP Interval	Time between the clock compare measurements used for the generation of CLK-CMP messages.	50 ms	50 ms	50 ms
SS	Lost DL-MAP Interval	Time since last received DL-MAP message before DL synchronization is considered lost.	—	—	600 ms (during initial network entry) 655 s (after initial network entry)
SS	Lost UL-MAP Interval	Time since last received UL-MAP message before UL synchronization is considered lost.	—	—	600 ms (during initial network entry) 655 s (after initial network entry)
SS	Contention Ranging Retries	Number of retries on contention Ranging Requests.	8	—	—
BS	Invited Ranging Retries	Number of retries on inviting Ranging Requests.	16	—	—
SS	Request Retries	Number of retries on bandwidth allocation requests.	16	—	—
SS	Registration Request Retries	Number of retries on registration requests.	3	—	—
BS, SS	T_{proc}	Time provided between arrival of the last bit of a UL-MAP at an SS and effectiveness of that map. For OFDMA mode, the time shall be counted starting from the end of the burst carrying the UL-MAP.	SC: 200 µs OFDM: 1 ms OFDMA: $T_{proc} = T_f$ WirelessMAN-CX: Tproc should allow UL scheduling in the same frame	—	—
BS	SS Ranging Response Processing Time	Time allowed for an SS following receipt of a ranging response before it is expected to reply to an invited ranging request.	10 ms	—	—

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
SS, BS	Minislot size (SC only)	Size of minislot for UL transmission. Shall be a power of 2 (in units of PS).	1 PS	—	—
SS, BS	DSx Request Retries	Number of Timeout Retries on DSA/ DSC/DSD Requests.	—	3	—
SS, BS	DSx Response Retries	Number of Timeout Retries on DSA/ DSC/DSD Responses.	—	3	—
SS	TFTP Backoff Start	Initial value for TFTP backoff.	1 s	—	—
SS	TFTP Backoff End	Last value for TFTP backoff.	16 s	—	—
SS	TFTP Request Retries	Number of retries on TFTP request.	16	—	—
SS	TFTP Download Retries	Number of retries on entire TFTP downloads.	3	—	—
SS	TFTP Wait	The duration between two consecutive TFTP retries.	2 min	—	—
SS	Time of Day Retries	Number of Retries per Time of Day Retry Period.	3	—	—
SS	Time of Day Retry Period	Time period for Time of Day retries.	5 min	—	—
SS	T1	Wait for DCD timeout.	—	—	5 × DCD interval maximum value
SS	T2	Wait for broadcast ranging timeout.	—	—	5 × ranging interval

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
SS, MS	T3	Ranging response reception timeout following the transmission of a ranging request.	—	OFDMA: 60 ms: RNG-RSP after CDMA ranging or RNG-REQ during initial or periodic ranging 50 ms: RNG-RSP after RNG-REQ during HO to negotiated target BS 200 ms: RNG-RSP after RNG-REQ during HO to non-negotiated target BS 200 ms: RNG-RSP after RNG-REQ during location update or reentry from idle mode 80 ms: RNG-RSP after CDMA ranging using Initial/HO Ranging Code set 1 or 2 during initial ranging/handover/ location update/ reentry from idle mode 100 ms: 1) RNG-RSP after RNG-REQ following usage of Initial Ranging Code set 1 during initial ranging, 2) RNG-RSP after RNG-REQ following usage of HO Ranging code set 1 or 2 during handover to negotiated target BS, or 3) RNG-RSP after RNG-REQ on the Primary Management Connection during initial ranging/ handover to negotiated target BS/ location update/ reentry from idle mode. 30 msec: UL bandwidth allocation for RNG-REQ after receiving RNG-RSP during M2M small burst transmission.	200 ms

