



**IEEE Standard for
Local and metropolitan area networks**

Part 16: Air Interface for Broadband Wireless Access Systems

Amendment 1: Multihop Relay Specification

**IEEE Computer Society
and the
IEEE Microwave Theory and Techniques Society**

Sponsored by the
LAN/MAN Standards Committee

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(Amendment to
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Abstract: This amendment specifies OFDMA physical layer and medium access control layer enhancements to IEEE Std 802.16 for licensed bands to enable the operation of relay stations.

Keywords: broadband wireless access (BWA), MAN, microwave, mobile, multihop relay, OFDM, OFDMA, radio, standard, wireless access systems (WAS), WirelessMAN[®], wireless metropolitan area network

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Introduction

This introduction is not part of IEEE Std 802.16j-2009, IEEE Standard for Local and metropolitan area networks—Part 16: Air Interface for Broadband Wireless Access Systems—Amendment 1: Multihop Relay Specification.

This amendment updates and expands IEEE Std 802.16, specifying OFDMA physical layer and medium access control layer enhancements to IEEE Std 802.16 for licensed bands to enable the operation of relay stations. Subscriber station specifications are not changed. As of the publication date, the current applicable version of IEEE Std 802.16 is IEEE Std 802.16-2009, as amended by IEEE 802.16j-2009.

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IEEE Standard for
Local and metropolitan area networks

Part 16: Air Interface for Broadband
Wireless Access Systems
Amendment 1: Multihop Relay Specification

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NOTE—The editing instructions contained in this amendment define how to merge the material contained herein into the existing base standard and its amendments to form a comprehensive standard.

The editing instructions are shown ***bold italic***. Four editing instructions are used: ***change***, ***delete***, ***insert***, and ***replace***. ***Change*** is used to make small corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by either using ~~striketrough~~ (to remove old material) or underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make large changes in existing text, subclauses, tables, or figures by removing existing material and replacing it with new material. Editorial notes will not be carried over into future editions because the changes will be incorporated into the base standard.

1. Overview

1.1 Scope

1.2 Purpose

1.3.4 Air interface nomenclature and compliance

Insert the following rows in Table 1 as follows:

Table 1—Air interface variant nomenclature and compliance

Designation	Applicability	PHY specification	System features	Duplexing alternative
<u>WirelessMAN-OFDMA MR</u>	<u>Licensed bands below 11 GHz</u>	<u>8.4</u>	<u>=</u>	<u>TDD</u>

Insert new subclause 1.6 as follows:

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.

3. Definitions

Insert the following new definitions in alphabetical order and renumber appropriately:

3.97 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. The access link is either an uplink or downlink.

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

3.99 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).

3.100 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.

3.101 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.

3.102 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.

3.103 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.

3.104 infrastructure station: An MR-BS or RS.

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

3.106 management 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.

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

3.108 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)**.

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

3.110 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.

3.111 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)**.

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

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

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

3.115 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.

3.116 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.

3.117 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.

3.118 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.

3.119 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.

3.120 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.

3.121 simultaneous transmit and receive (STR) relaying: A relay mechanism where transmission to subordinate station(s) and reception from the superordinate station, or transmission to the superordinate station and reception from subordinate station(s) are performed simultaneously.

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

3.123 time-division transmit and receive (TTR) relaying: A relay mechanism where transmission to subordinate station(s) and reception from the superordinate station, or transmission to the superordinate station and reception from subordinate station(s) is separated in time.

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

3.125 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.

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

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

3.128 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.

3.129 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.

4. Abbreviations and acronyms

Insert the following abbreviations and acronyms in alphabetical order:

AC	authentication control
FRS	fixed relay station
HR	handover ranging
IR	initial ranging
IS	infrastructure station
MRS	mobile relay station
MR-BS	multihop relay base station
RS	relay station
RTD	round trip delay
R-ACK	relay ACK
R-DL	relay downlink
R-FCH	relay zone frame control header
R-MAP	relay zone MAP
R-RTI	relay receive/transmit transition interval
R-TTI	relay transmit/receive transition interval
R-UL	relay uplink
R-Zone	relay zone
TDU	tunnel data unit

6. MAC common part sublayer

6.3 Data/Control plane

6.3.1 Addressing and connections

6.3.1.1 Point-to-multipoint (PMP)

Change 6.3.1.1 as indicated:

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 38 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 6.3.21.2.11). The message dialogs provide three CID values. The same CID value is assigned to both members (UL and DL) of each connection pair.

Insert new subclause 6.3.1.2 as follows:

6.3.1.2 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 6.3.1.1. 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 6.3.1.1 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 6.3.34). 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.

Insert new subclause 6.3.1.3.1 as follows:

6.3.1.2.1 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.

6.3.2 MAC PDU formats

Insert the following paragraph at the end of 6.3.2:

MAC PDUs sent on a relay link through a tunnel shall be constructed into a relay MAC PDU of the form illustrated in Figure 21a. Each relay MAC PDU shall begin with a fixed length relay MAC header (see 6.3.2.1.1.1). 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 20. 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.

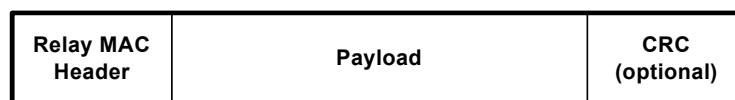


Figure 21a—Relay MAC PDU format

6.3.2.1 MAC header formats

Insert new subclause 6.3.2.1.1.1 as follows:

6.3.2.1.1.1 Relay MAC header format

The header of the relay MAC PDU shall be of the format defined in Table 6a and further illustrated in Figure 23a.

