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Re:	GRIDMAN Amendment Working Draft for 802.16rev3
Abstract	Draft of 802.16n Amendment, based on 802.16rev3 D2, 802.16n-11/0009r1, and comment resolutions approved during Session #75 as documented in Commentary database 802.16n-11/0017r2
Purpose	
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IEEE 802.16n AWD (Oct 2011)

Amendment Working Document (AWD) to IEEE Standard for

Local and metropolitan area networks

Part 16: Air Interface for Broadband Wireless Access Systems —

Enhancements to Support Higher Reliability Operations

NOTE- The editing instructions are shown in ***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 using strike through (to remove old material) and 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. New materials to be added to existing standard are blue underlined. New materials under Clause 16 are in black and are not underlined.

1. Overview

1.7 Higher Reliability Operations

2. Normative References

3. Definitions

[Insert the following definitions (renumbering may be required):]

3.224 Degraded Network: The failure of one or more 802.16 network infrastructure nodes or network connectivity.

3.225 Robustness: The capability of the network to withstand and automatically recover from degradation to provide the required availability to support mission critical applications (essential to the core function of society and the economy) including recovery from a single point of failure.

3.226 Mobile Base Station: A base station which is capable of maintaining service while moving.

3.227 Radio Path Redundancy: The ability to provide alternative paths between base stations, relay stations, and subscriber stations.

3.228 HR-MS: A subscriber station that complies with the requirements for subscriber stations in high reliable network.

3.229 HR-BS: A base station that complies with the requirements for base stations in high reliable network.

3.230 HR-RS: A relay that complies with the requirements for relays in high reliable network.

3.231 HR-Network: A network whose stations comply with their respective HR requirements.

3.232 HR-station: An HR-MS, HR-BS, or HR-RS.

3.233 Infrastructure station: An HR-BS or HR-RS.

3.234 Directly Associated: An HR-MS is directly associated with an infrastructure station if it is effectively controlled directly by it.

3.235 Indirectly Associated: An HR-MS is indirectly associated with an infrastructure station if it is effectively controlled by it through a forwarding HR-MS.

3.236 Coexistence: Coexistence is a state by which multiple wireless communications systems in same vicinity share a same radio frequency channel while minimizing harmful interference to each other by appropriate measures.

3.237 Self-coexistence: In HR network, self-coexistence is coexistence of multiple HR cells.

3.238 Self-coexistence mode: Self-coexistence mode is an operation mode of HR network, in which multiple HR cells share the same frequency channel in time.

3.239 Forwarding Between Infrastructure Stations (FBIS): The function of forwarding data between Infrastructure stations through a sub-ordinate station in HR-Network.

3.240 Designated FBIS HR-MS: A HR-MS which is designated to forward data between Infrastructure stations in HR-Network.

3.241 FBIS connection: A unidirectional mapping between two Infrastructure stations using Forwarding Between Infrastructure Stations in HR-Network. Forwarding connections are divided into outgoing Forwarding connection and incoming Forwarding connection in the initiating Infrastructure Station point-of-view. A Forwarding connection consists of two connections (connections between a sub-ordinate station and each Infrastructure station) and two connections are coupled each other at the sub-ordinate station.

4. Abbreviations and Acronyms

[Insert the following abbreviations:]

HR	High Reliability
PPDR	Public Protection and Disaster Relief
SPOF	Single Point of Failure

5. Service-specific CS

6. MAC common part sublayer

6.3 MAC PDU formats

6.3.2.3 MAC management messages

[Change Table 54 as indicated (renumbering may be required):]

Table 54—MAC management messages

Type	Message Name	Message Description	Connection
110	MM-ADV	Multimode Advertisement message	
111	MMRS-REQ	Multimode Relay Request message	
112	MMRS-RSP	Multimode Relay Response message	
113	MMRL-REQ	Multimode Release Request message	
114	MMRL-RSP	Multimode Release Response message	
115	DSA_REQ	Dynamic Service Add Request message	
116	DSA_RSP	Dynamic Service Add Response message	
117	DSA_ACK	Dynamic Service Add Acknowledge message	
118	DSX_RVD		
119	DC_DISCOV	Direct Communication Discovery message	
120	AP-NBR-REQ	message	
121	AP-NBR-REP		

6.3.2.3.5 RNG-REQ (ranging request) message

[Change the text in 6.3.2.3.5 RNG-REQ (ranging request) message as follows:]

…….

The following TLV parameter shall be included in the RNG-REQ message when the MS is attempting to perform reentry, HO, or location update:

Ranging Purpose Indication

The presence of this item in the message indicates the following MS action:

If Bit 0 is set to 1, in combination with a serving BSID, it indicates that the MS is currently attempting to HO or reentry; or, in combination with a Paging Controller ID, indicates that the MS is attempting network reentry from idle mode to the BS.

If Bit 1 is set to 1, it indicates that the MS is initiating the idle mode location update process.

Bit 2: Seamless HO indication. When this bit is set to 1 in combination with other included information elements, it indicates the MS is initiating ranging as part of seamless HO procedure.

Bit 3: Ranging Request for Emergency Call Setup. When this bit is set to 1, it indicates MS action of Emergency Call Process.

Bit 4: MBS update. When this bit is set to 1, the MS is currently attempting to perform location update due to a need to update service flow management encodings for MBS flows.

Bit 5: HR Multicast service flow update. When this bit is set to 1, the MS is currently a need to update multicast service flow management encodings for multicast transmission due to crossing Multicast Group zone.

Bits ~~5~~6–7: *Reserved*

…….

6.3.2.3.6 RNG-RSP (ranging response) message

[Insert the following text at the end of 6.3.2.3.6 RNG-RSP (ranging response) message as follows:]

The following parameters shall be included only if the bit 4 of ranging purpose indication in the RNG-REQ message is set to 1.

HR multicast service flow update mapping info (see 11.1.13)

HR multicast service flow update mapping info is used by the BS' in one multicast zone to provide consistency of HR Multicast CID mapping used in other multicast zone as determined by the serving multicast zone.

6.3.2.3.42 MOB_NBR-ADV (neighbor advertisement) message

[Insert the following text at the end of 6.3.2.3.42 MOB_NBR-ADV (neighbor advertisement) message as follows:]

HR multicast service flow update mapping info (see 11.1.13)

HR multicast service flow update mapping info is used by the BS' in one multicast zone to provide consistency of HR Multicast CID mapping used in other multicast zone as determined by the serving multicast zone.

6.3.2.3.47 MOB_BSHO-REQ (BS HO request) message

[Change Table 168 as indicated:]

Table 168 – MOB_BSHO-REQ message format

Syntax	Size (bit)	Notes
…		
Mode	3	0b000: HO Request 0b001: MDHO/FBSS request: Anchor BS update with CID update 0b010: MDHO/FBSS request: Anchor BS update without CID update 0b011: MDHO/FBSS request: Diversity set update with CID update 0b100: MDHO/FBSS request: Diversity set update without CID update 0b101: MDHO/FBSS request: Diversity set update with CID update for newly added BS 0b110: MDHO/FBSS request: Diversity set update without CID update for newly added BS ~~0b111: *Reserved.*~~ 0b111: Alternative Path (only for HR-Network)
Padding	5	Shall be set to zero.
If (Mode == 0b000 or 0b111)	-	-
…		
HO_authorization policy indicator	1	Indicates whether Seamless HO mode is supported 0: Not supported 1: Supported
Seamless HO mode flag	1	Indicates whether Seamless HO mode is supported 0: Not supported 1: Supported
If (Mode == 0b111) {	-	-
Role	1	0b0: Stay as HR-MS; 0b1: Change to HR-RS;
CDMA_code	8	-
Transmission_opportunity_offset	8	-
Basic CID	16	-
}		

[Change the definition for Action Time in* MOB_BSHO-REQ message as *indicated:]

Action Time

For HO, this value is defined as number of frames until the Target BS allocates a dedicated transmission opportunity for RNG-REQ message to be transmitted by the MS using Fast_Ranging_IE. Dedicated allocation for transmission of RNG-REQ means that channel parameters for that BS learned by the MS before HO stay valid and can be reused during actual Network Re-entry without preceding CDMA-based Ranging. Final Action Time shall be decided by the Serving BS based on the information obtained from potential Target BSs over the backbone network. A value of zero indicates no opportunity to allocate Fast Ranging IE in any candidate target BS.

For MDHO/FBSS, this is the time of update of Anchor BS and/or Diversity Set. A value of zero in this parameter signifies that this parameter shall be ignored.

For Alternative Path, this is the wait time in units of 1 ms before the HR-MS performs fast network reentry to target station.

6.3.2.3.98 MAC management messages for HR-Network

6.3.2.3.98.1 MM-ADV (multimode advertisement) message

Infrastructure stations and HR-MS acting as HR-BS or HR-RS may transmit MM-ADV message to support multimode operation in the case as follows:

- When the backhaul link is down or up
- During maintaining relay link due to unavailable backhaul link, PHY/MAC layer parameters need be reconfigured such as
    - Power down
    - Power reduction
    - FA change
- Multimode service establish/release/change to inform subordinate stations to perform handover

6.3.2.3.98.2 MMRS-REQ (multimode relay request) message

To establish relay link between a multimode station and superordinate HR-BS, MMRS-REQ message is transmitted by the multimode station or the superordinate HR-BS.

6.3.2.3.98.3 MMRS-RSP (multimode relay response) message

An MMRS-RSP message is transmitted by multimode station or superordinate HR-BS in response to MMRS-REQ message.

6.3.2.3.98.4 MMRL-REQ (multimode release request) message

HR-MS transmits MMRL-REQ message for the purpose as follows:

- to release its relay mode and to return its original role
- to response or reject the unsolicited MMRL-RSP message by the HR-BS

6.3.2.3.98.5 MMRL-RSP (multimode release response) message

An MMRL-RSP message is transmitted by multimode station or superordinate HR-BS in response to MMRL-REQ message.

6.3.2.3.98.6 DSA_REQ message

When HR-BS establishes direct communication between the source and destination HR-MSs, the DSA_REQ from HR-BS to the destination HR-MS shall contain a TLV that indicates of direct communication link setting up.

The TLV for direct communication is defined in 11.13.46.

6.3.2.3.98.7 DSA_RSP message

When HR-BS establishes service flow over direct communication between the source and destination HR-MSs setting up direct communication, the DSA_RSP from HR-BS to the source HR-MS shall indicate by a TLV that a direct communication link should be used for the coming flow.

6.3.2.3.98.8 DSA_ACK message

After receiving the DSA_ACK from the destination HR-MS, the HR-BS shall send DSA_RSP to the source HR-MS.

6.3.2.3.98.9 DSX_RVD message

When setting up a direct communication link between source and destination HR-MSs, HR-BS should set the confirmation code in DSX_RVD to direct-com-setup as defined in table713.