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
M2M device	T32	RNG-RSP reception timeout following the transmission of a ranging preamble code sent by a group delegate.	—	—	—
M2M device	Abnormal Power Down Ranging Opportunity Selection Parameter	Constant used in defining the CDF used for selecting a ranging opportunity to report an abnormal power down event in Idle Mode. Refer to 6.1.9.2.	—	—	—
M2M device, BS	Abnormal Power Down Ranging Code	Ranging code used to indicate an abnormal power down event. Refer to 6.1.9. This code is selected from the initial ranging code set.	—	—	—
M2M device	Abnormal Power Down Confirmation timer	Abnormal power down confirmation reception timeout following the transmission of an abnormal power down report.	—	50 msec	—
BS	T50	See 6.3.22.1	100 ms	250 ms	500 ms
SS	T4	Wait for ranging opportunity or data grant. If the pending-until-complete field was used earlier by this SS, then the value of that field shall be added to this interval. For OFDMA, it is a timer to start Periodic Ranging.	—	—	35 s
SS	T6	Wait for registration response.	—	—	3 s
SS, BS	T7	Wait for DSA/DSC/DSD Response timeout.	—	—	1 s
SS, BS	T8	Wait for DSA/DSC Acknowledge timeout.	—	—	300 ms

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	T9	The time allowed between the BS sending a RNG-RSP (include Basic CID + Primary CID) to an SS, and receiving a SBC-REQ from that same SS.	300 ms	300 ms	—
SS, BS	T10	Wait for Transaction End timeout	—	—	3 s
SS	T12	Wait for UCD descriptor	—	—	5 × UCD Interval maximum value
BS	T13	The time allowed for an SS, following receipt of a REG-RSP message to send a TFTP-CPLT message to the BS.	15 min	15 min	—
SS	T14	Wait for DSX-RVD Timeout.	—	—	200 ms
BS	T15	Wait for MCA-RSP.	20 ms	20 ms	—
BS	T17	Time allowed for SS to complete SS Authorization and Key Exchange.	5 min	5 min	—
SS	T18	Wait for SBC-RSP timeout.	—	50 ms	<< T9
SS	T20	Time the SS searches for preambles on a given channel.	2 MAC frames	—	—
SS	T21	Time the SS searches for decodable DL-MAP on a given channel.	—	—	11 s
SS, BS	T22	Wait for ARQ-Reset.	—	—	0.5 s
SS	SBC Request Retries	Number of retries on SBC Request.	3	3	16
SS	TFTP-CPLT Retries	Number of retries on TFTP-CPLT.	3	3	16
SS	T26	Wait for TFTP-RSP.	10 ms	200 ms	200 ms

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	T27 as Idle Timer	Maximum time between unicast grants to SS when BS believes SS UL transmission quality is *good enough.*	SS Ranging Response Processing Time	—	—
BS	T27 as Active Timer	Maximum time between unicast grants to SS when BS believes SS UL transmission quality is *not good enough.*	SS Ranging Response Processing Time	—	—
SS	FPC Processing Time	The earliest start time of an UL allocation to which the MS shall apply the FPC correction.	2.5 ms	2.5 ms	2.5 ms
BS	Ranging Correction Retries	Number of Ranging Correction Retries.	—	16	—
SS	RNG-RSP Processing Time	Time allowed for an SS following receipt of a RNG-RSP before it is expected to apply the corrections instructed by the BS Minimum value.	—	—	2.5 ms from the start of the frame (*n*+1) were frame n is the frame containing the RNG-RSP. If there is an UL allocation to the SS before the 2.5 ms in frame *n*+1, then the power change shall be applied before the end of the frame *n*+1.
SS	Power Control IE Processing Time	Time allowed for an SS following receipt of a UL-MAP including a Power Control IE before it is expected to apply the corrections instructed by the BS.	—	—	2.5 ms from the start of the frame (*n*+1) were frame *n* is the frame containing the UL map containing the Power Control IE. If there is an UL allocation to the SS before the 2.5 ms in frame *n*+1, then the power change shall be applied before the end of the frame *n*+1.