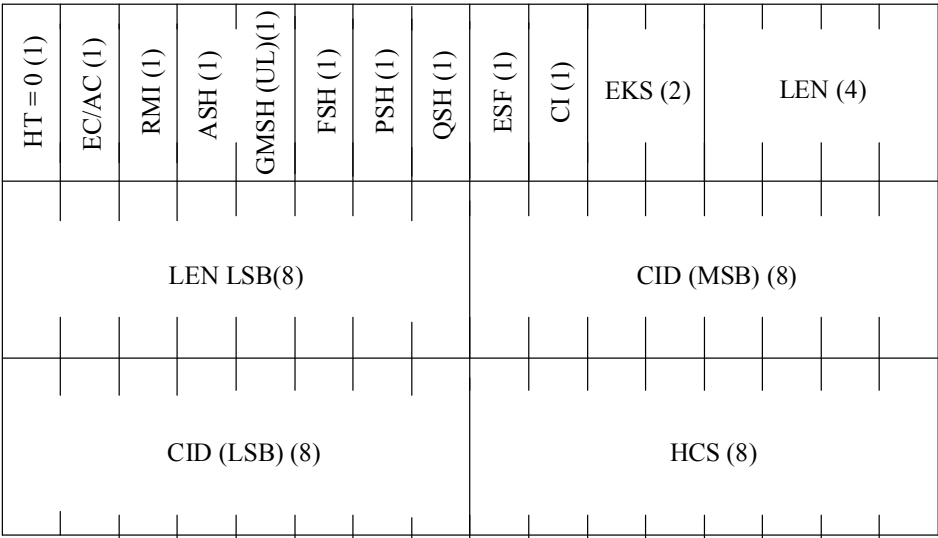


Figure 23a—Header format of relay MAC PDU with payload

Table 6a—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 3. 1 = Payload starting with MT_Transfer message defined in Table 166ag.
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: <i>reserved</i> , shall be set to 0.
FSH	1	Fragmentation subheader (FSH) 1=present; 0=absent
PSH	1	Packing subheader (PSH) 1=present; 0=absent

Table 6a—Description of relay MAC header fields (continued)

Name	Length (bits)	Description
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.

6.3.2.1.2.2 MAC signaling header type II

Change the last row of Table 15 as indicated:

Table 15—Type field encodings for MAC signaling header type II

Type field	MAC header Type (with HT/EC=0b11)	Reference figure	Reference table
1	~~Reserved~~ Extended relay MAC Signaling Header Type II	Figure 34a	Table 18a

6.3.2.1.2.2.1 Feedback header

Change the first paragraph of 6.3.2.1.2.2.1 as indicated:

The feedback header is sent by an MS/RS either as a response to a Feedback Polling IE (see 8.4.5.4.28) or as an unsolicited feedback. When sent as a response to a Feedback Polling IE, the MS/RS shall send a feedback header using the assigned resource indicated in the Feedback Polling IE. When sent as unsolicited feedback, the MS/RS can either send the feedback header on currently allocated UL resource or request additional UL resource by sending an Indication flag on the fast-feedback channel or the enhanced fast-feedback channel (refer to 8.4.5.4.10.11) or by sending a BR ranging code.

Change the two paragraphs before Table 17 of 6.3.2.1.2.2.1 as indicated:

The feedback header may be used by the MS/RS to provide its feedback(s). An MS/RS receiving a feedback header on the DL shall discard the PDU.

The support of feedback header is OFDMA-PHY-specific and shall be negotiated between the BS and SS (or between the MR-BS and RS) as part of the registration dialog (REG-REQ/RSP).

Change Table 17 as indicated:

Table 17—Feedback type and feedback content

Feedback type (binary)	Feedback contents	Description
1110	<u>Early/Late Indication (1bit) +</u> <u>Arrival Delta (8 bits) +</u> <u>CID (16 bits)</u>	<u>Access link transmission status feedback</u> <u>This feedback header type is sent by RS to MR-BS to provide access link transmission status for data. The feedback is used when MR-BS provides a target transmission time of the MAC PDU and the RS detects any abnormality in transmitting the MAC PDU. The RS may report missed transmission due to late arrival of a MAC PDU or abnormal early arrival of a MAC PDU in respect to transmission time.</u> <u>Early/Late Indication:</u> <u>0: Early Indication</u> <u>1: Late Indication</u> <u>Arrival Delta:</u> <u>Number of frames RS received frames early or late based on Early/Late Indication. For Late indication, this value is the difference in frame number between the target transmission time and frame in which the MAC PDU arrives at the RS. For Early indication, this value is the difference between the transit delay of the MAC PDU through the RS and the early detection threshold as set by the “Relay Data Early Arrival Report Threshold” TLV in the SBC-RSP.</u> <u>CID:</u> <u>CID of transport connection between RS and MR-BS</u>
1111	<u>Aggregated MS CQI parameters, in the form of either:</u> <u>Full CQICH reporting: 6×5 bits</u> <u>or</u> <u>Differential CQICH reporting:</u> <u>if N_agg = 0 then 10×3 bits</u> <u>if N_agg = 1 then 16×2 bits</u>	<u>Aggregated MSs CQICH codewords relayed by RS.</u> <u>N_agg is defined in MR-Fast-Feedback region allocation IE.</u>
1110-1111	Reserved for future use	—

Insert new subclause 6.3.2.1.2.2.1.2 as follows:

6.3.2.1.2.2.1.2 Fast feedback reporting in an MR system

In a multihop relay system with RSs operating in centralized scheduling mode, an MR-BS may configure an RS to report on the relay link either full or differential fast feedback reporting using the feedback header defined in 6.3.2.1.2.2.1. Differential fast feedback reporting uses fewer bits; therefore the RS can map multiple MS's fast feedback information on to the feedback header defined by Figure 30.

Differential feedback reporting can be used to report either physical CINR feedback or effective CINR feedback. If differential feedback reporting is performed on effective CINR, then the RS shall perform the differential operation based on the "label" of Table 517.

If an access RS receives a codeword other than physical or effective CINR feedback (e.g., indication flag feedback, MIMO mode feedback or AMC mode transition) on the CQICH channel or Feedback Header from an MS, then the access RS shall not perform the differential operation on the special codeword and shall send the special codeword indication to the MR-BS. The access RS stores the received special codeword and forwards the latest received special codeword to the MR-BS when the MR-BS requests full feedback reporting. When a CINR codeword is followed by a special codeword, differential operation shall be resumed. When an MR-BS receives a special codeword indication, the MR-BS may request full feedback reporting from the RS. An MR-BS may also request full feedback reporting periodically.

An MR-BS may allocate resources on the relay link for forwarding MS CQI parameter reports using a Feedback polling IE as defined in Table 413.