6.3.2.3.98.10 DC_DISCOV (Direct Communication Discovery) message

The discovery message follows the DL-MAP and shall take the following encoding format:

Table 1001—DC discovery message encodings

Syntax	Size (bit)	Notes
DC_DISCOV_Message() {	—	—
Length	16	The length of the message
NBR Count	8	Number of neighboring HR-MSs
for(i=0;i<n;i++){		
DC_DISCOV_IE();		
}		

}		

MAC Address

MAC address is the 48 bit address assigned to the HR-MS device. It shall be used as unique identity of the HR-MS in network discovery.

NBR Count

The value indicates the number of neighboring HR-MSs that the current HR-MS discovered via the neighbor discovery process.

DC_DISCOV_IE

Various information such as name of the HR-MS, MAC address of the neighboring node, invitation for communication etc is contained in the IEs.

6.3.2.3.98.10.1 Encoding of DC_DISCOV_IEs

The IEs contained in discovery message has a common encoding format as follows:

Table 1002—DC discovery IE encodings

Syntax	Size (bit)	Notes
DC_DISCOV_IE() {	—	—
Type	8	—
Length	8	The length of data contained in the value field
Value	variable	
}		

A few type of IE has been defined in Table 1003.

Table 1003—DC discovery IE types

Type	**Name**
0x01	DC_DISCOV_NODE_NAME
0x02	DC_DISCOV_NBR_ADDR
0x03	DC_DISCOV_INVITE
0x04	DC_DISCOV_INVITE_ACCEPT
0x05	DC_DISCOV_INVITE_REJECT
0x06 – 0xfe	Reserved
0xff	DC_DISCOV_DATA

6.3.2.3.98.10.1.1 DC_DISCOV_NODE_NAME

The node name is an ASCII string. The maximum length is 16 bytes.

Table 1004—DC HR-MS Name

Type (1 byte)	Length (1 byte)	Value (variable length)
0x01	1 – 16	A name given by the user of HR-MS

6.3.2.3.98.10.1.2 DC_DISCOV_NBR_ADDR

It contains MAC addresses of neighboring HR-MSs discovered by the current HR-MS. Each MAC address takes six bytes. Multiple MAC addresses can be transmitted in the same DC_DISCOV_NBR_ADDR IE.

Table 1005—DC Neighbor Address IE

Type (1 byte)	Length (1 byte)	Value (variable length)
0x02	variable	MAC Address of the HR-MSs

6.3.2.3.98.10.1.3 DC_DISCOV_INVITE

The IE contains MAC address of the HR-MS that the current HR-MS want to setup connections. Multiple MAC addresses can be contained in the IE.

Table 1006—DC Invitation IE

Type (1 byte)	Length (1 byte)	Value (variable length)
0x03	variable	MAC address of the invited HR-MS

6.3.2.3.98.10.1.4 DC_DISCOV_INVITE_ACCEPT

The current HR-MS decided to accept the invitation. It intends to join the HR-MS network once the HR-MS become a coordinator.

Table 1007—DC Accept IE

Type (1 byte)	Length (1 byte)	Value (variable length)
0x04	6	MAC address

The MAC address belongs to the HR-MS who sends out a DC_DISCOV_INVITE_ACCEPT message

6.3.2.3.98.10.1.5 DC_DISCOV_INVITE_REJECT

The current HR-MS rejects the invitation from the HR-MS. The IE contains the MAC address of the HR-MS who sends out a DC_DISCOV_INVITE message. It indicates that the current HR-MS declines to communicate with the other HR-MS.

Table 1008—DC Reject IE

Type (1 byte)	Length (1 byte)	Value (variable length)
0x05	6	MAC address of the inviting HR-MS

6.3.2.3.98.10.1.6 DC_DISCOV_DATA

A short data packet is contained in the IE. The interpretation of the data is up to application.

Table 1009—DC Data IE

Type (1 byte)	Length (1 byte)	Value (variable length)
0xff	1 – 255	First 6 bytes is the MAC address of intended HR-MS and follows by the data from upper layer.

6.3.2.3.98.11 AP-NBR-REQ message

Table 1010 ---- AP-NBR-REQ message field and description

Field	Size (bits)	Value/Description	Condition
Discovery mode requested	2	0b00: Normal neighbor discovery 0b01: Discovery to prepare for BS determine alternative path 0b10: Discovery to prepare for MS determine alternative path 0b11: reserve	In the case of 0b10, HR-BS shall reply HR-MS in the message AP-NBR-REP.
}			

6.3.2.3.98.12 AP-NBR-REP message

Table 1011 ---- AP-NBR-REP message field and description

Field	Size (bits)	Value/Description	Condition
For (*i* = 0; *i* < Number of neighbor HR-MSs; *i* ++){			
Index	4	Index of the neighbor HR-MSs	
SINR	4	Indicates the received SINR of the ranging code from neighbor HR-MSs. The 4 bit value from 0b0000 to 0b1111 represent values among {–9, –8.5, –8, –7.5, –7, –6.5,–6, –5.5, –5, –4.5, –4, –3.5, –3, –2.5,–2, –1.5} dB	
Hop	2	Number of hop to HR-BS 00 1 hop 01 2 hop 10 3 hop 11 4 hop	
}			

6.3.2.3.98.13 NCI Message

The NCI message is transmitted by the HR-MS so that HR-MS outside the coverage can access the network with the FTN scheme provided in this section.

Table 1012 ---- NCI message field and description

Syntax	Size (bit)	Notes
NCI_Message_Format() {	—	—
Management Message Type = [TBD]	8	—
PHY Synchronization Field	32	Specified in Table 319, 8 bits for frame duration and 24 bits for frame number.
Base Station ID	48	
Allocation Start Time	8	In number of OFDMA symbols, should include the RTG/TTG gap in the calculation.
OFDMA Symbol offset	8	
Subchannel offset	7	

No. OFDMA Symbols	7	
No. Subchannels	7	
Ranging Method	2	0b00: Initial ranging over two symbols 0b01: Initial ranging over four symbols 0b10: BR/periodic ranging over one symbol 0b11: BR/periodic ranging over three symbols

6.3.2.3.98.14 Direct Communication Link Creation Request

When HR-BS creates direct communication link between two HR-MSs. It shall allocate a CID for the direct communication link and send link creation message to both source and destination HR-MSs. Direct communication link creation can only be initiated by the HR-BS.

Table 1013— Direct Communication Link Creation Request

Syntax	Size (bit)	Notes
DC-LINK-CREATE-REQ () {		
_Management Message Type = [TBD]	8	—
_CID assigned to transmitting	16	
_CID assigned for receiving	16	
}		

CID assigned for transmitting

The CID is used by the HR-MS for transmitting. The peer HR-MS of the DC-link shall receive on the resource specified by this CID.

CID assigned for receiving

The HR-MS shall receive on the resource specified by this CID since it is assigned to the peer HR-MS on the DC-Link for transmission.

6.3.2.3.98.15 Direct Communication Link Creation Response

The HR-MSs shall send back a response once they receive the direct communication link creation request.

Table 1014— Direct Communication Link Creation Response

Syntax	Size (bit)	Notes
DC-LINK-CREATE- RSP () {		

Management Message Type = [TBD]	8	—
CID assigned to DC link	16	CID assigned for transmission
Confirmation Code	1	0x00: accept 0x01: reject
Reserved	7	—
}		

6.3.2.3.98.16 Direct Communication Link Deletion Request

When HR-BS wants remove a direct communication link, it shall send deletion request to both HR-MS and wait for responses from the HR-MSs.

Table 1015-- Direct Communication Deletion Request

Syntax	Size (bit)	Notes
DC-LINK-DEL () {		
Management Message Type = [TBD]	8	—
CID of DC link	16	CID assigned for transmitting
}		

6.3.2.3.98.17 Direct Communication Deletion Response

The HR-MS shall reply with reasons to HR-BS when it receives the link deletion request from HR-BS.

Table 1016—Direct Communication Deletion Response

Syntax	Size (bit)	Notes
DC-LINK-DEL-ACK () {		
Management Message Type = [TBD]	8	—
CID of DC link	16	CID assigned for transmitting
Confirmation Code	1	0x00: accept 0x01: reject
Reserved	7	—
}		

6.3.2.3.98.18 Direct Communication Link Report Request

HR-BS may require the HR-MS report the status of the direct communication link by sending a request to the relative HR-MS.

Table 1017—Direct Communication Link Report Request

Syntax	Size (bit)	Notes
DC-LINK-REPORT-REQ () {		
Management Message Type = [TBD]	8	—
CID of DC link	16	CID assigned for transmitting
Report Request TLVs	*variable*	Specified in section 11.11
}		

6.3.2.3.98.19 Direct Communication Link Report

HR-MS shall send back report regarding the direct communication link when it receives a link report request from HR-BS.

Table 1018—Direct Communication Link Report

Syntax	Size (bit)	Notes
DC-LINK-REPORT-RSP () {		
Management Message Type = [TBD]	8	—
CID of DC link	16	CID assigned for transmitting
Link state	1	0x00: active 0x01: no link found
reserved	7	—
Report Response TLVs	*variable*	Specified in section 11.11
}		

6.3.13 Establishment of multicast connections

[Change Section 6.3.13 as indicated:]

The BS may establish a DL multicast and broadcast service by creating a multicast connection with each SS to be associated with the service. Any available traffic CID value may be used for the service (i.e., there are no dedicated CIDs for multicast transport connections). To ensure proper multicast operation, the CID used for the service is the same for all SSs on the same channel that participate in the connection. The SSs need not be aware that the connection is a multicast connection. However, for multicast and broadcast services which utilize MBS specific features, the multicast connection shall be established using a multicast CID The data transmitted on the connection with the given CID shall be received and processed by the MAC of each involved SS. Thus, each multicast or broadcast SDU is transmitted only once per BS channel. Since a multicast connection is associated with a service flow, it is associated with the QoS and traffic parameters for that service flow.

ARQ is not applicable to multicast connections.

To ensure proper multicast based two-way communications such as Push to Talk (PTT) service among a group of HR-MSs, optimized multicast operation as described in 16.9 shall be provided.

If a DL multicast connection is to be encrypted, each SS participating in the connection shall have an additional security association (SA), allowing that connection to be encrypted using keys that are independent of those used for other encrypted transmissions between the SSs and the BS.

7. Security sublayer

8. Physical layer (PHY)

8.4 WirelessMAN-OFDMA PHY

8.4.1 Introduction

[Insert the following sentence into section 8.4.1 on Page 921 at the end of 2nd paragraph:]

The OFDMA PHY may support the VHF mode specified in 16.12 .