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
SS	T28	DBPC-REQ retry timer for requesting less robust burst profile after rejection by the BS.	200 ms	1 s	1 min
SS	T29	RNG-REQ/DBPC-REQ retry timer for requesting more robust burst profile after rejecting by the BS.	200 ms	1 s	30 s
SS	T30	DBPC-RSP reception timeout following the transmission of a DBPC-REQ.	200 ms	200 ms	200 ms
MS	Min_Sleep _Interval	Minimum sleeping time allowed to MS.	1 frame	—	—
MS	Max_Sleep _Interval	Maximum sleeping time allowed to MS.	—	—	1024 frames
MS	Listening_I nterval	The time duration during which the MS, after waking up and synchronizing with the DL transmissions, can demodulate DL transmissions and decide whether to stay awake or go back to sleep.	—	—	64 frames
BS	MOB_NBR -ADV Interval	Nominal time between transmission of MOB_NBR-ADV messages.	—	—	30 s
BS, MS	ASC-AGING-TIMER	Nominal time for aging of MS associations.	0.1 s	—	10 s
MS	Serving BSID AGING-TIMER	Nominal time for aging of serving BS association. Timer recycles on successful serving BS DL-MAP read.	—	—	655 s
MS	T42	MOB_HO-IND timeout when sent with HO_IND_type = 0b10.	—	—	—

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	Paging Retry Count	Number of retries on paging transmission. If the BS does not receive RNG-REQ from the MS until this value decreases to zero, it determines that the MS is unavailable.	—	3	16
BS, MS	Mode Selection Feedback Processing Time	The time allowed between the end of the burst carrying the mode selection feedback subheader and the start of the UL subframe carrying the mode selection feedback response.	TDD: Frame duration FDD: 1/2 frame duration	—	—
MS	Idle Mode Timer	MS timed interval to conduct location update. Set timer to MS idle mode timeout capabilities setting. Timer recycles on successful idle mode location update.	128 s	4096 s	65 536 s
BS	Idle Mode System Timer	For BS acting as paging controller, timed interval to receive notification of MS idle mode location update. Set timer to MS Idle Mode Timeout. Timer recycles on successful idle mode location update.	128 s	4096 s	65 536 s
MS	T43	Time the MS waits for MOB_SLP-RSP or DL sleep control extended subheader.	—	—	—
MS	T44	Time the MS waits for MOB_SCN-RSP.	—	—	—
MS	T45	Time the MS waits for DREG-CMD.	—	250 ms	500 ms

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	Management Resource Holding Timer	Time the BS maintain connection information with the MS after the BS send DREG-CMD to the MS.	—	500 ms	1 s
MS	DREG Request Retry Count	Number of retries on DREG Request message.	3	3	16
BS	DREG Command Retry Count	Number of retries on DREG Command message.	3	3	16
BS	T46	Time the BS waits for DREG-REQ in case of unsolicited idle mode initiation from BS.	—	—	—
MS	HO Process Optimization MS Timer Retries	Number of SBC-REQ and/or REG-REQ retries while waiting for unsolicited SBC-RSP and/or REG-RSP as part of MS network reentry and as indicated by HO Process Optimization message element of RNG-RSP.	3	—	—
BS	T47	PMC_RSP Timer: BS may send the PMC_RSP before T47 + 1 frames after BS receives PMC_REQ (Confirmation = 0) correctly.	8 frames	64 frames	1024 frames
MS, BS	Paging Interval Length	Time duration of paging interval of the BS.	1 frame	—	5 frames
MS	Max Dir Scan Time	Maximum scanning time of neighbor BSs by MS before reporting any results.	—	—	—
BS, MS	SAChallengeTimer	Time prior to resend of SA-TEK-Challenge.	0.5 s	1.0 s	2.0 s

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS, MS	SAChallengeMax-Resends	Maximum number of transmissions of SA-TEK-Challenge.	1	3	3
MS, BS	SATEKTimer	Time prior to resend of SA-TEK-Request.	0.1 s	0.3 s	1.0 s
MS, BS	SATEKRequestMax-Resends	Maximum number of transmissions of SA-TEK-Request.	1	3	3
MS	MS Handover Retransmission Timer	MS Handover Retransmission Timer.	—	—	—
MS	Max Report Processing Time	Maximum time allowed from reception of REP-REQ until transmission of corresponding REP-RSP.	—	—	60 ms
MS	T48	Maximum duration that MS shall wait to receive UL transmission opportunities allocated by BS after keep-alive check operation starts in the frame specified by Next Periodic Ranging TLV encoding (refer to 6.3.19.7.1).	5 s	—	50 s
BS	T49	Maximum duration that BS shall wait to receive RNG-REQ messages from MS on UL transmission opportunities after keep-alive check operation starts in the frame specified by Next Periodic Ranging TLV encoding (refer to 6.3.19.7.1).	5 s	—	50 s