An MR-BS configures the RSs type of reporting (full or differential) using the RS_CQICH_Control IE (see 8.4.5.10.9). An access RS performs differential feedback reporting on behalf of an MS. An access RS extracts the MS's fast feedback channel information from either the CQICH_Allocation_IE or CQICH_enhanced_allocation_IE transmitted in the UL-MAP. When an access RS performs differential feedback reporting, it uses the N_agg field of the RS_CQICH_Control IE for aggregating differential feedback reporting.

The 32-bits payload of "feedback header without CID field" defined in Figure 32 is constructed by aggregating the payload bits from Table 18a or Table 18b, starting from the most significant bits to the least significant bits. The payloads 0b100 and 0b10, respectively, are used to indicate that the access RS received special codewords from the MS. The access RS aggregates the payloads of the corresponding MSs in the 32-bits feedback header in the UL relay zone, starting with the MSB and ending with LSB. The aggregation is performed in the order of the feedback information received in the UL access zone by the RS. Dummy payload bits corresponding to dummy MSs are set to zero, and these bits may be used to fill the payload of the feedback header.

Table 18a—3 bit differential fast feedback encoding per differential CQI report with seven levels of quantization

Quantization step	Payload bits
+3	0b000
+2	0b001
+1	0b010
0	0b011
−1	0b101
−2	0b110
−3	0b111
Special codeword indication	0b100

Table 18b—2 bit differential feedback encoding per differential CQI report with three levels of quantization

Quantization step	Payload bits
+1	0b00
0	0b01
−1	0b11
Special codeword indication	0b10

An access RS stores the last received full feedback information of the MSs and performs differential feedback reporting based on the received feedback information and last stored full feedback information. An access RS quantizes the difference into either seven or three steps according to Table 18a or Table 18b, respectively. If the difference of the two full feedback information is outside the range of the differential quantization steps, then the RS reports the closest quantization step.

When an access RS is requested to transmit differential feedback reporting, it transmits the differential feedback information to the superordinate RS according to the same order in which it receives the fast feedback reporting from the MSs in the fast feedback region of the UL access zone.

Intermediate RSs simply forward to the superordinate station the fast feedback information received in the relay zone. When an RS forwards the fast feedback information to a superordinate station, it puts the differential fast feedback information corresponding to its access zone before the fast feedback information received in the relay zone.

Insert new subclause 6.3.2.1.2.2.2 as follows:

6.3.2.1.2.2.2 Extended MAC signaling header type II

This type of MAC header is only supported on the R-UL. There is no payload following the MAC header. The Extended MAC signaling header type II is illustrated in Figure 34a. Table 18c describes the encoding of the 3-bit extended type field following the type field.

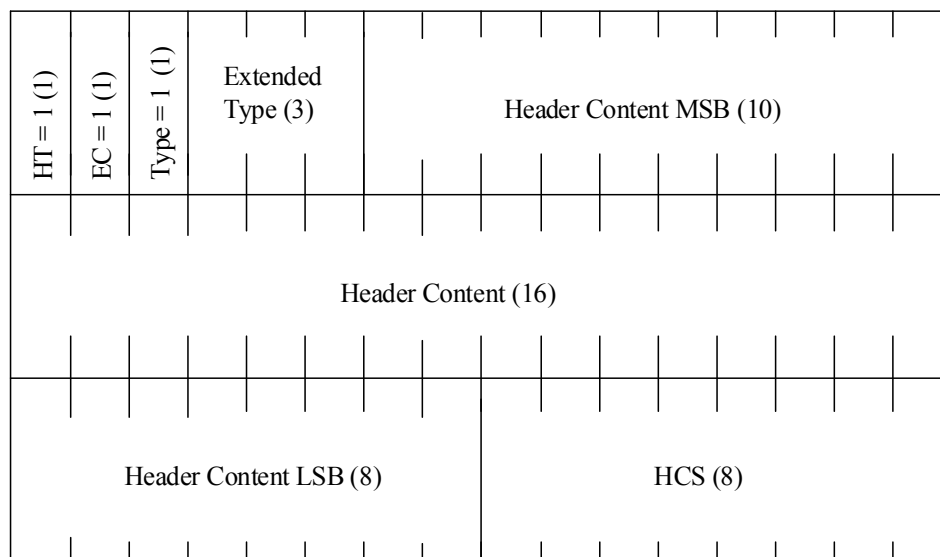


Figure 34a—Extended MAC signaling header type II format

Table 18c—Extended Type field encodings for extended MAC signaling header type II

Extended Type field	MAC header type	Reference figure	Reference table
0	RS BR header	Figure 34b	Table 18d
1	RS UL_DCH signaling header	Figure 34c	Table 18e
2	MR Acknowledgment header	Figure 34d	Table 18f
3	MR HARQ error report header	Figure 34e	Table 18g
4	MR Code-REP header	Figure 34f	Table 18h
5	<i>Reserved</i>	—	—
6	Tunnel BR header	Figure 34g	Table 18i
7	DL Flow Control Header	Figure 34h	Table 18j

Insert new subclause 6.3.2.1.2.2.2.1 as follows:

6.3.2.1.2.2.2.1 RS bandwidth request header (RS BR)

The RS BR header may be sent by a non-transparent RS operating in centralized scheduling mode to the MR-BS to request bandwidth on its access link for the purposes of transmitting messages composed by the RS (such as RNG-RSP, MOB_NBR-ADV, DCD, and UCD). This header shall not be transmitted by a scheduling RS. The RS BR header is illustrated in Figure 34b.