8.4.3 OFDMA basic terms definition

8.4.3.1 Slot and data region

[Change the 2nd and 3rd bullet points in Section 8.4.3.1as indicated:]

— For DL PUSC (defined in 8.4.6.1.2.1), one slot is one subchannel by two OFDMA symbols. For VHF mode DL PUSC, one slot is one subchannel by four OFDMA symbols.

— For UL PUSC (defined in 8.4.6.2.1 and 8.4.6.2.5) and for DL TUSC1 and TUSC2 (defined in 8.4.6.1.2.4 and 8.4.6.1.2.5), one slot is one subchannel by three OFDMA symbols. For VHF mode UL PUSC, one slot is one subchannel by seven OFDMA symbols.

8.4.4.3 OFDMA Frame Parameters and Operations

[Insert the following text at the end of Section 8.4.4.3:]

In VHF mode, subcarrier allocation scheme of PUSC (defined in 8.4.6.1.2.1.1 and 8.4.6.2.2) is used for both UL and DL and duplex method is TDD, and MIMO, STC scheme are not used.

8.4.4.4 DL frame prefix

[Insert the following text at the end of Section 8.4.4.4:]

For VHF mode, CC encoding used on DL-MAP is selected as "Coding_Indication" from DL frame prefix format shown in Table 393. The FFT size of 1024 is selected from Table 394.

8.4.5 Map message fields and IEs

8.4.5.2 Frame duration codes

[Change Table 401 as indicated:]

Table401—OFDMA frame duration (*Tf* ms) codes

Code (N)	Frame duration (ms)	Frames per second
0	*Reserved*	N/A
1	2	500
2	2.5	400
3	4	250
4	5	200
5	8	125
6	10	100
7	12.5	80
8	20	50
9-255~~5~~4	Reserved	
255	Infinity	0

[Insert the following text at the end of Section 8.4.5.2:]

The code 255 is used for HR-MS direct communication without infrastructure station only.

8.4.5.3 DL-MAP IE format

[Change the text in 8.4.5.3.2.3 as follows:]

8.4.5.3.2.3 DL-MAP Extended-3 IE encoding format

A DL-MAP IE entry with an Extended-2 DIUC = 0xF indicates that the IE carries special information and conforms to the structure shown in Table408. A station shall ignore an extended-3 IE entry with an extended-3 DIUC value for which the station has no knowledge. In the case of a known extended-3 DIUC value but with a length field longer than expected, the station shall process information up to the known length and ignore the remainder of the IE.

Table408—DL-MAP Extended-3 IE format

Syntax	Size (bit)	Notes
DL_Extended-3_IE() {		
Extended-2 DIUC	4	0xF
Length	8	Length in bytes of the unspecified data field plus the extended-3 DIUC field
Extended-3 DIUC	4	0x0 … 0xF
Unspecified data	variable	
}		

Table 409 defines the encoding for extended-3 DIUC that shall be used by DL-MAP Extended-3 IEs.

Table 409—Extended-3 DIUC code assignment for Extended-2 DIUC = 15

Extended-3 DIUC	Usage
0x0	Power Boosting IE
0x1	HR Multicast DL MAP IE
0x~~1~~2 – 0xF	Reserved

[Change the text in 8.4.5.3.21 as follows:]

8.4.5.3.21 HARQ DL MAP IE

The following modes of HARQ shall be supported by the HARQ DL MAP IE:

a) Chase combining HARQ for all FEC types (HARQ Chase). In this mode, the burst profile is indicated by a DIUC.

b) Incremental redundancy HARQ with CTC (HARQ IR). In this mode, the burst profile is indicated by the parameters NEP, NSCH.

c) Incremental redundancy HARQ for convolutional code (HARQ CC-IR).

d) HR Multicast DL burst. In this mode, the burst profile is indicated by a DIUC.

The IE may also be used to indicate a non-HARQ transmission when ACK disable = 1.

……

Table 431—HARQ DL MAP IE format

Syntax	Size (bit)	Notes
HARQ_DL_MAP_IE() {		
Extended-2 DIUC	4	HARQ_DL_MAP_IE() = 0x7

Length	8	Length in bytes
RCID_Type	2	0b00: Normal CID 0b01: RCID11 0b10: RCID7 0b11: RCID3 For HR Multicast, RCID_Type is set to 0b00 and Normal CID is replaced by HR Multicast CID
ACK region index	1	The index of the ACK region associated with all subbursts (except HR multicast DL burst) defined in this HARQ DL map IE (FDD/ H-FDD only). 0: first ACK region 1: second ACK region This bit shall be set to 0 for TDD mode.
Reserved	1	
While (data remains) {		
Boosting	3	0b000: Normal (not boosted) 0b001: +6dB 0b010: .6dB 0b011: +9dB 0b100: +3dB 0b101: .3dB 0b110: .9dB 0b111: .12dB;
Region_ID use indicator	1 bit	0: not use Region_ID 1: use Region_ID
If (Region_ID use indicator == 0) {		
OFDMA symbol offset	8	Offset from the start symbol of DL subframe
Subchannel offset	7	
Number of OFDMA symbols	7	
Number of subchannels	7	
Rectangular subburst Indication	1	Indicates subburst allocations are time-first rectangular. The duration field in each subburst IE specifies the number of subchannels for each rectangular allocation. This is only valid for AMC allocations and all allocations with dedicated pilots. When this field is clear, subbursts shall be allocated in frequency-first manner and the duration field reverts to the default operation.
Reserved	2	
} else {		
Region_ID	8	Index to the DL region defined in DL region definition TLV in DCD
}		

Mode	4	Indicates the mode of this HARQ region: 0b0000: Chase HARQ 0b0001: Incremental redundancy HARQ for CTC 0b0010: Incremental redundancy HARQ for Convolutional Code 0b0011: MIMO Chase HARQ 0b0100: MIMO IR HARQ 0b0101: MIMO IR HARQ for Convolutional Code 0b0110: MIMO STC HARQ 0b0111: HR Multicast DL subburst ~~0b0111~~0b1000 - 0b1111: *Reserved*
Subburst IE Length	8	Length, in nibbles, to indicate the size of the sub-burst IE in this HARQ mode. The MS may skip DL HARQ Subburst IE if it does not support the HARQ mode. However, the MS shall decode N ACK Channel field from each DL HARQ Subburst IE to determine the UL ACK channel it shall use for its DL HARQ burst.
If (Mode == 0b0000) {		
DL_HARQ_Chase_subburst_IE()	*variable*	
} else if (Mode == 0b0001) {		
DL_HARQ_IR_CTC_subburst_IE ()	*variable*	
} else if (Mode == 0b0010) {		
DL_HARQ_IR_CC_subburst_IE()	*variable*	
} else if (Mode == 0b0011) {		
MIMO_DL_Chase_HARQ_subburst _IE()	*variable*	
} else if (Mode == 0b0100) {		
MIMO_DL_IR_HARQ_subburst_IE ()	*variable*	
} else if (Mode == 0b0101) {		
MIMO_DL_IR_HARQ_for_CC_ subburst_IE()	*variable*	
} else if (Mode == 0b0110) {		
MIMO_DL_STC_HARQ_subburst_IE()	*variable*	
} elseif (Mode == 0b0111){		
HR Multicast DL subburst IE	*variable*	Table 1023
}		
}		
Padding	*variable*	Padding to byte for the unspecified portion of this IE, i.e., not including the first two fields, “Extended-2 DIUC” and “Length”; shall be set to 0
}		

1

[Change the text in 8.4.5.3.29 as follows:]

8.4.5.3.29 Persistent HARQ DL MAP Allocation IE

Downlink persistent allocations are used by the BS to make downlink time-frequency resource assignments which repeat periodically. The logical time-frequency resource assigned using the Persistent HARQ DL MAP IE repeats at a periodic interval. For downlink persistent allocations, the BS transmits the Persistent HARQ DL MAP IE, with the mode field set to one of the following values:

- 0b0000: Persistent DL Chase HARQ
- 0b0001: Persistent DL Incremental redundancy HARQ for CTC
- 0b0010: Persistent DL Incremental redundancy HARQ for Convolutional Code
- 0b0011: Persistent MIMO DL Chase HARQ
- 0b0100: Persistent MIMO DL IR HARQ
- 0b0101: Persistent MIMO DL IR HARQ for Convolutional Code
- 0b0110: Persistent MIMO DL STC HARQ
- 0b0111: HR Multicast DL subburst

The Persistent HARQ DL MAP IE may be used for non persistent allocations by setting the persistent flag in the subburst IE to 0.

Table 447—Persistent HARQ DL MAP allocation IE

Syntax	Size (bit)	Notes
Persistent_HARQ_DL_MAP_IE() {		
Extended-2 DIUC	4	Persistent_HARQ_DL_MAP_IE = 0xD
Length	8	Length in bytes
RCID_Type	2	0b00: Normal CID 0b01: RCID11 0b10: RCID7 0b11: RCID3 For HR Multicast, RCID_Type is set to 0b00 and Normal CID is replaced by HR Multicast CID
ACK Region Index	1	The index of the ACK region associated with all subbursts (except HR multicast DL burst) defined in this Persistent HARQ DL MAP (FDD/H-FDD only)
while (data_remains){		
Region ID use indicator	1	0: Region ID not used 1: Region ID used
Change Indicator	1	0: No change occurred 1: Change occurred

if (Region ID use indicator == 0){		
OFDMA Symbol offset	8	
Subchannel offset	7	
Number of OFDMA symbols	7	
Number of subchannels	7	
Rectangular subburst indication	1	Indicates subburst allocations are time-first rectangular. The duration field in each subburst IE specifies the number of subchannels for each rectangular allocation. The slot offset field in each subburst IE specifies the subchannel offset from the first subchannel for each rectangular allocation. When this field is clear, subbursts shall be allocated in frequency-first manner and the duration field reverts to the default operation
}		
else{		
Region ID	8	Index to the DL region defined in DL region definition TLV in DCD
}		
Power boost per subburst	1	Set to 1 to signal power boost per subburst. This field shall be set to 0 if Rectangular subburst indication is set to 0
if (Power boost per subburst == 0){		
Boosting	3	0b000: Normal (not boosted) 0b001: +6dB 0b010: –6dB 0b011: +9dB 0b100: +3dB 0b101: –3dB 0b110: –9dB 0b111: –12dB Note that if the Persistent flag is set, the boosting value applies to each allocation instance of the persistent allocation
}		
Mode	4	Indicates the mode in this HARQ region 0b0000: Persistent DL Chase HARQ 0b0001: Persistent DL Incremental redundancy HARQ for CTC 0b0010: Persistent DL Incremental redundancy HARQ for Convolutional Code