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
BS, MS	T55	This timer starts in the frame where the MS expects to receive the Fast Ranging IE. Upon expiration of this timer, the MS shall not expect the Target BS to grant an UL allocation via the Fast Ranging IE and shall release the HO ID.	8 frames	—	—
BS	LBS-ADV interval	Nominal time between transmission of LBS-ADV messages.	2 s	10 s	1800 s
BS	SII-ADV interval	Nominal time between transmission of SII-ADV messages.	—	10 s	30 s
BS	T56	The time allowed between the SBC response and PKM-REQ.	—	—	—
BS	T57	The time allowed between the PKM-REQ (Code=31) and PKM-REQ for security procedure initiation.	—	—	—
BS	DL_radio_resources_window_size	The number of frames over which the Available DL Radio Resources are calculated.	—	200	—
BS	UL_radio_resources_window_size	The number of frames over which the Available UL Radio Resources are calculated.	—	200	—
BS	MIH max cycles	The maximum number of cycles that an MS waits for an MIH response during initial entry. Refer to 6.3.23.	3	3	—

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
SS	Ranging Request Retries	Number of retries on ranging requests by RNG-REQ messages (OFDMA only).	3	—	16
MS	$N_{MS\_max\_neighbors}$	Maximum size of neighbor list.	32	—	255
MR-BS	T58	Time the MR-BS waits for MR_Generic-ACK from RS	—	—	7 + 4 × (maximum hop count number of the MR system) (frames)
MR-BS	T59	Time the MR-BS waits for DSA-RSP from RS	—	—	<< T7
MR-BS, RS	T60 as triggered by CDMA code	Wait for MR_RNG-REP message from the subordinate RS triggering by receiving CDMA ranging code	—	6 frames	<T3
MR-BS, RS	T60 as triggered by message	Wait for MR_RNG-REP message from the subordinate RS triggering by receiving MR_RNG-REP message	—	T60 as triggering by CDMA code $-T_{FD}$ x $((FN_{Rx} - FN_{Msg})$ mod 256), where T_{FD}: the frame duration, FN_{Rx}: the relevant frame number when receiving message, FN_{Msg}: the frame number in the received message	<T3
MR-BS	MR_SLP_INFO_retry_count	Number of retries on MR_SLP-INFO transmission	3	3	16
MR-BS	T61	Waiting for ACK from RS for DCD/ UCD messages	—	—	300 ms
RS	T62	The timer between RS sending an RS BR header to MR-BS and receiving the allocation for RNG-RSP.	—	—	< T3
MR-BS	T63	Maximum duration that BS shall wait to receive relayed RNG-REQ from its subordinate RSs after the paging retry count decrease to zero.	—	—	—

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
MR-BS	T64	Wait for RS_NBR_MEAS-REP after sending REG-RSP to RS.	300 ms	300 ms	—
RS	T65	Wait for DSA-REQ after receiving RNG-RSP with Path-Addition TLV or Path-CID-Binding-Update TLV.	—	—	—
RS	T66	Wait for RNG-RSP from MR-BS after relaying the received RNG-REQ from MS to MR-BS.	—	(default value of T3) - (RS processing time)	< T3
RS	T67 as performing measurement report	Wait for RS_AccessRS-REQ or RS_Config-CMD after sending RS_NBR_MEAS-REP to MR-BS.	—	—	1 sec
RS	T67 as skipping measurement report	Wait for RS_Config-CMD after receiving REG-RSP from MR-BS and RS shall skip neighbor measurement step.	—	—	300 ms
MR-BS	T68	Wait for ACK after sending RS_Config-CMD to RS.	—	—	100 ms
RS	T69	Time the RS waits for unsolicited RS_BW-Alloc_IE from MR-BS.	—	—	< DCD/UCD interval
RS	Lost R-MAP Interval	Time since last received R-MAP message before RL synchronization is considered lost.	—	—	600 ms
MR-BS	T70	Wait for RNG-REQ message after receiving ACK for RS_AccessRS-REQ message.	—	—	300 ms