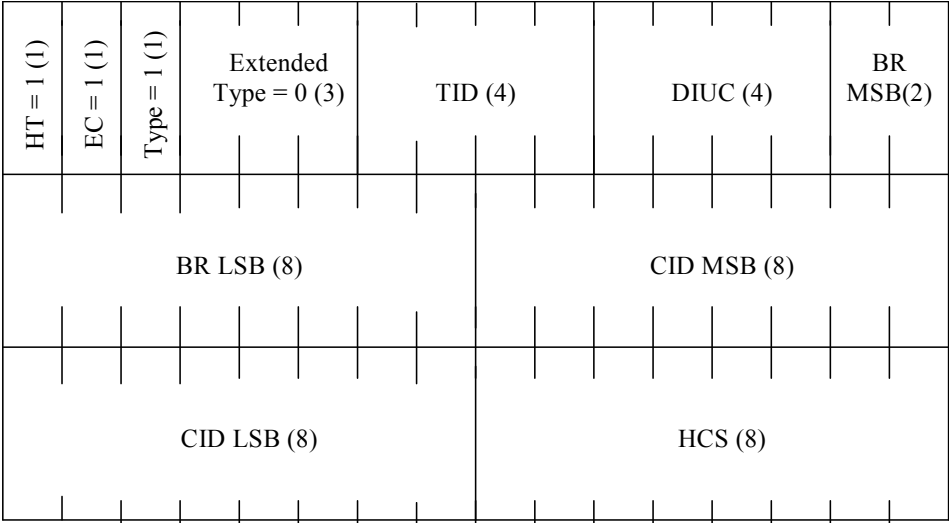


Figure 34b—RS BR header format

Table 18d—Description of fields in RS BR header

Name	Length (bit)	Description
TID	4	Transaction Identifier. MR-BS when allocating resources in response to an RS BR header shall include the same TID in the RS_BW_Alloc_IE as in the RS BR header. The counter used to generate the transaction ID shall be unique per CID per MR-BS.
DIUC	4	Indicates the DIUC used by RS to transmit the message. The MR-BS shall allocate sufficient resources based on the indicated DIUC to send the message from the RS using RS_BW_Alloc_IE.
BR	10	Requested amount of bandwidth in unit of bytes.
CID	16	Basic CID of the RS for which the RS bandwidth request header is sent.
HCS	8	Header Check Sequence (same usage as HCS entry in Table 5).

Insert new subclause 6.3.2.1.2.2.2.2 as follows:

6.3.2.1.2.2.2.2 RS UL DCH signaling header (RS UL_DCH)

A non-transparent RS may request dedicated uplink resources for signaling and data transmissions instead of explicit BW request and allocation for each transmission. The dedicated uplink channel is allocated after receiving the RS_UL_DCH assignment IE. The assignment is a periodic allocation of uplink bandwidth and no subsequent periodic UL-MAP IE is needed in UL-MAP or R-MAP. For the rate based DCH request, the RS only specifies an average required data rate without a specific allocation frequency. The MR-BS or superordinate station determines a specific BW size and frequency configuration in response to the rate based request.

The RS requests a dedicated uplink resource by specifying Relay Link DCH Request through the RS UL_DCH signaling header. The RS confirms the successful reception of the RS_UL_DCH assignment IE by specifying DCH Assignment Acknowledgement (ACK).

It may also be used by an intermediate RS operating in centralized scheduling mode to request HARQ retransmission resource from the MR-BS by specifying HARQ Retransmission Request. The MR-BS responds with RS_UL_DCH HARQ RETX IE.

The format of this header is illustrated in Figure 34c and described in Table 18e.

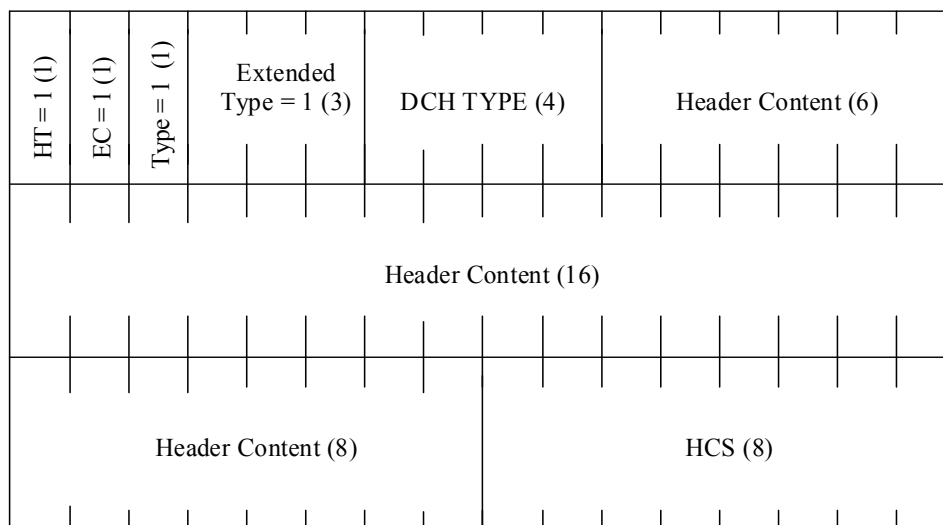


Figure 34c—RS UL_DCH signaling header format

Table 18e—Description of fields in RS UL_DCH signaling header

Name	Length (bits)	Description
HT	1	Shall be set to 1
EC	1	Shall be set to 1
Type	1	Shall be set to 1
Extended Type	3	Shall be set to 001 for RS UL_DCH signaling header
DCH TYPE	4	0000 = Relay Link DCH Request 0001 = DCH Assignment Acknowledgement (ACK) 0010 = HARQ retransmission request 0011–1111 = <i>Reserved</i>
if (DCH TYPE == 0000){	—	Relay Link DCH Request
Request Type	2	00 = DCH Request Incremental 01 = DCH Request Aggregate 10 = DCH Request Rate Based 11 = <i>Reserved</i>
if (Request Type == 00){	—	DCH Request Incremental

Table 18e—Description of fields in RS_UL_DCH signaling header (continued)

Name	Length (bits)	Description
Bandwidth request	16	Number of bytes requested by the RS
N	4	Allocation repeats once every N frames
}elseif (Request Type == 01){		DCH Request Aggregate
Bandwidth Request	16	Number of bytes requested by the RS. Zero in this field indicates DCH release request
N	4	Allocation repeats once every N frames
}elseif (Request Type == 10){	—	DCH Request Rate Based
Average rate	20	Average data rate in units of bytes per second 18 MSB bits: magnitude 2 LSB bits: base-10 exponent
}	—	—
RS CID	8	8 LSBs of Basic CID of RS
} else if (DCH TYPE == 0001) {	—	DCH Assignment Acknowledgement (ACK)
Frame Number	8	8-bit LSBs of the frame in which the RS_UL_DCH assignment IE is received
DCH resource ID	3	The value of DCH resource ID in the corresponding RS_UL_DCH assignment IE
RS CID	8	8 LSBs of Basic CID of RS
<i>Reserved</i>	11	Shall be set to 0
} else if (DCH TYPE == 0010) {	—	HARQ retransmission request
RS CID	8	8 LSB of Basic CID of the RS requiring HARQ retransmission
Number of bursts	2	—
for (i=0;i< Number of bursts; i++) {	—	—
DCH resource ID	3	ID of the DCH resource that needs HARQ retransmission
DCH ACID	4	HARQ channel require retransmission
<i>Reserved</i>	1	Shall be set to 0
}	—	—
Padding	<i>variable</i>	Shall be set to 0
}	—	—
HCS	8	Header check sequence