		0b0011: Persistent MIMO DL Chase HARQ 0b0100: Persistent MIMO DL IR HARQ 0b0101: Persistent MIMO DL IR HARQ for Convolutional Code 0b0110: Persistent MIMO DL STC HARQ 0b0111: HR Multicast DL subburst ~~0b0111~~0b1000 to 0b1111: *Reserved*
Subburst IE Length	8	Length, in nibbles, to indicate the size of the subburst IE in this HARQ mode. The MS may skip DL HARQ Subburst IE if it does not support the HARQ mode. However, the MS shall decode NACK Channel field from each DL HARQ Subburst IE to determine the UL ACK channel it shall use for its DL HARQ burst
if(Mode == 0b0000){		
Persistent DL Chase HARQ subburst IE	*variable*	
} elseif (Mode == 0b0001){		
Persistent DL Incremental redundancy HARQ for CTC subburst IE	*variable*	
} elseif (Mode == 0b0010){		
Persistent DL Incremental redundancy HARQ for Convolutional Code	*variable*	
} elseif (Mode == 0b0011){		
Persistent MIMO DL Chase HARQ	*variable*	
} elseif (Mode == 0b0100){		
Persistent MIMO DL IR HARQ	*variable*	
} elseif (Mode == 0b0101){		
Persistent MIMO DL IR HARQ for Convolutional Code	*variable*	
} elseif (Mode == 0b0110){		
Persistent MIMO DL STC HARQ	*variable*	
} elseif (Mode == 0b0111){		
HR Multicast DL subburst IE	*variable*	Table 1023
}		
}		
Padding	*variable*	Padding to byte for the unspecified portion of

		this IE (i.e., not including the first two fields, "Extended-2 DIUC" and "Length"); shall be set to 0.
}		

8.4.6 OFDMA subcarrier allocations

[Insert the following text at the end of Section 8.4.6:]

In VHF mode, sampling factor n is 8/7 for the channel bandwidth of 5 MHz and also subcarrier allocation scheme of PUSC (defined in 8.4.6.1.2.1 and 8.4.6.2.5) is used for both UL and DL.

8.4.6.1.2.1 Symbol structure for PUSC

[Insert the following text at the end of Section 8.4.6.1.2.1:]

For VHF mode, the symbol is first divided into basic tiles (as defined in Figure 332a) and zero carriers are allocated. Pilots and data carriers are allocated within each tile. Table 442a summaries the parameters of the symbol structure under this PHY mode.

A slot in the DL of VHF mode is composed of **four (4)** OFDMA symbols and one subchannel. Within each slot, there are **48** data subcarriers and **16** fixed-location pilots as shown in Table 332a. The subchannel is constructed from **four(4)** DL tiles. Each tile has four successive active subcarriers, and its configuration is illustrated in Figure 332a.

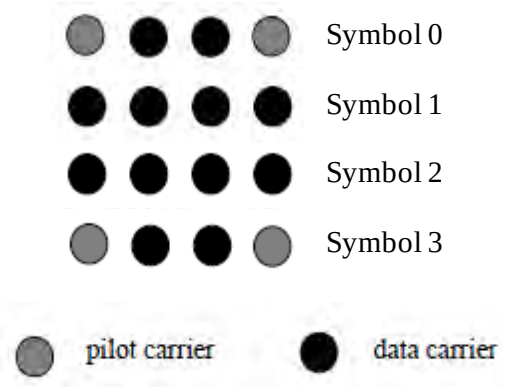


Figure 332a—Description of a DL tile in VHF Mode

8.4.6.2.1 Symbol structure for subchannel (PUSC)

[Insert the following text at the end of Section 8.4.6.2.1:]

For VHF mode, a slot in the UL is composed of **seven (7)** OFDMA symbols and one subchannel. Within each slot, there are **48** data subcarriers and 8 fixed-location pilots as shown in Table 334a. The subchannel is constructed from **two(2)** UL tiles. Each tile has four successive active subcarriers, and its configuration is illustrated in Figure 334a.

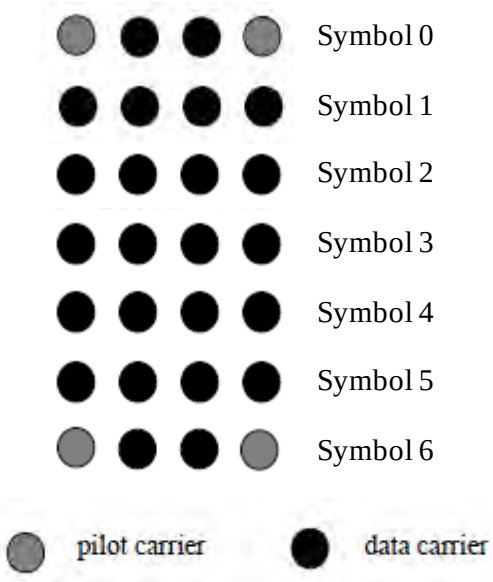


Figure 334a—Description of an UL tile in PHY Mode specified for HR-Network

8.4.9.3 Interleaving

[Insert the following text at Section 8.4.9.3 on Page 1061 before the last 2nd paragraph:]

For VHF mode, the first and second permutation follows the equations (121) and (122), respectively with d=18.

9. Configuration

10. Parameters and constants

10. 1 Global values

[Insert the following row at the end of Table 654:]

Table 654—Parameters and constants

System	Name	Time reference	Minimum value	Default value	Maximum value
SS	T74	Wait for DSA/DSC acknowldegement timeout in case the flow runs over a	—	—	600 ms

		direct communication link			

11. TLV encodings

11.1 Common encodings

[Change Table 660 - Type values for common TLV encodings as indicated:]

Type	Name
149	HMAC Tuple
148	MAC Version Encoding
147	Current Transmit Power
146	Downlink Service Flow
145	Uplink Service Flow
144	Vendor ID Encoding
143	Vendor-Specific Information
142	SA-TEK-Update
141	CMAC tuple
140	Short-HMAC tuple
139	Enabled-Action-Triggered
138	SLPID_Update
137	Next Periodic Ranging
136	MAC Hash Skip Threshold
135	Paging Controller ID
134	Paging Information
133	NSP List
132	Verbose NSP Name List
131	MIHF frame
130	MIHF frame type
129	Query ID
128	MCID Pre-allocation and Transmission info
127	MCID Continuity and Transmission Info
117	HR multicast service flow update mapping info

[Insert the following at the end of 11.1 (renumbering may be required):]

11.1.13 HR multicast service flow update mapping info

The TLV encodings defined in this subclause are specific to the RNG-RSP (6.3.2.3.6) and MOB_NBR-ADV (6.3.2.3.42) MAC management message. This TLV indicates the mapping of HR Multicast CID used in the current Multicast zone to new HR Multicast CID within a neighboring Multicast zone and information regarding the HR-Multicast MAP transmission in the neighbor Multicast Zone.

Type	Length (bytes)	Value	Scope
126	Variable (3+Nx4)	See Table 1019	RNG-RSP, MOB_NBR-ADV

Table 1019 ---- HR Multicast service flow update mapping info definition

Field	Length (bits)	Note
Multicast_Group_Zone_ID	12	Multicast zone identifier for current Multicast Zone
Neighboring_Multicast Group_ZONE_ID	12	Multicast Group zone identifier for neighboring Multicast Group Zone
List of HR Multicast CID Mappings	variable (Nx4)	Current_HR_MCID(1), New_HR_MCID(1), ..., Current_HR_MCID(N), New_HR_MCID(N)

A value of 0xFFFF in the New_HR_MCID field indicates that the service flow corresponding to Current_HR_MCID is not available in the Multicast Zone identified by the TLV.

11.4 DCD management message encodings

11.4.1 DCD channel encodings

[Insert the following row at the end of Table 678:]

Multicast group zone identifier	xxx	1	This parameter shall include multicast zone identifier with which BS is associated. A Multicast Group Zone identifier is 1 byte long. bits 11 through 0 are the Multicast Group Zone Identifier, bits 16 through 13 are set to 0 in each byte. The Multicast Group Zone identifier shall not be '0'. When the parameter is part of a compound DCD_settings TLV (refer to 11.18.1), a value of 0 means that the neighbor BS is not affiliated with any Multicast Group zone	All

11.5 RNG-REQ management message encodings

[Change Table 685* - RNG-REQ message encodings *as indicated:]

Table 685—RNG-REQ message encodings

Name	Type (1byte)	Length	Value (variable length)	PHY scope
……	…	…	……	…
Ranging Purpose Indication	6	1	Bit 0: HO indication (when this bit is set to 1 in combination with other included information elements indicates the MS is currently attempting to HO or network reentry from idle mode to the BS) Bit 1: Location update request (when this bit is set to 1, it indicates MS action of idle mode location update process) Bit 2: Seamless HO indication (when this bit is set to 1 in combination with other included information elements indicates the MS is currently initiating ranging as part of the seamless HO procedure) Bit 3: Ranging Request for Emergency Call Setup (when this bit is set to 1, it indicates MS action of Emergency Call Process) Bit 4: MBS update. When this bit is set to 1, the MS is currently attempting to perform location update due to a need to update service flow management encodings for MBS flows. Bit 5: HR Multicast service flow update. When this bit is set to 1, the MS is currently a need to update multicast service flow management encodings for multicast transmission due to crossing Multicast Group zone. Bits ~~5~~6–7: *Reserved*	
……	…	…	……	…

11.13 Service flow management encodings

[Insert the following rows at the end of Table 712:]

Table 712—Service flow encodings

Type	Parameter
58	Direct Communication
59	HR multicast service
60	HR multicast group zone identifier assignment

[Insert the following row at the end of Table 713:]

Table 713—CC values

CC	Status
19	direct-comm-setup

[Insert the following section:]

11.13.46 Direct Communication Service Addition/Change TLV

The value of this field specifies that the flow specified in this DSA_REQ will be transmitted over a direct communication link.

Type	Length	Value	Scope
145.58	1	0	DSA_REQ

11.13.47 HR multicast service

This TLV indicates whether the multicast service is being requested or provided for the connection that is being setup. A value of 1 indicates that an multicast service limited to the serving BS is being requested and a value of 2 indicates multi-BS Multicast regardless of proving macro-diversity. If MS or BS wants to initiate multicast service, DSA-REQ with HR multicast service TLV shall be used. The DSA-RSP message shall contain the acceptance or rejection of request and if there is no available multicast, multicast service value shall be set to 0.

Type	Length	Value	Scope
[145/146].59	1	0: No available multicast service 1: Multicast in Serving BS Only 2: Multicast in a multi-BS Zone supporting 3-255: Reserved	DSA-REQ, DSA-RSP, DSA-ACK, DSC-REQ, DSC-RSP

11.13.48 Multicast Group Zone Identifier Assignment parameter

The DSA-REQ/RSP message may contain the value of this parameter to specify a Multicast Group Zone identifier. This parameter indicates a Multicast Group zone through which the connection or virtual connection for the associated service flow is valid.