Table 10-1—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
RS	T71	Time the RS sends an MR_RNG-REP after the RS detects one or more CDMA codes during contention-based initial ranging.	—	—	< T60 as triggered by CDMA code
MR-BS, RS	T72	Time the egress station of a tunnel waits for subsequent fragments of a TDU before discarding all the received fragments of the TDU.	—	—	—
MR-BS	T73	Wait for ACK after sending RS_AccessRS-REQ to RS.	—	—	100 ms
HR-MS	T74	Wait for DSA/DSC acknowledgment timeout in case the flow runs over a direct communication link	—	—	600 ms
SBS	Standby_Mode_Activation	The SBS enters standby mode at the expiration of Standby_Mode_Activation timer	30 min	—	—
SBS	Standby_Mode_Deactivation	The SBS terminates standby mode at the expiration of Standby_Mode_Deactivation timer	30 min	—	—

10.2 PKM parameter values

Table 10-2 defines the ranges and default values for the PKM configuration and operational parameters.

Table 10-2—Operational ranges for privacy configuration settings

System	Name	Description	Minimum value	Default value	Maximum value
BS	AK Lifetime	Lifetime, in seconds, BS assigns to new AK	1 day (86 400 s)	7 days (604 800 s)	70 days (6 048 000 s)
BS	TEK Lifetime	Lifetime, in seconds, BS assigns to new TEK	30 min (1800 s)	12 h (43 200 s)	7 days (604 800 s)
SS	Authorize Wait Timeout	Auth Req retransmission interval from Auth Wait state	2 s	10 s	30 s
SS	Reauthorize Wait Timeout	Auth Req retransmission interval from Reauth Wait state	2 s	10 s	30 s
SS	Authorization Grace Time	Time prior to Authorization expiration SS begins reauthorization	5 min (300 s)	10 min (600 s)	35 days (3 024 000 s).
SS	Operational Wait Timeout	Key Req retransmission interval from Op Wait state	1 s	1 s	10 s
SS	Rekey Wait Timeout	Key Req retransmission interval from Rekey Wait state	1 s	1 s	10 s
SS	TEK Grace Time	Time prior to TEK expiration SS begins rekeying	5 min (300 s)	1 h (3600 s)	3.5 days (302 399 s)
SS	Authorize Reject Wait Timeout	Delay before resending Auth Request after receiving Auth Reject	10 s	60 s	10 min (600 s)

Table 10-3 defines the ranges and default values for the PKMv2 configuration and operational parameters.

Table 10-3—Operational ranges for privacy configuration settings for PKMv2

System	Name	Description	Minimum value	Default value	Maximum value
MS, BS	PMK or PAK prehandshake lifetime	The lifetime assigned to PMK when created	5 s	10 s	15 min
BS	PMK lifetime	If MSK lifetime is unspecified (i.e., by AAA server), PMK lifetime shall be set to this value	60 s	3600 s	86 400 s
BS, MS	SAChallenge-Timer	Time prior to resend of SA-TEK-Challenge	0.5 s	1.0 s	2.0 s

Table 10-3—Operational ranges for privacy configuration settings for PKMv2 *(continued)*

System	Name	Description	Minimum value	Default value	Maximum value
BS, MS	SaChallengeMax Resends	Maximum number of transmissions of SA-TEK-Challenge	1	3	3
MS, BS	SATEKTimer	Time prior to resend of SA-TEK-Request	0.1 s	0.3 s	1.0 s
MS, BS	SATEKRequest-MaxResends	Maximum number of transmissions of SA-TEK-Request	1	3	3
BS	PAK Lifetime	Lifetime, in seconds, BS assigns to new PAK	1 day (86 400 s)	7 days (604 800 s)	70 days (6 048 000 s)
BS	TEK Lifetime	Lifetime, in seconds, BS assigns to new TEK	30 min (1800 s)	12 h (43 200 s)	7 days (604 800 s)
MS	Authorize Wait Timeout	PKMv2 RSA-Request retransmission interval from Auth Wait state	2 s	10 s	30 s
MS	Reauthorize Wait Timeout	PKMv2 RSA-Request retransmission interval from Reauth Wait state	2 s	10 s	30 s
MS	Authorization Grace Time	Time prior to Authorization expiration SS begins reauthorization	5 min (300 s)	10 min (600 s)	1 h (3 600 s)
MS	Operational Wait Timeout	PKMv2 Key-Request retransmission interval from Op Wait state	1 s	1 s	10 s
MS	Rekey Wait Timeout	PKMv2 Key-Request retransmission interval from Rekey Wait state	1 s	1 s	10 s
MS	TEK Grace Time	Time prior to TEK expiration SS begins rekeying	1 min (60 s)	5 min (300 s))	1 h (3 600 s)
MS	Authorize Reject Wait Timeout	Delay before resending PKMv2 RSA-Request after receiving PKMv2 RSA-Reject	10 s	60 s	10 min (600 s)
MS	EAP start timeout	Timer between resend of EAP start if reauthentication was not completed	10 s	10 s	60 s