Insert new subclause 6.3.2.1.2.2.3 as follows:

6.3.2.1.2.2.3 MR Acknowledgment header

An MR acknowledgment header may be sent by an RS as a response to a MAC management message received from the MR-BS or its superordinate RS that requires acknowledgment. When an acknowledgment is required, unsolicited uplink bandwidth may be provided to the RS to send this header to the MR-BS or its superordinate RS as an indication of the message reception. The MR acknowledgment header shall be sent on the same CID as the received MAC management message. The MR acknowledgment header is illustrated in Figure 34d. The support of MR acknowledgment header is optional for both MR-BS and RS and shall be negotiated during network entry of an RS using REG-REQ and REG-RSP message.

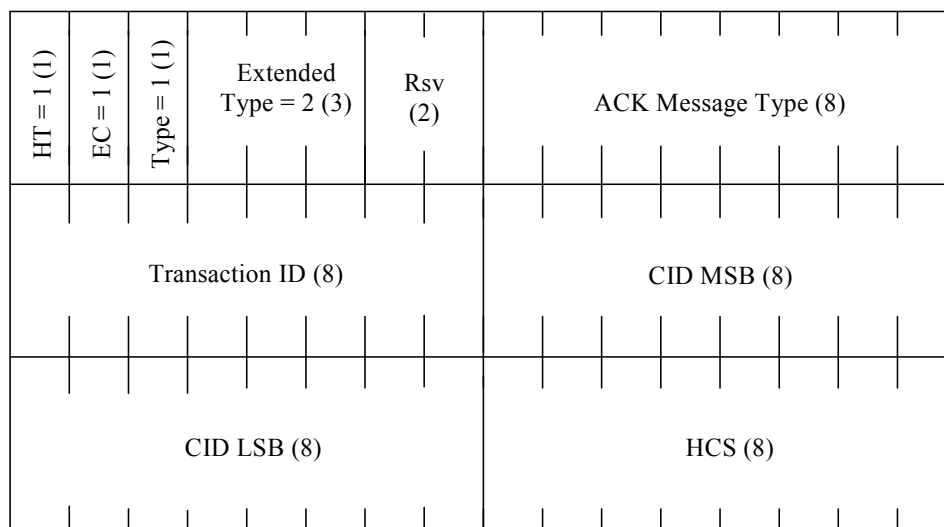


Figure 34d—MR Acknowledgement header format

Table 18f—Description of fields in MR acknowledgement header

Name	Length (bits)	Description
Rsv	2	<i>Reserved</i>
ACK Message Type	8	The MAC message type of the message received by the RS from the MR-BS or its superordinate RS.
Transaction ID	8	8 LSB of the Transaction ID included in the MAC management message received from the MR-BS. If Transaction ID is not included, set this field to zero. The counter used to generate the transaction ID shall be unique per CID per MR-BS.
CID	16	The same CID as the received MAC management message.
HCS	8	Header Check Sequence (same usage as HCS entry in Table 5).

Insert new subclause 6.3.2.1.2.2.4 as follows:

6.3.2.1.2.2.4 MR HARQ error report header

In case of centralized scheduling, the MR HARQ Error Report header may be transmitted by RS to provide ACK/NAK to MR-BS when RS is unable to decode the HARQ DL data successfully. The RS may send this header to MR-BS or superordinate RS as an unsolicited feedback in UL relay zone. Intermediate RS forwards the MR HARQ Error report header toward the MR-BS. The header format is illustrated in Figure 34e.

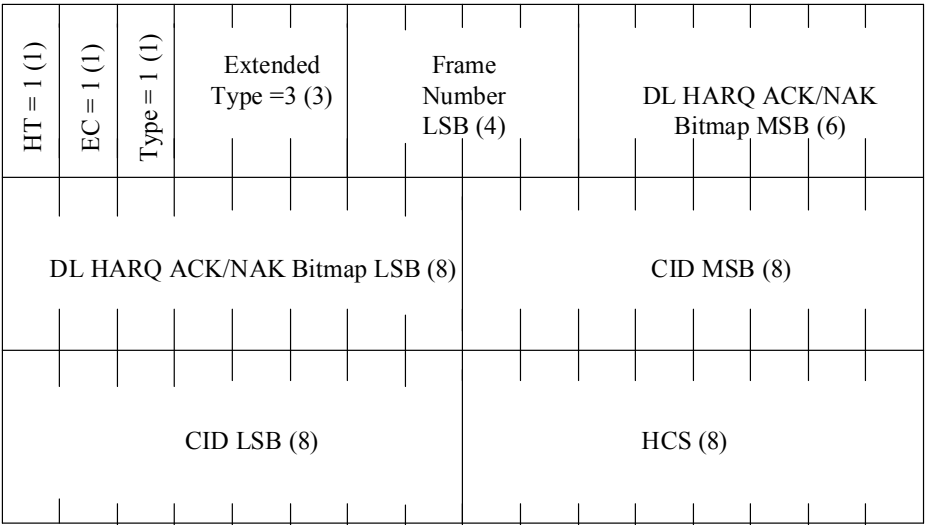


Figure 34e—MR HARQ error report header format

Table 18g—Description of fields in MR HARQ error report header

Name	Length (bit)	Description
Frame Number	4	Least significant 4 bits of frame number where the DL HARQ burst is received by the RS
DL HARQ ACK/NAK bitmap	14	RS transmits ACK/NAK Bitmap of DL HARQ data of previous frame. The order of Bitmap from MSB to LSB follows the order of DL HARQ subburst
CID	16	Basic CID of the RS
HCS	8	Header Check Sequence (same usage as HCS entry in Table 5)

Insert new subclause 6.3.2.1.2.2.2.5 as follows:

6.3.2.1.2.2.2.5 MR Code-REP header

MR Code-REP header, illustrated in Table 18h, is used by a non-transparent RS operating in centralized scheduling mode to request the MR-BS to generate CDMA Allocation IEs with the following fields set to zero: Frame Number Index, Ranging Code, Ranging Symbol, and Ranging Subchannel. This header may also be used for requesting permission from the MR-BS to accept MSs attempting network entry.