Type	Length	Value	Scope
[145/146].60	1	Multicast group zone identifier (bits 11 through 0 are the Multicast Group Zone Identifier, bits 15 through 12 are set to 0)	REG-REQ, REG-RSP, DSA-REQ, DSA-RSP, DSC-REQ, DSC-RSP

12. System profiles

13. MIB modules

14. Management interfaces and procedures

15. Mechanisms for coordinated coexistence

[Insert the following new clause 16:]

16. Support for HR-Network

16.1 Multi-mode operation

16.1.1 Relay function for HR-BS

An HR-BS (affected HR-BS) may operate as a relay station to communicate with another HR-BS (serving HR-BS) that has connection to backhaul.

An HR-BS acting as RS mode operates in either TTR mode or STR mode.

The procedure for mode change consists of following activities:
a) establishing a relay link with a serving HR-BS
b) if necessary, informing some of its subordinate stations to perform handover
c) if necessary, reconfiguring the physical frame
d) commencing the new operation.

The affected HR-BS establishes relay link with a serving HR-BS as described in16.1.1.1 . The procedure applies to both STR and TTR relay modes.

When supporting STR relay mode, the affected HR-BS maintains base station functionality.

16.1.1.1 Relay link establishment

The HR-BS having no connection to backhaul transmits MM-ADV message with action

type = 0b100 described in 6.3.2.3.98.1 including expected time of backhaul link available. Based on the expected time, HR-MS handovers to neighbor infrastructure station or staying in the HR-BS until restarting service with available backhaul link.

To establish relay link with a serving HR-BS, the HR-BS having no connection to backhaul follows network entry and initialization for relay link described in 6.3.9. In addition, the HR-BS shall perform the relay link establishment procedure as follows:

a) Scan for DL channel and establish synchronization with the HR-BS having connection to backhaul
b) Perform the first stage access station selection
c) Obtain DL/UL parameters (from UCD message)
d) Perform ranging
e) Negotiate basic capabilities, if needed
f) Authorization, authentication, and key exchange, if needed
g) Registration with the HR-BS, if needed
h) Obtain neighbor station measurement report, if needed
i) Perform the second stage access station selection, if needed
j) Path creation and tunnel establishment, if needed
k) Establish IP connectivity, if needed
l) Establish time of day, if needed
m) Configuration operational parameters including initiating relay link using MMRS-REQ/RSP and RS-CONFIG-CMD messages

To establish relay link with another HR-BS (serving HR-BS), HR-BS having no connection to backhaul transmits MMRS-REQ message described in 6.3.2.3.98.2 including relay mode, i.e., either TTR or STR mode. In response to MMRS-REQ, the serving HR-BS transmits MMRS-RSP message described in 6.3.2.3.98.3 to inform whether the request is accepted or rejected. Upon receiving the MMRS-RSP message, the affected HR-BS starts establishing the relay link with serving HR-BS immediately or retransmits MMRS-REQ message at the action time expires. If the serving HR-BS rejects the request, the serving HR-BS informs the HR-BS having no connection to backhaul the rejection of the request. Upon receiving the MMRS-RSP message with rejection information, the HR-BS either tries to establish relay link with another HR-BS or follows standalone network operation described in 16.4 .

To support handover as a part of robustness against SPOF as described in 16.7, an indication of whether MAC context information of the subordinate HR-MS is being shared by infrastructure stations shall be transmitted to HR-MS.

16.1.1.2 Relay link configuration

During establishing relay link, serving HR-BS transmits RS-Config-CMD message described in 6.3.2.3.63 to configure PHY layer parameter set including Frame Number Action indicating the time to establish relay link.

While HR-BS is maintaining relay link, the serving HR-BS shall send R-link channel descriptor (RCD) message described in 6.3.2.3.60 in the DL relay zone. The HR-BS also shall send RS-Config-CMD message in the DL relay zone when PHY layer parameter needs to be reconfigured.

HR-BS acting as relay may transmit MM-ADV message with action type described in 6.3.2.3.98.1 to update PHY/MAC layer parameter after receiving RCD or RS-Config-CMD message.

16.1.1.3 Relay link release

If the HR-BS recovers from failure of backhaul, it may inform network or notify the current serving HR-BS of the HR-BS having recovered backhaul link through the backhaul network interface. The superordinate serving HR-BS may then initiate HR-MS handover back to the HR-BS in which the recovered HR-BS should be listed in the first priority. The HR-BS having recovered backhaul may store MAC context information of the serving MSs (basic capabilities, security capabilities, etc.). Such context information allows HR-MS to perform optimized network reentry when returning back to the HR-BS upon its recovery.

HR-BS transmits MM-ADV message with action type = 0b101 described in 16.2.3.70 including expected time of backhaul link up. When receiving the MM-ADV message, HR-MS performs either handover to neighbor infrastructure station and returns to the HR-BS at the expected time or waiting in the HR-BS until restarting service with available backhaul link.

16.1.2 Relay function for HR-MS

An HR-MS may operate as an HR-RS to provide connectivity for multiple out-of-coverage HR-MSs. During basic capability negotiation at network entry, an HR-MS that is capable of role change to HR-RS shall report such capability to the super-ordinate HR-BS/HR-RS.

While operating as HR-RS, the station may maintain certain HR-MS functionalities. A mode switch to HR-RS shall be commanded by its superordinate HR-BS.

16.1.2.1 Relay link establishment

To support relay function for HR-MS, HR-MS capable of relay function may establish relay link with HR-BS.

An HR-MS acting as HR-RS is operated in either TTR mode or STR mode and its relay mode is determined by HR-BS.

To request subordinate HR-MS to change its role as HR-RS, HR-BS transmits MMRS-

REQ message described in 6.3.2.3.98.2 including relay mode (i.e., either TTR or STR mode).

In response to MMRS-REQ, the HR-MS transmits MMRS-RSP message described in 6.3.2.3.98.3.

During establishing relay link, HR-BS transmits RS_Config-CMD message described in 6.3.2.3.63 to configure the operation parameters of HR-RS.

To support handover as a part of robustness against SPOF as described in 16.7, an indication of whether MAC context information of the subordinate HR-MS is being shared by infrastructure stations shall be transmitted to HR-MS.

16.1.2.2 Relay link configuration

While HR-MS is acting as relay mode, the superordinate HR-BS may send an RCD message to configure the Relay operation parameters as specified in 6.3.9.18. The HR-BS also shall send RS-Config-CMD message in the DL relay zone when PHY layer parameter needs to be reconfigured.

While an HR-MS operating as HR-BS, any communication is performing with superordinate HR-BS in DL/UL relay zone to maintain HR-MS functionalities.

HR-MS acting as relay mode may transmit MM-ADV message described in 6.3.2.3.98.1 to update PHY/MAC layer parameter after receiving RCD or RS-Config-CMD message.

16.1.2.3 Relay link release

An HR-MS acting as RS may end its relay service and remove the relay link from the HR-BS. During the HR-MS' relay mode release process, all subordinate HR-MSs of the HR-MS acting as RS shall be transferred to another infrastructure station prior to HR-MS' relay mode release. The HR-MS acting as RS prevents HR-MS (re)entry and transmits MM-ADV message to transfer all subordinate HR-MSs to another infrastructure station. An HR-MS acting as RS may transmit an MMRL-REQ message described in 6.3.2.3.98.4 in UL relay zone to an HR-BS so that it initiates the release procedure and requests handover of all its subordinate HR-MSs. Upon receiving the MMRL-REQ message, the HR-BS decides whether it allows the HR-MS' relay mode release. If the request is accepted, the HR-BS may transmit the MMRL-RSP message described in 6.3.2.3.98.5 in DL relay zone to inform the acceptance and start BS-initiated handover process for the requested HR-MSs. After handover procedures between the HR-BS and HR-MS acting as RS' subordinate HR-MSs are completed, the HR-BS informs the HR-MS acting as RS that handover is completed by transmitting an MMRL-RSP message in DL relay zone. Upon receiving the MMRL-RSP message, the HR-MS acting as RS starts relay mode release process immediately or at action time expires. If the HR-BS rejects the request, the HR-BS informs the HR-MS acting as RS the rejection of the request by transmitting the MMRL-RSP message in DL relay zone. Upon receiving the MMRL-RSP message with rejection information, the HR-MS acting as RS continues

operating in relay mode. After action time expires, the HR-MS acting as RS retransmits an MMRL-REQ message in UL relay zone to the HR-BS.

The mode release process may be initiated by an HR-BS through transmitting an unsolicited MMRL-RSP message in DL relay zone.

After mode release process, all the relay-related connections and resource are released between the HR-BS and the HR-MS.

16.1.3 Base station function for HR-MS

An HR-MS may operate as an HR-BS to provide connectivity for itself and other HR-MSs. During basic capability negotiation at network entry, an HR-MS that is capable of role change to HR-BS shall report such capability to the super-ordinate HR-BS/HR-RS.

While operating as an HR-BS, the station may maintain certain HR-MS functionalities

The HR-MS may start operating as an HR-BS in a Proactive operation or a Reactive operation. For proactive operation, the mode switch is directed by the superordinate HR-BS of the HR-MS; In reactive operation, the mode switch is initiated by the HR-MS itself.

16.1.3.1 Proactive Operation

A superordinate HR-BS may select a target HR-MS among its subordinate HR-MSs which are capable of role changing to HR-BS, according to the measured signal power at HR-BS and/or subordinate HR-MS' status information such as the battery level. The subordinate HR-MS capable of role changing to HR-BS may report its status information to the superordinate HR-BS via MM-STAT-REP MAC control message. The triggering condition for reporting status information may be configured by the superordinate HR-BS.

After selecting the target HR-MS, the superordinate HR-BS requests the target HR-MS to change its mode to HR-BS by exchanging HRBS-REQ/RSP message. If the target HR-MS accepts the request from the superordinate HR-BS to change the mode to HR-BS, the superordinate HR-BS may transmit HRBS-CONFIG-CMD message to request the target HR-MS to set the configuration parameters and the trigger conditions for operating as HR-BS.

16.1.3.2 Reactive Operation

The HR-MSs which are capable of role changing to HR-BS may contend for operating at BS mode when the superordinate HR-BS fails. The HR-MSs may initiate a mode switch to HR-BS after expiration of a random backoff timer to avoid potential collision among adjacent HR-MSs trying to perform a mode switch to HR-BS at the same time.

After completion of mode switch, the HR-MS acting as HR-BS may request mode change to one of its subordinate HR-MSs in order to hand HR-BS role over. In this case, it follows the procedure for Proactive operation as described in16.1.3.1.

16.2 Support for Direct Communication between HR-MSs

16.2.1 General Description

In HR-MS direct communication, data packets are exchanged between two HR-MSs directly or by passing through another HR-MS. The two communicating HR-MSs are the source and the sink of data. The data packets are passed from upper layers to MAC at the source HR-MS and back to upper layers at the sink HR-MS.