For the purposes of protocol testing, it is useful to run the privacy protocol with timer values well below the low end of the operational ranges. The shorter timer values “speed up” privacy’s clock, causing privacy protocol state machine events to occur far more rapidly than they would under an “operational” configuration. While privacy implementations need not be designed to operate efficiently at this accelerated privacy pace, the protocol implementation should operate correctly under these shorter timer values.

Table 10-4 provides a list of shortened parameter values that are likely to be employed in protocol conformance and certification testing.

Table 10-4—Values for privacy configuration setting for protocol testing

Parameter	Shortened value [min (s)]
AK Lifetime	5 (300)
TEK Lifetime	3 (180)
Authorization Grace Time	1 (60)
TEK Grace time	1 (60)

The TEK Grace Time shall be less than half the TEK lifetime.

10.3 PHY-specific values

10.3.1 WirelessMAN-SC parameter and constant definitions

10.3.1.1 PS

For the WirelessMAN-SC PHY, a PS is the duration of four modulation symbols at the symbol rate of the DL transmission.

10.3.1.2 Symbol rate

The symbol rate shall be in the range 10–44.8 MBd, in increments of 100 kBd.

10.3.1.3 UL center frequency

The UL center frequency shall be a multiple of 250 kHz.

10.3.1.4 DL center frequency

The DL center frequency shall be a multiple of 250 kHz.

10.3.1.5 Tolerated poll jitter

For the 10–66 GHz PHY, the minimum value of the Tolerated Poll Jitter (see 11.13.12) shall be 3000 μs.

10.3.1.6 Allocation Start Time

Unit of Allocation Start Time shall be minislots from the start of the DL frame in which the UL-MAP message occurred.

10.3.1.7 Timing Adjust Units

The timing adjust units shall be 1/4 modulation symbols. During periodic ranging, the range of the value of this parameter shall be limited to ± 2 modulation symbols.

10.3.2 *Reserved*

10.3.3 WirelessMAN-OFDM parameters and constant definitions

10.3.3.1 Uplink Allocation Start Time

The unit of allocation start time shall be PSs from the start of the DL frame in which the UL-MAP message occurred or from the start of the AAS zone if the UL MAP was transmitted in AAS zone. The minimum value specified for this parameter shall correspond to a point in the frame 1 ms after the last symbol of the UL-MAP.

10.3.3.2 PS

PSs are defined as in Equation (10-1).

$$PS = 4/F_s \tag{10-1}$$

10.3.3.3 Timing adjust units

The timing adjust units shall be $1/F_s$.

10.3.4 WirelessMAN-OFDMA parameters and constant definitions

10.3.4.1 Uplink Allocation Start Time

The unit of allocation start time shall be PSs from the start of the DL frame in which the UL-MAP message occurred. The minimum value specified for this parameter shall refer to the time indicated by T_{proc}, defined in Table 10-1.

F_s is the sampling frequency of the downlink.

10.3.4.2 PS

PSs are defined as Equation (10-2).

$$PS = 4/F_s \tag{10-2}$$

10.3.4.3 Timing adjust units

The timing adjust units shall be $1/F_s$.

10.4 Well-known addresses and identifiers

There are several CIDs defined in Table 10-5 that have specific meaning. These identifiers shall not be used for any other purposes.

It is noted that the multicast CID may have a format with Reduced CID on HARQ region.