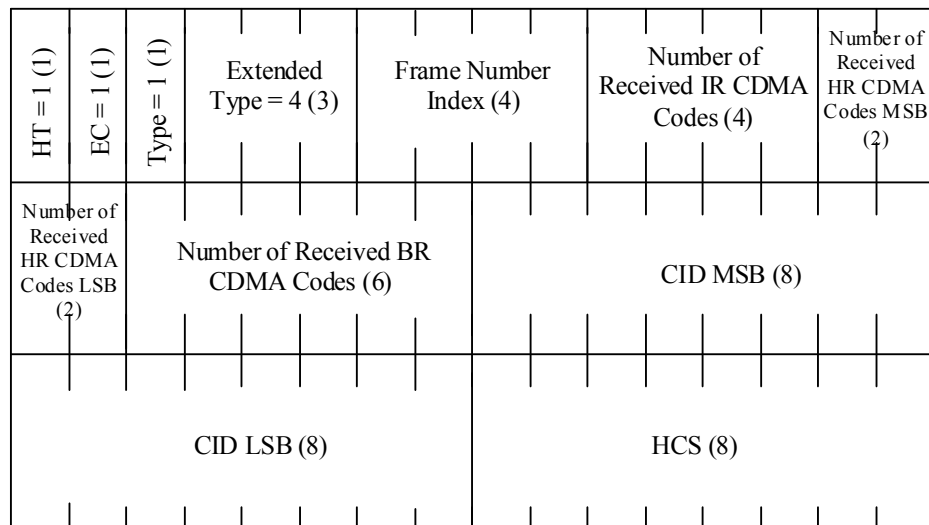


Figure 34f—MR Code-REP header format

Table 18h—Description of fields in MR Code-REP header

Name	Length (bits)	Description
Frame Number Index	4	LSBs of relevant frame number
Number of Received IR CDMA Codes	4	Number of CDMA initial ranging code that requires no correction
Number of Received HR CDMA Codes	4	Number of CDMA handover ranging code that requires no correction
Number of Received BR CDMA Codes	6	Number of CDMA bandwidth request ranging codes
Basic CID	16	RS basic CID
HCS	8	Header Check Sequence (same usage as HCS entry in Table 5)

Insert new subclause 6.3.2.1.2.2.2.6 as follows:

6.3.2.1.2.2.2.6 Tunnel BR header

When tunnel mode is used by scheduling RSs and when QoS subheader is used, the RS may send tunnel BR (Bandwidth Request) to the superordinate scheduling station to request bandwidth. The scheduling type field and priority field are used to indicate the QoS type of bandwidth requested, and the CID field is tunnel CID.

The tunnel BR header is illustrated in Figure 34g.

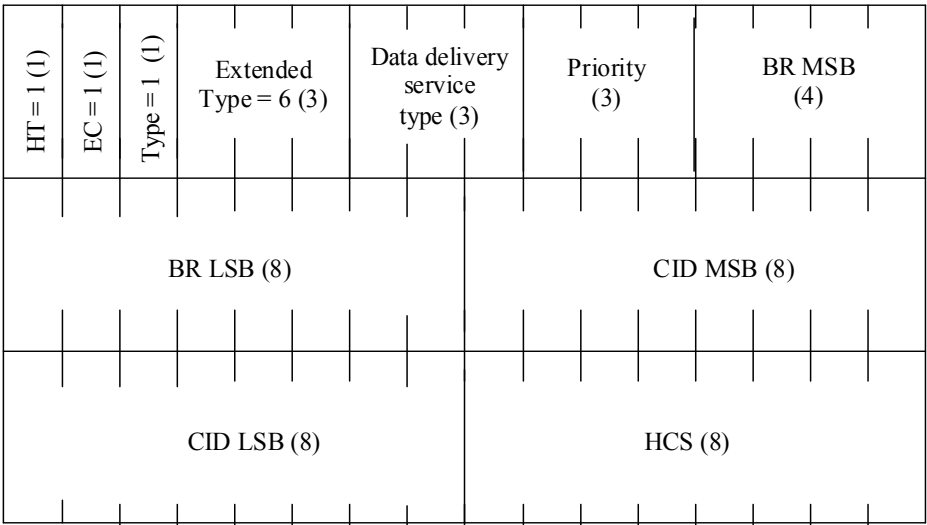


Figure 34g—Tunnel BR header format

Table 18i—Description of fields in Tunnel BR header

Name	Length (bit)	Description
Data delivery service type	3	0: UGS; 1: RT-VR; 2: NRT-VR; 3:BE; 4:ERT-VR; 5–7: <i>Reserved</i>
Priority	3	Priority defined in 11.13.5
BR	12	Requested amount of bandwidth (128 byte/bit)
CID	16	Tunnel CID which requires the bandwidth
HCS	8	Header check sequence (same usage as HCS entry in Table 5)

Insert new subclause 6.3.2.1.2.2.7 as follows:

6.3.2.1.2.2.7 DL flow control header

The DL flow control header is used to perform DL flow control between a scheduling RS and its scheduling station. This header is sent by an RS to its superordinate RS or MR-BS to report the number of bytes that the RS can receive in the DL direction. See 6.3.6.7.1.3 for the usage of this message.