HR-MS direct communication is applicable when 1) the two HR-MSs are in coverage of and are directly associated to an HR infrastructure station; 2) one HR-MS is in coverage of and directly associated to an HR infrastructure station, while the other HR-MS is out of coverage of any HR infrastructure stations; 3) the two HR-MSs are out of coverage of any HR infrastructure stations.

HR-MS direct communication using centralized resource allocated by HR-BS, that is called BS-controlled direct communication, is described in 16.2.2.

HR-MS direct communication using distributed resource allocation among nearby HR-MSs, that is called talk-around direct communication, is described in16.2.3.

For case-3, direct communications between HR-MSs shall satisfy:

- When HR-MSs are out of coverage of any HR infrastructure stations, the operation of HR-MSs shall not interfere with any existing infrastructure stations. When HR-MS cannot receive any BS preamble from any infrastructure station and HR-MS direct communication without infrastructure is permitted by device configuration, HR-MSs are allowed to communicate with each other in the same band without getting permission from infrastructure stations.
- A Coordinator is selected for the coordination of transmission among HR-MSs. Until a coordinator is selected, an HR-MS is only allowed to transmit signals necessary to enable coordinator selection. To avoid collisions among HR-MSs in coordinator selection, the HR-MS follow a collision avoidance procedure. The procedure is defined in 16.2.4.
- A coordinator shall function as a simplified HR-BS except it may not support handover.
- The coordinator and any HR-MS that are communicating through the coordinator shall continue cell search operation and shall cease DC operation as soon as the criteria for DC and prevention of interference above are not met.

Resource for HR-MS direct communication may be allocated in a distributed manner among nearby HR-MSs independent of infrastructure node deployment for cases (1), (2), and (3).

16.2.2 BS-controlled direct communication

Resource for HR-MS direct communication can be allocated by the HR infrastructure station for cases (1) and (2).

16.2.2.1 Medium access control

16.2.2.1.1 HR-MS Neighbor Discovery

HR-MS neighbor discovery is a key functionality to enable other 16n features such as path discovery and management, HR-MS direct communications (with or without presence of infrastructure), and HR-MS forwarding to network. HR-MS neighbor discovery procedures are specified for two scenarios: i) when HR-MSs associated with a common super-ordinate station (HR-BS/RS or a coordinating HR-MS) attempt to discovery each other and ii) when an out-of-coverage HR-MS attempts to discover an HR-MS in order to connect through it to network infrastructure.

16.2.2.1.1.1 Neighbor Discovery among associated HR-MSs (Use Case 1)

For associated HR-MSs to discover each other, the serving HR-BS/HR-RS shall schedule some HR-MSs to broadcast predefined self-advertizing (PSA) signals so that other HR-MSs can try to receive and verify their neighbor relationship. Ranging preambles shall be used as PSA signals.

The process of neighbor discovery for registered HR-MSs is as follows:

- The serving HR-BS/HR-RS sends HR-DCV-CMD message to schedule one or multiple associated HR-MSs to broadcast ranging sequences in assigned channels. Multiple HR-MSs may share the same ranging sequence or the same assigned channel.
- In the same HR-DCV-CMD message, the serving HR-BS/HR-RS also schedules some other HR-MSs to listen on those channels scheduled for ranging signals.
- Each HR-MS that is scheduled to receive ranging sequences shall determine what sequences it can properly decode, together with related information such as estimations of time/frequency offsets and signal strength.
- The receiving HR-MSs may report their measurements to the serving HR-BS/HR-RS using HR-DCV-REP message. Whether a receiving HR-MS shall report its measurements or not may be based on a threshold.

The transmission of HR-DCV-CMD can be described as follows. The HR-BS unicasts HR-DCV-CMD message to a single HR-MS or multicasts the message to a group of HR-MSs that are supposed to broadcast the ranging signal. The HR-BS unicasts HR-DCV-

CMD message to a single HR-MS or multicasts the message to a group of HR-MSs that are supposed to attempt to receive the ranging signal. The HR-BS can also broadcast the HR-DCV-CMD message to all of its subordinates HR-MS. In such a case, all HR-MS that are not involved in UL transmission during the ranging opportunity index shall attempt to receive the ranging signal.

16.2.2.1.2 Connection establishment and management

HR-BS/HR-RS shall check DSA_REQ messages received from HR-MS and determine whether HR-MS direct communication can be adopted for a flow. The HR-BS/HR-RS may help the source and destination HR-MSs setting up a direct communication link through DSA signaling.

HR-BS knows the possibility of setting up a direct communication between two HR-MSs by checking the HR-MS neighbor tables. If the two nodes are neighbor, HR-MS may schedule the two HR-MSs to do channel measurement and determine whether a direct communication link should be setup.

To support direct communication between a pair of HR-MSs, a direct communication link shall be setup between the HR-MSs. When the link is first setup, two basic CIDs are assigned to each DC-link to facilitate the two way communication for control message. Of the two assigned, each HR-MS is assigned one of the CIDs for transmitting the control message such as ARQ.

The CID is referred in the link management messages such as link deletion and status report.

A security association may be setup between the two HR-MS linked by the direct communication. The procedure to setup security association over a direct communication link is defined in section 16.10.1.1. The security association is shared by different flows over the direct communication link.

After a direct communication link is setup, data flows can be setup over the DC-link with the DSA transactions as specified in section 16.2.4. When a flow is assigned over a DC-link, the sender and receiver shall monitor on the CIDs within the MAP and transmit/receive over the allocated resources.

HR-BS may take a few steps to setup a direct communication link between two HR-MS.

Firstly, the HR-BS shall schedule the two HR-MSs do a channel measurement with the method specified in section 16.2.2.1.3. The HR-MSs reports the channel measurement results to the HR-BS after the measurement.

If HR-BS decides to setup a direct communication link, it shall assign CIDs to the direct communication link and send CIDs to the two HR-MSs using DC-LINK-CREATION-REQ messages. The HR-MSs shall sends back DC-LINK-CREATION-ACK for confirmation.

After receiving DC-LINK-CREATION-ACK from both HR-MSs, the HR-BS may help the two HR-MSs establish a security association over the direct communication link if security is required. The setup of security association over direct communication link is specified in section 16.2.10.

Once a security association is setup, then the communication link is considered being established between the two HR-MSs. The HR-MSs shall find the existing flows between the two HR-MSs and move the existing flows by setting up new flows over the direct communication link with DSA method specified in section 16.2.4.

Figure 801shows the procedure to setup a direct communication link between HR-MSs.

When HR-MS want to delete the direct communication link, it shall send DC-LINK-DELETE-REQ to the two HR-MSs involved.

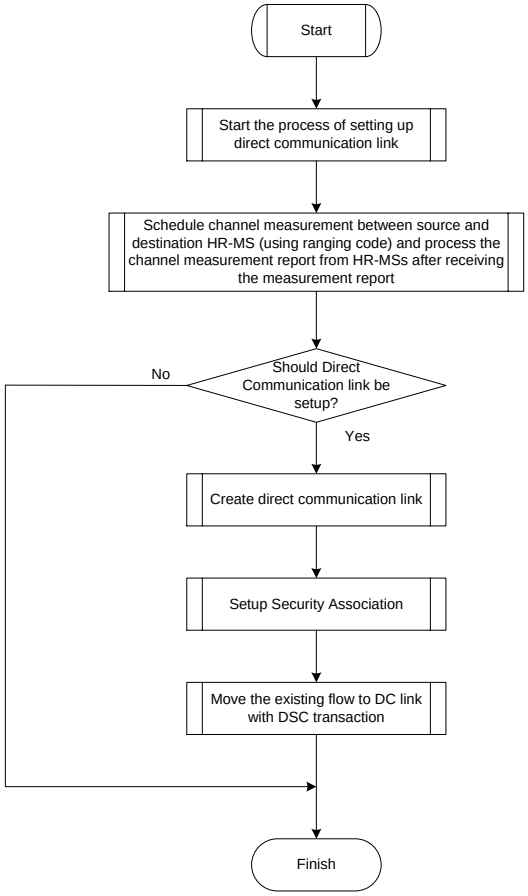


Figure 801— The overall procedure to setup direct communication

16.2.2.1.2.1 Direct Communication Link Management

16.2.2.1.2.1.1 Direct Communication Link Creation

When HR-BS creates direct communication link between two HR-MSs. It shall allocate a CID for the direct communication link and send link creation message to both source and destination HR-MSs. Direct communication link creation can only be initiated by the HR-BS.

The HR-MSs shall send back a response once they receive the direct communication link creation request.

Once the HR-BS receives responses from both HR-MSs, it can continue on other steps of direct communication setup.

16.2.2.1.2.1.2 Direct Communication Link Deletion

When HR-BS wants remove a direct communication link, it shall send deletion request to both HR-MS and wait for responses from the HR-MSs.

The HR-MS shall reply with reasons to HR-BS when it receives the link deletion request from HR-BS.

16.2.2.1.2.1.3 Direct Communication Link Report

HR-BS may require the HR-MS report the status of the direct communication link by sending a request to the relative HR-MS.

Report Request TLVs
The HR-MS only provides measurement for CINR and RSSI.

HR-MS shall send back report regarding the direct communication link when it receives a link report request from HR-BS.

Upon sending a Channel Measurement REP-RSP message, an SS shall reset all its measurement counters for each channel on which it reported.

16.2.2.1.2.2 Direct communication service flow management

16.2.2.1.2.2.1 Service flow creation over direct communication link

After a direct communication link has been setup between the source and destination HR-MS, the source HR-MS can setup flows over the direct communication link.

A direct communication setup protocol is illustrated in Figure 802 and described in detail in 16.2.2.1.2.2.3.

When HR-BS receives DSA-REQ from HR-MS, it checks whether a direct communication can be setup between the source and destination. If direct communication can be setup, HR-BS sends back a DSX_RVD to source HR-MS with indication of direct communication link. If direct communication is possible, the HR-BS holds on the transmission of DSA-RSP to source HR-MS until it finishes DSA negotiation with the destination HR-MS.