Table 10-5—CIDs

CID	Value	Description
Ranging CID	0x0000	Used by SS and BS during initial ranging process.
Basic or RS basic	0x0001– *m*	The same value is assigned to both the DL and UL connection.
Primary Management or RS primary management	*m*+1 – 2*m*	The same value is assigned to both the DL and UL connection.
Transport, Secondary Management, Tunnel or Management Tunnel, Multicast management CID	2*m*+1–*n*	For the secondary management connection, the same value is assigned to both the DL and UL connection. Tunnel CID is used for tunnel transport connections. Management Tunnel CID is used for tunnel management connections. Multicast management CID is used for the downlink multicast management services.
M2MCID	*n* + 1 – 0xFE9E	M2M multicast connection identifiers.
M2M management CID	0xFE9F	Used in DL-MAP to denote bursts for transmission of DL broadcast information to M2M devices. May also be used in MOB_MTE-IND/MGMC messages.
Multicast CIDs	0xFEA0–0xFEFE	For the DL multicast service, the same value is assigned to all MSs on the same channel that participate in this connection.
AAS Initial Ranging	0xFEFF	A BS supporting AAS shall use this CID when allocating an AAS ranging period (using AAS Ranging Allocation IE).
Multicast Polling	0xFF00–0xFFF9	A MS may be included in one or more multicast polling groups for the purpose of obtaining bandwidth via polling. These connections have no associated service flow.
Normal Mode Multicast	0xFFFA	Used in DL-MAP to denote bursts for transmission of DL broadcast information to normal mode MS.
Sleep Mode Multicast	0xFFFB	Used in DL-MAP to denote bursts for transmission of DL broadcast information to sleep mode MS. May also be used in MOB_TRF-IND messages.
Idle Mode Multicast	0xFFFC	Used in DL-MAP to denote bursts for transmission of DL broadcast information to idle mode MS. May also be used in MOB_PAG-ADV messages.
Fragmentable Broadcast	0xFFFD	Used by the BS for transmission of management broadcast information with fragmentation. The fragment subheader shall use 11-bit FSN on this connection.
Padding	0xFFFE	Used for transmission of padding information by SS and BS.
Broadcast	0xFFFF	Used for broadcast information that is transmitted on a DL to all SS.

10.5 Coexistence specific values

10.5.1 Coexistence Control Channel

The coexistence control channel timers are as follows in Table 10-6.

Table 10-6—Parameter of coexistence control channel timer

Timer	Subclause	Reference	Value
Tcc	15.3.1	Average period of the coexistence control channel time slots or 1/2 period between DL slots or 1/2 period of the UL slots.	161 ms
Tcc_s	15.3.1	Duration of the coexistence control channel slots in subchannels 2 and 3.	1.9 ms
Tcc_ss	15.3.1	Offset of the DL coexistence control channel slots from the start of the DL subframe in subchannels 2 and 3.	1 ms
Tcc_se	15.3.1	Duration from the end of the UL coexistence control channel slots to the end of the MAC Frame, for MAC Frames of 5 ms,10 ms, and 20 ms.	0.2 ms
Tcxcc	15.3.1	Duration of the coexistence control channel (CXCC) cycle.	5.12 s

10.5.2 CSI timing parameters

The CSI timing parameters are listed in the table that follows:

System	Name	Time reference	Minimum value	Default value	Maximum value
BS/SS	$T_{CSIEREF}$	CSI end reference time is defined as an offset from the starting point of the synchronized frame. CSI end reference time is the time offset to the end of the last symbol in downlink.			
BS/SS	$T_{CSISREF}$	CSI start reference time is defined as an offset value from the starting point of the synchronized frame. CSI shall start within the last symbol or earlier. (See 11.4.1.)		$T_{CSIEREF}$ - 100 μs	
BS/SS	Tcsi_start	Starting point of the CSI in each frame (15.3.4.1), which is counted in symbols according to $T_{CSIEREF}$ requirement.		Starting time of the symbol right before $T_{CSISREF}$ requirement.	