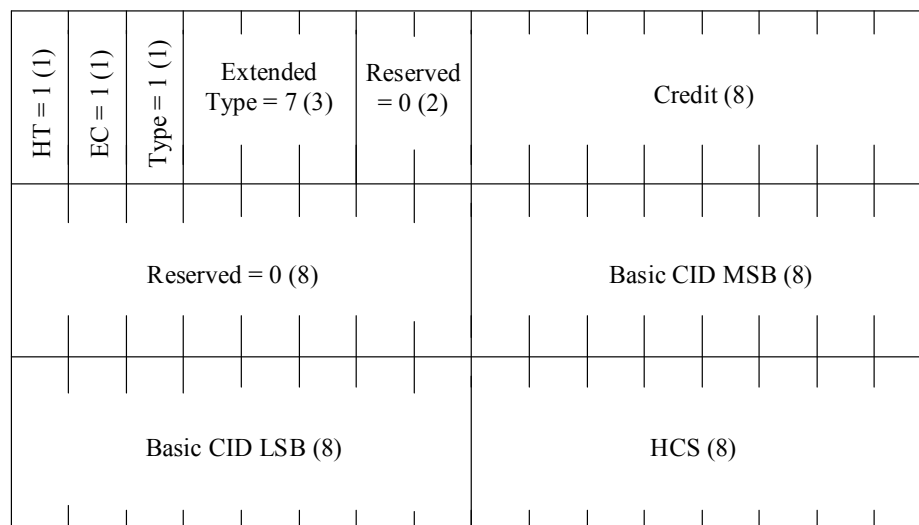


Figure 34h—DL flow control header format

Table 18j—Description of fields in DL Flow Control header

Name	Length (bit)	Description
<i>Reserved</i>	2	Set to 0.
Credit	8	Indicates the state of the flow control protocol and number of bytes of DL traffic that the superordinate RS or MR-BS can send to the subordinate RS. 0–254: Flow control is in controlled state. The value indicates the number of bytes of DL traffic that can be safely received according to the following formula: Credit × 256 255: Flow control is in the uncontrolled state.
<i>Reserved</i>	8	Set to 0.
Basic CID MSB	8	MSB of Basic CID of the station whose traffic is to be flow controlled.
Basic CID LSB	8	LSB of Basic CID of the station whose traffic is to be flow controlled.
HCS	8	Header Check Sequence.

6.3.2.2 MAC subheaders and special payloads

Insert new subclause 6.3.2.2.8 as follows:

6.3.2.2.8 Relay MAC PDU subheaders

Five types of subheaders may be present in a relay MAC PDU: Fragmentation subheader, Packing subheader, QoS subheader, Grant management subheader and Allocation subheader. The Packing and Fragmentation subheaders are mutually exclusive and shall not both be present within the same relay MAC PDU. When multiple subheaders are present in the same relay MAC PDU, they shall be ordered as follows: Grant management subheader, QoS subheader, Fragmentation or Packing subheader, and Allocation subheader. All subheaders in the relay MAC PDU are not encrypted.

Extended subheaders may also be present in a relay MAC PDU. When present, the extended subheader shall always appear immediately after the Relay MAC header, and before all other subheaders. All extended subheaders are not encrypted.

Insert new subclause 6.3.2.2.8.1 as follows:

6.3.2.2.8.1 QoS subheader (QSH)

The QoS subheader is specified in Table 37a. The QoS subheader may be used for relay MAC PDU on relay link in a transport tunnel.

Table 37a—QoS subheader format

Syntax	Size (bit)	Notes
QoS Subheader() {	—	—
Data delivery service	3	0:UGS; 1: RT-VR; 2: NRT-VR; 3:BE; 4:ERT-VR; 5–7: <i>Reserved</i>
Priority	3	Priority is as defined in 11.13.5
<i>Reserved</i>	2	—
}	—	—

Insert new subclause 6.3.2.2.8.2 as follows:

6.3.2.2.8.2 Allocation subheader

The MR-BS may include the allocation subheader in a relay MAC PDU. When operating in centralized scheduling mode, the MR-BS shall use the Allocation subheader to indicate the frame in which the RS shall relay the MAC PDU. When included, the MR-BS shall use one allocation subheader per RS for the relay link, and one or more allocation subheader for the access link. The allocation subheaders corresponding to the relay link shall precede the ones for access link. If there are multiple intermediate RSs, the allocation subheader associated with the RS that is nearest to the MR-BS shall be included first. The access RS shall use the continuation bit in the allocation subheader to detect whether there is a subsequent allocation subheader.

When operating in distributed scheduling mode, the MR-BS may include the Allocation subheader to indicate the frame in which the RS shall transmit an MBS MAC PDU over the access link. When included, MR-BS shall use only one Allocation subheader per MBS MAC PDU. The access RS shall transmit the MBS MAC PDU over the access link in the target transmission frame specified in Allocation subheader.

The allocation subheader format is specified in Table 37b. When used in distributed scheduling mode for MBS MAC PDU, only the target transmission frame field shall be used.

Table 37b—Allocation subheader format

Syntax	Size (bits)	Notes
Allocation subheader{	—	—
Target Transmission Frame	6	LSB 6 bits of frame number of the frame that RS shall transmit the MAC PDU.
Allocation Index	6	Allocation Index pointing to DL-MAP_IE in the RS_Relay-MAP and the RS_Access-MAP message.
Number of MAC PDUs	3	Number of MAC PDUs in this allocation.
Continuation	1	1: Another Allocation subheader follows 0: This is the last Allocation subheader for the RS.
}	—	—

Insert new subclause 6.3.2.2.8.3 as follows:

6.3.2.2.8.3 Fragmentation subheader (FSH)

The FSH in a relay MAC PDU indicates the location of a fragment of a TDU originating from the ingress station of the tunnel. The format of the fragmentation subheader is specified in Table 37c.

Table 37c—Fragmentation subheader format

Syntax	Size (bits)	Notes
Fragmentation subheader{	—	—
More fragments (MF) flag	1	MF is set for all fragments of the same TDU except the last one.
TDU sequence number (TSN)	7	The sequence number of the TDU to which this fragment belongs.
Fragment offset (FO)	12	The offset of the fragment relative to the beginning of the TDU.
<i>Reserved</i>	4	Shall be set to zero.
}	—	—

Insert new subclause 6.3.2.2.8.4 as follows:

6.3.2.2.8.4 Packing subheader (PSH)

The PSH in a relay MAC PDU indicates the location and the length of a fragment of a TDU originating from the ingress station of the tunnel. The format of the packing subheader is specified in Table 37d.