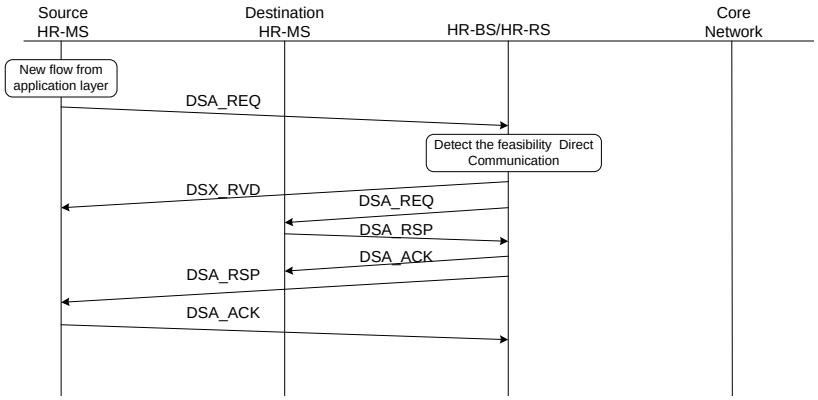


Figure 802—The establishment of direct communication between HR-MS

16.2.2.1.2.2.2 Modification and Deletion of Dynamic Service Flow over direct communication link

In addition to the methods presented in **16.2.2.1.2.2.3** for creating service flows, protocols are defined for modifying and deleting service flows; see **16.2.2.1.2.2.4** and **16.2.2.1.2.2.5**.

The modification of parameters of a service flow over direct communication link also involves both the source and destination HR-MS.

If the modification is initiated by one HR-MS, then if and only if the HR-BS and the other HR-MS agree with the modification, then the modification can be applied. If the modification is initiated by the HR-BS, then if and only if both HR-MSs agrees with the change then the modification can be applied.

16.2.2.1.2.2.3 Dynamic Service Addition

When HR-BS receives a DSA_REQ from an HR-MS and find that direct communication can be setup between the source and destination HR-MSs by checking the source and destination addresses after testing the integrity. If direct communication can be setup, the Confirmation Code in DSX_RVD message shall be set to **direct-comm-setup** as defined in table 713 so that the source HR-MS knows that a direct communication link is going to be setup between the source and destination HR-MSs and Timer 74 instead of timer T7. Else, the HR-BS processes the DSA_REQ as a normal request.

HR-BS creates a flow_id based on the QOS requirement in the DSA_REQ.

Before sending DSA_RSP back to the source HR-MS, the HR-BS shall finish the DSA transaction with destination HR-MS with indication of direct communication. The process is illustrated in the Table 1020.

Table 1020—DSA Process for the direct communication

Source SS	Destination SS		BS
New service flow needed Check if resources are available			
Send DSA-REQ Set Timers T7 and T14		---DSA-REQ-->	Receive DSA-REQ DSA-REQ integrity valid
Timer T14 Stops; If direct communication is feasible, Timer T7 stops; Set Timer T74.			Check whether source and destination SS can support direct communication.
		<-- DSX-RVD--	Check whether source and destination are neighbors. Check whether SS is authorized for service Check whether service flow QoS can be Supported Create SFID
	Receive DSA-REQ Confirm that SS can support service flow Add DL SFID (if present) Enable reception on any new DL service flow	<-- DSA-REQ--	Send DSA-REQ Set Timer T7
	Send DSA-RSP	---DSA-RSP-->	Receive DSA-RSP Timer T7 Stops Enable transmission (DL) or reception (UL) of data on new service flow

	Receive DSA-ACK Enable transmission on new UL service Flow	<-- DSA-ACK---	Send DSA-ACK
Receive DSA-RSP Timer T74 Stops If ActiveQoSParamSet is non-null, Enable transmission or reception of data on new service flow		<--DSA-RSP---	Send DSA-RSP
Send DSA-ACK		---DSA-ACK-->	Receive DSA-ACK If DL ActiveQoSParamSet is non-null, Enable transmission of data on new DL service flow

16.2.2.1.2.2.4 Dynamic Service Change

With direct communication, the data flow is uni-direction, from source to destination HR-MS. Only source HR-MS and HR-BS are allowed to change the service flow parameters.

Source HR-MS initiated DSC procedure

When receving DSC-REQ from source HR-MS, the HR-BS shall delay the DSC-RSP to the source HR-MS and finish the DSC transaction with destination HR-MS first. Once the DSC transaction with destination HR-MS is finished, then the HR-MS sends a DSC-RSP to the source HR-MS and wait for the ACK. The process is illustrated in the Table 1021.

Table 1021—HR-MS initiated DSC procedure for direct communication

Source HR-MS	**Destination HR-MS**	**HR-BS**
Service flow requires modifying Send DSC-REQ Set Timers T74 and T14	--- DSC-REQ ---->	Receive DSC-REQ
Timer T14 Stops	<-- DSX-RVD ---	DSC-REQ integrity valid

			Validate Request
	Receive DSC-REQ Validate request Modify service flow	<-- DSC-REQ ---	Set Timers T7
	Send DSC-RSP	--- DSC-RSP ---->	Receive DSC-RSP Timer T7 Stops Increase Channel Bandwidth if Required
	Receive DSC-ACK	<-- DSC-ACK ---	Send DSC-ACK
Receive DSC-RSP Timer T74 Stops Reduce Payload Bandwidth if Required		<-- DSC-RSP ----	Send DSC-RSP
Send DSC-ACK Increase Payload Bandwidth if Required		--- DSC-ACK ---->	Decrease channel Bandwidth if Required

HR-BS Initiated

HR-BS can do the modification over DSC transaction with source and destination HR-MSs separately but with certain order.

In case bandwidth allocated to the direct communication link will be increased, the HR-BS should finish the transaction with destination HR-MS first and followed by the DSC transaction with source HR-MS.

In case bandwidth allocated to the direct communication link will be reduced, the HR-BS should finish the transaction with source HR-MS first and followed by the DSC transaction with destination HR-MS.

16.2.2.1.2.2.5 Dynamic Service Deletion

An HR-MS wishing to delete a service flow over HR-MS direct communication link generates a delete request to the HR-BS using a DSD-REQ message. The HR-BS finds the other HR-MS that also associates to the service flow first and then removes the service flow. After that, the HR-BS generates a response using a DSD-RSP message to

the HR-MS who sends DSD_REQ. At the same time, the HR-BS also generates DSD-REQ to the other HR-MS who also associates to this service flow.

A BS wishing to delete a dynamic service flow over HR-MS direct communication link generates two delete requests to the associated HR-MSs respectively using DSD-REQs. The HR-MSs removes the service flows and generate responses using DSD-RSPs. This process is illustrated in Table 1021.

16.2.2.1.3 Synchronization between HR-MSs involving in HR-MS DC/FTN

This section describes the process of maintaining synchronization between two HR-MSs that communicate directly with each other under HR-MS DC and FTN. The process is employed after HR-MS DC/FTN has been setup, and therefore should be differentiated from the discovery process described in 16.3.2.1.1. Synchronization between HR-MSs is classified into two levels:

- The frame-level should allow HR-MSs to share a common understanding of frame and/or superframe timing and configuration.

- The symbol-level should allow reliable (i.e. received within the appropriate reception threshold) bi-directional transmissions between HR-MSs.

Synchronization mechanisms are specified for three different use cases as follows.

16.2.2.1.3.1 Use case 1: both HR-MSs are within the coverage of HR-BS/RS

The following synchronization mechanisms are used for HR-MS DC/FTN scheduled in uplink area of a frame.

Frame-level Synchronization:

When both HR-MSs are able to receive preambles and DL control signals from a common serving HR-BS/HR-RS, they shall use these to achieve frame-level synchronization (with respect to HR-BS/HR-RS and between themselves). When both HR-MSs involved in DC or FTN are within the coverage of HR-BS/HR-RS, frame-level synchronization means the HR-MSs acquire DL synchronization with the serving HR-BS/HR-RS and are able to achieve system configuration and control messages.

Symbol-level Synchronization:

When the HR-MS/HR-MS direct link is scheduled in a UL area of a frame, the transmitting HR-MS shall follow the same timing advance as has been adjusted and agreed with the serving HR-BS/HR-RS. This means the transmitting HR-MS shall time its direct transmissions as if these are normal UL transmissions toward the serving HR-BS/HR-RS.

It is the responsibility of the receiving HR-MS to adjust its receive timing to match the time of arrival (TOA) of the signal transmitted by the other HR-MS. This time adjustment shall be achieved by the serving HR-BS/HR-RS scheduling the HR-MSs to

transmit ranging sequences to each other. Based on a received ranging sequence, an HR-MS can estimate and correct its time offset with the transmitting HR-MS. To facilitate this process, the serving HR-BS/HR-RS shall assign dedicated ranging sequences and ranging channels in UL area of a frame for HR-MS/HR-MS direct ranging.
To enhance bi-directional communication between HR-MSs, the serving HR-BS/HR-RS can allocate ranging resources to both involved HR-MSs in a single assignment. This allows the receiving HR-MS to transmit back a ranging sequence right after successfully processing the ranging sequence transmitted by the other HR-MS.

The serving HR-BS/RS schedules ranging between two HR-MSs through HR-DCV-CMD message.

16.2.2.1.3.2 Use case 2: one HR-MS is inside and the other is outside the coverage of HR-BS/RS

The following synchronization mechanisms are used for HR-MS DC/FTN scheduled in uplink area of a frame.

Frame-level Synchronization:

When two HR-MSs need to achieve frame-level synchronization and only one of them is within the coverage of the serving HR-BS/HR-RS, the inside-of-coverage HR-MS shall first acquires DL synchronization with the serving HR-BS/HR-RS (based on preambles and control messages from the serving HR-BS/HR-RS). The inside-of-coverage HR-MS shall subsequently broadcast preambles and possibly network configuration information (NCI) for the outside-of-coverage HR-MS to co-synchronize.

The registered HR-MS shall transmit preambles either at the first OFDMA symbol or the last OFDMA symbol of the frame. The NCI shall be transmitted in an UL area. The location of the NCI, relative to the transmitted preambles, shall be determinable by the outside-of-coverage HR-MS.

Symbol-level Synchronization:

Using the preambles and NCI transmitted by the inside-of-coverage HR-MS, the outside-of-coverage HR-MS shall adjust its timing to receive messages transmitted from the inside-of-coverage HR-MS. To further improve synchronization in this direction, the inside-of-coverage HR-MS can transmit ranging signal toward the outside-of-coverage HR-MS so that this node can estimate and correct its time/frequency offsets. Symbol-level synchronization in the opposite direction, i.e., from the outside-of-coverage of HR-MS toward the inside-of-coverage HR-MS shall be achieved by the outside-of-coverage HR-MS transmitting ranging signal toward the inside-of-coverage HR-MS. Upon processing the received ranging signal, the inside-of-coverage HR-MS can either adjust its own receive timing or request the outside-of-coverage HR-MS to adjust the transmit timing.

The serving HR-BS/RS schedules ranging between two HR-MSs through HR-DCV-CMD message.

16.2.2.1.4 Support for direct multicast operation

Two-way direct multicast among a group of HR-MS is supported through the following addressing mechanism:

- The base station assigns a 16-bit CID to each HR-MS of a two-way direct communications group. The CIDs assigned to different HR-MSs belonging to the same group can be the same or different;

- The base station can also specify one primary management CID for itself to multicast to all HR-MSs belonging to a particular two-way direct communication group;

- The base station informs all members of each two-way direct communication group of all the CIDs that have been assigned to the members of the group; including the CID reserved by the base station, if such a CID is reserved.