System	Name	Time reference	Minimum value	Default value	Maximum value
BS/SS	CSI duration	Time duration of each CSI interval (15.3.4.1), which is counted in symbols according to $T_{CSISREF}$ requirement.	1 symbol	The ceiling number counted in symbols for 100 µs	
BS/SS	CSI cycle	CSI cycle in unit of CX-Frame (15.3.4.1).		1	
BS/SS	CSI sequence length	Length of CSI sequence (15.3.4.1.3) in unit of CSI cycle.	256	256	256
BS/SS	CSIN	The OCSI allocation of this system (OCSI1-OCSI3).	0 (OCSI1:OCSI in frame 4N)		2 (OCSI3:OCSI in frame 4N + 2)
BS	OCSI Backoff Start	Initial backoff window size for OCSI contention, expressed as a power of 2. (15.3.4.4)	1	2	6
BS	OCSI Backoff End	Final backoff window size for OCSI contention, expressed as a power of 2. (15.3.4.4)	2	4	6
BS	OCSI Backoff counter start	The initial value of the decreasing counter on the backoff window size change. (15.3.4.4)	1	3	10

10.5.3 CX-CBI parameters

The CX-CBI parameters are listed in the table that follows:

System	Name	Time reference	Minimum value	Default value	Maximum value
BS/SS	CX_LBT_Time	Listen-before-talk time for CX-CBI		50 µs	
BS/SS	T_Bursty_Detect	Duration to assess the lack of bursty systems		10s	
BS/SS	CX_LBT_Start_Min	Delay of the frame start	approx. 200 µs		

10.5.4 Timer for CX-FWD-RSP and CX-FWD-ACK messages

The timer for CX-FWD-RSP and CX-FWD-ACK messages is listed in the table that follows:

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	CX_FWD_RSP_timer	After the expiry of this timer the BS will not wait for the corresponding CX-FWD-RSP or CX-FWD-ACK	100 ms		

12. TLV encodings

12.1 Common encodings

Common TLV fields and their associated type codes are presented in Table 12-1.

Table 12-1—Type values for common TLV encodings

Type	Name
115	CSGID
116	HR multicast service flow update mapping info
117	ABS information for direct HO
118	Network address for intersystem communication
119	UCD encodings
120	DCD encodings
121	SA-SZK-Update
122	Path Info
123	Path CID Binding Update
124	Path Addition
125	Path ID
126	Bi-directional service flow
127	MCID Continuity and Transmission Info
128	MCID Pre-allocation and Transmission info
129	Query ID
130	MIHF frame type
131	MIHF frame
132	Verbose NSP Name List
133	NSP List
134	Paging Information
135	Paging Controller ID
136	MAC Hash Skip Threshold
137	Next Periodic Ranging
138	SLPID_Update
139	Enabled-Action-Triggered
140	Short-HMAC tuple
141	CMAC tuple
142	SA-TEK-Update

Table 12-1—Type values for common TLV encodings *(continued)*

Type	Name
143	Vendor-Specific Information
144	Vendor ID Encoding
145	Uplink Service Flow
146	Downlink Service Flow
147	Current Transmit Power
148	MAC Version Encoding
149	HMAC Tuple

13. System profiles

This clause defines system profiles listing sets of features to be used in typical implementation cases. Each profile is assigned an identifier for use in documents such as PICS proforma statements. These profiles do not alter the mandatory or optional nature of features specified elsewhere in this standard. Compliance to a profile depends on compliance with the underlying radio interface specification in the appropriate variant. In addition, features specified as “required” in a profile are required for compliance to that profile. Likewise, features specified as “conditionally required” in a profile are required for compliance to that profile under the specified conditions.

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Table 13-1 defines system profiles for systems operating with the WirelessMAN-SC air interface.

Table 13-1—Profile definitions

Identifier	Description
profM1	Basic ATM MAC profile
profM2	Basic packet MAC profile
profP1	25 MHz channel PHY profile
profP1f	25 MHz channel PHY profile – FDD
profP1t	25 MHz channel PHY profile – TDD
profP2	28 MHz channel PHY profile
profP2f	28 MHz channel PHY profile – FDD
profP2t	28 MHz channel PHY profile – TDD

13.1.1

14. MIB Modules

15. Management interfaces and procedures

16. Mechanisms for coordinated coexistence

16.1

16. Support for HR-Network

17. Support for Multi-tier Networks

17.1