Table 37d—Packing subheader format

Syntax	Size (bit)	Notes
Packing subheader{	—	—
More fragments (MF) flag	1	MF is set for all fragments of the same TDU except the last one
TDU sequence number (TSN)	7	The sequence number of the TDU to which this fragment belongs
Fragment offset (FO)	12	The offset of the fragment relative to the beginning of the TDU
Fragment Length	12	The length of the fragment
}	—	—

6.3.2.3 MAC management messages

Change Table 38 as indicated:

Table 38—MAC management messages

Type	Message name	Message description	Connection
0	UCD	UL Channel Descriptor	Fragmentable broadcast or <u>RS Primary Management</u> or <u>RS Multicast Management</u>
1	DCD	DL Channel Descriptor	Fragmentable broadcast or <u>RS Primary Management</u> or <u>RS Multicast Management</u>
<u>70</u>	<u>RCD</u>	<u>R-link channel descriptor</u>	<u>RS Primary Management</u> , <u>RS Multicast Management</u>
<u>71</u>	<u>MR_NBR-INFO</u>	<u>MR_NBR-INFO</u>	<u>RS Primary Management</u>
<u>72</u>	<u>MR_RNG-REP</u>	<u>MR Ranging report</u>	<u>RS Basic</u>
<u>73</u>	<u>RS_Config-CMD</u>	<u>RS configuration command</u>	<u>RS Primary Management</u>
<u>74</u>	<u>RS_NBR_MEAS-REP</u>	<u>RS neighbor station measurement report</u>	<u>RS Basic</u>
<u>75</u>	<u>MR_LOC-REQ</u>	<u>MR location information request</u>	<u>RS Primary Management</u>

Table 38—MAC management messages (continued)

76	<u>MR_LOC-RSP</u>	<u>MR location information response</u>	<u>RS Primary Management</u>
77	<u>MS_SCN-INF</u>	<u>MS scanning inform</u>	<u>RS Basic</u>
78	<u>MS_SCN-CLT</u>	<u>MS scanning completion</u>	<u>RS Basic</u>
79	<u>MS_INFO-DEL</u>	<u>MS context information delete</u>	<u>RS Basic</u>
80	<u>CLK-SYNC</u>	<u>RS clock synchronization</u>	<u>RS Multicast Management</u>
81	<u>MR_ASC-REQ</u>	<u>MR association request</u>	<u>RS Basic</u>
82	<u>MR_ASC-RSP</u>	<u>MR association report</u>	<u>RS Basic</u>
83	<u>RS_MOB_MEAS REQ</u>	<u>RS group measurement request</u>	<u>RS Multicast Management</u>
84	<u>HARO_Chase_ER-REP</u>	<u>RS chase HARQ error report</u>	<u>RS Basic</u>
85	<u>HARO_IR_ER-REP</u>	<u>RS IR HARQ error report</u>	<u>RS Basic</u>
86	<u>MR_SLP-INFO</u>	<u>MS sleep mode information</u>	<u>RS Basic</u>
87	<u>RS_AccessRS-REQ</u>	<u>RS access station selection request</u>	<u>RS Basic</u>
88	<u>RS-SCH</u>	<u>RS scheduling information</u>	<u>RS Basic</u>
89	<u>RS_Member_List_Update</u>	<u>RS group member list update</u>	<u>RS Multicast Management</u>
90	<u>MR_PBBR-INFO</u>	<u>MR piggybacked bandwidth request information</u>	<u>RS Basic</u>
91	<u>MR_Generic-ACK</u>	<u>Generic ACK of received message</u>	<u>RS Basic</u>
92	<u>RS_Access-MAP</u>	<u>MAP information in centralized scheduling mode</u>	<u>RS Basic, RS Multicast Management</u>
93	<u>RS_Relay-MAP</u>	<u>R-MAP information in centralized scheduling mode</u>	<u>RS Basic</u>
94	<u>MOB_INF-IND</u>	<u>Mobile information indication</u>	<u>RS Basic</u>
95	<u>MS_Context-REQ</u>	<u>MS's context request</u>	<u>RS Basic</u>
96	<u>MS_Context-RSP</u>	<u>MS's context response</u>	<u>RS Basic</u>
97	<u>MT_Transfer</u>	<u>Transfer of MAC management messages in management tunnel</u>	<u>RS Management Tunnel</u>
98–255	—	<i>Reserved</i>	—

An extended set of MAC management messages specific to an MR system are defined and listed in Table 38. These messages may be exchanged between an RS and its superordinate station on either the RS's primary management, RS's basic or RS's multicast management connections in addition to the non-MR system specific messages.

6.3.2.3.6 RNG-RSP (ranging response) message

Change Table 44 as indicated:

Table 44—RNG-RSP message format

Syntax	Size (bit)	Notes
RNG-RSP_Message_Format() {	—	—
Management Message Type = 5	8	—
<i>Reserved</i>	~~8~~	Shall be set to zero
<u>H-FDD Group Indicator</u>	1	<u>0: Group 1</u> <u>1: Group 2</u>
TLV Encoded Information	<i>variable</i>	TLV-specific
}	—	—

Change the paragraph of 6.3.2.3.6 as follows:

Preamble Index Override

Preamble Indices of new target BS(s), and RS(s) where the MS or RS should redo ranging. If the TLV includes two or more Preamble Indices, the first one in the list is the most preferable and the second is the next preferable. When the TLV is used with Downlink frequency override TLV, the MS or RS should redo ranging on the new DL channel identified by the Preamble Indices.

Insert the following text at the end of 6.3.2.3.6:

The following parameter may be included in the RNG-RSP message for the purpose of assigning CDMA ranging codes to an RS:

RS CDMA Codes TLV (see 11.6)

The MR-BS may include the following TLV parameter to identify re-entry process management messages that may be omitted during an RS handover:

RS Network Entry Optimization (see 11.6)

Identifies entry or re-entry process management messages that may be omitted during the current entry or re-entry attempt.

During network re-entry, the RS shall not enter Normal Operation with Target MR-BS until completing receiving all network reentry, MAC management message responses as indicated in this TLV.

The following parameter may be included in the RNG-RSP message when the MRS is attempting to perform network re-entry or handover:

CID List TLV (see 11.6.1)

The RNG-RSP message transmitted to an RS may contain the following TLVs:

Path Addition (see Table 11.1.13.2)

Specification of the path addition operations