- For each DL-MAP Information Element, or UL-MAP Information Element, the base station specified the CID of the allocated HR-MS.

16.2.2.2 Physical layer

16.2.2.2.1 Frame Structure and Resource Allocation

Resources for HR-MS Direct Communications and HR-MS Forwarding to Network shall be scheduled by the serving HR-BS/RS when one exists. Serving HR-BS/RS can schedule direct communication in an on-demand and dynamic manner, and can multiplex this with transmissions between HR-MS and HR-BS / HR-RS.

To optimize the signaling and switching cost and improve QoS provisioning to HR-MS direct communication, serving HR-BS / HR-RS can schedule resource for DC/FTN zone for multiplexing DC/FTN transmissions. An HR-MS DC / FTN Zone is an area of continuous OFDMA resources in time and logical subchannels or resource units. The size and location of DC/FTN zone is dynamically or semi-stationary determined by the serving HR-BS.

When an infrastructure node doesn't exist, one of the HR-MS shall fulfill this coordinating role. It is understood that the coordinating HR-MS needs to take on some of the functionality of a HR-BS and may also require new functionality.
All resource scheduling shall be conveyed through MAP or DL control messages from serving HR-BS/RS or a coordinating HR-MS. In the case of HR-MS Forwarding to Network, the scheduling messages shall be forwarded by the forwarding HR-MS.

Random access channels may be used for bandwidth request. For case-1, bandwidth request are sent directly to the serving HR-BS /HR-RS. For case 2, bandwidth requests are forwarded by the forwarding HR-MS.

16.2.2.2.2 Power control for mobile to mobile communication

16.2.2.2.2.1 Power control for two HR-MS associated with an HR-BS

When two HR-MS that are associated with an HR-BS are transmitting to each other their power control related commands are generated by their serving HR-BS.

The HR-BS may define measurements to be performed by the HR-MS on resources used for MS-MS communications and on the desired MS-MS signal to be reported to the HR-BS.

Definition of power control procedure is TBD.

16.2.2.2.2.2 Power control for one HR-MS associated with an HR-BS

The transmission power of a forwarding HR-MS transmitting to forwarded HR-MS is controlled by messages from the forwarded HR-MS that are derived from HR-BS controls

The transmission power of a forwarded HR-MS is controlled by messages from the forwarding HR-MS that are derived from HR-BS controls

Power control procedure details TBD.

16.2.2.2.2.3 Power control for no HR-MS associated with an HR-BS

If a coordinator is used then it controls transmission power for the pair in the same way as a baseline HR-BS would.

The HR-BS signals power control parameters to all HR-MS with active links.

HR-MS may be instructed by the HR-BS to estimate path loss between HR-MSs.

The receiver of data generate offset controls that are based on constraints or parameters, signaled from HR-BS

The same procedure is applied for BS-controlled FTN and BS-controlled direct communication.

16.2.3 Talk-around direct communication

HR-MSs by themselves synchronize and perform contention-based transmission. The synchronization and the contention-based transmission are performed among those HR-MSs on a dedicated resource unused by HR-BSs if at least one of the HR-MSs are under HR-BS coverage.

16.2.3.1 Medium access control

16.2.3.1.1 Key management for talk-around direct communication

Talk-around direct communication key is managed as described in 16.10.1.2 .

16.2.3.2 Physical layer

16.2.4 Coordinator-based direct communication

When HR-MS cannot receive any BS preamble from any infrastructure station or an HR-MS that is associated with an infrastructure station, and HR-MS direct communication without infrastructure is permitted by device configuration, then HR-MSs are allowed to transmit network discovery signals to the network.

An HR-MS stops the transmission of discovery message when it becomes coordinator, or when it starts to associate to an infrastructure station or coordinator.

16.2.4.1 Back-off Mechanism for the Transmitting of Discovery Message

When HR-MS sends out network discovery messages, to avoid collision with other HR-MSs, it should follow a random-back off mechanism as follows:

1) A back-off timer shall be started before an HR-MS transmits a discovery message. HR-MS should get the value for the duration of back-off from a window [0, CW] based on uniform distribution, the size of window can be adjusted based on the traffic of networks. The value of CW shall be between CW_{min} and CW_{max}, and inclusive. The back-off value and size of contention window shall be counted in a time unit of OFDMA symbol duration.

2) When the timer is timeout, HR-MS should sense the channel for the presence of preambles for a duration of four OFDMA symbols. If no preambles is detected for the selected channel, then the HR-MS should transmit the discovery message. If a preamble has been detected, then the HR-MS shall hold on the transmission. The HR-MS shall detect whether the preamble is from an infrastructure station or from an HR-MS. If it is from an isolated HR-MS that sends discovery messages also, the HR-MS shall double the value of CW if it is less than CWmax and restart the timer. If it is from an infrastructure station or HR-MS associated to an infrastructure station, the HR-MS shall stop the transmission of discovery message on the selected channel.

3) HR-MS should reset the value of CW to CW_{min} whenever a transmission is made. CW_{min} is 64 and CW_{max} is 1024.

16.2.4.2 Format of Discovery Message

The network discovery message shall take the following format: a frame preamble shall be transmitted first followed by control and discovery information. The control information includes FCH, DL-MAP. UL-MAP shall be omitted. Discovery information

should follow the DL-MAP. A data packet may be transmitted as part of the discovery information.

For the FCH, it takes the same format as defined in 8.4.4.4.

For the DL-MAP, the DCD messages transmitted in the PHY Synchronization Field shall set the value of frame duration code to 255. The value indicates that the message is not from a BS, it is from an HR-MS for the discovery purpose. DCD count shall be set to zero. The base station ID shall be set to the MAC address of the current HR-MS.

16.2.4.3 Synchronization between HR-MSs: in case of there is no HR-BS/RS

- The first level synchronization should be carried out in a Master-slave manner. It is understood that the master needs to take on some of the functionality of a BS and may also require new functionality.

- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

An example of this scenario is when HR-MS1 and HR-MS2 are having direct communications in an infrastructure-less deployment (or due to single point of failure). For this, an HR-MS (which can be HR-MS1, HR-MS2, or another node) should first be elected as the network coordinator. It is assumed that either one or both HR-MS1 and HR-MS2 then are within the coverage of the elected coordinator. After being elected, the coordinator shall periodically broadcast preambles for frame-level synchronization. With this, the control is back to one of the two earlier scenarios.

16.3 Support for HR-MS Forwarding to Network

16.3.1 General Description

In HR-MS Forwarding to Network, an HR-MS forwards user data and control signaling between an HR-MS and an HR infrastructure station. The user data and control signaling do not go through higher layer at the forwarding HR-MS. The origination and termination of the user data and control signaling are at the forwarded HR-MS and the HR infrastructure station respectively and vice versa.

HR-MS Forwarding to Network is applicable when 1) the forwarded HR-MS and the forwarding HR-MS are in coverage of and directly associated to an infrastructure station; 2) the forwarding HR-MS is in coverage of and directly associated to an HR infrastructure station, while the forwarded HR-MS is out of coverage of any HR infrastructure stations.

Under BS-controlled direction communication described in16.2.2, HR-MS forwarding to network is described in16.3.2.

Using talk-around direct communication described in16.2.3, HR-MS forwarding to network is described in16.3.3.

16.3.2 BS-Controlled HR-MS Forwarding to Network

The general operation of BS-controlled HR-MS forwarding to network (FTN) can be described as follows:

- At the beginning of the process, the serving HR-BS/RS instructs one or a group of its associated HR-MS to broadcast discoverable signals so that an out-of-coverage HR-MS can start network entry and get associated to the HR-BS/RS.
- After the out-of-coverage HR-MS has completed network entry and become an attached forwarded HR-MS, the forwarding HR-MS helps forward control and data messages between the forwarded HR-MS and the serving HR-BS/RS.

16.3.2.1 Medium access control

16.3.2.1.1 HR-MS Discover Network Infrastructure

For use case 2, The HR-BS may instruct HR-MS that are associated with it to transmit access information at pre-defined resources relative to the preambles transmitted by the HR-MS. The access information defines resources for access by the HR-MS that is not under HR-BS coverage. Access information may be omitted. If access information is omitted then access resources are defined by the index and the sub-carrier set index of the SA-Preamble. All or a group of the directly associated HR-MS may or may not transmit the same access information on the same or different resources.

An unassociated HR-MS that detects the associated HR-MS preamble(s) shall subsequently receive access information to determine the access resource. If access information is omitted then access resources are determined from the SA-Preamble. The unassociated HR-MS transmits a CDMA preamble.

The associated HR-MS that received the CDMA preamble responds with sufficient access information to complete the association procedure.

16.3.2.1.2 Discovery for HR-MS Forwarding to Network

To enable coverage extension, a serving HR-BS/HR-RS shall schedule some of its directly-associated HR-MSs to transmit preambles so that HR-MSs who are out of coverage of HR-BS/HR-RS can detect and start network entry. The directly-associated HR-MS shall transmit frame preamble at the first OFDM symbol and followed by the network configuration information (NCI).

16.3.2.1.2.1 Frame Structure

The HR-BS/HR-RS shall schedule the selected HR-MSs transmitting preamble and NCI at the end of the UL subframe. A zone in uplink with duration of three OFDMA symbols

shall be allocated for discovery. The preamble occupies one OFDMA symbol duration and the FCH and NCI. The format of NCI is defined in section in **6.3.2.3.98.13**.

Figure 803 shows the frame structure when HR-MS is scheduled to transmit preamble and NCI. The format of NCI is defined in **6.3.2.3.98.13**.

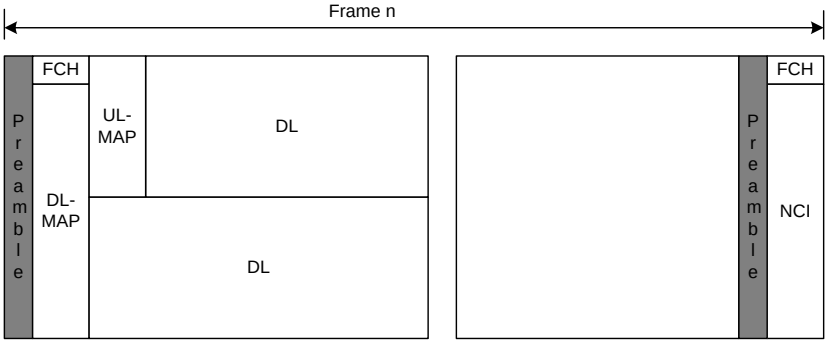


Figure 803----Frame structure for HR-MS transmitting preamble and NCI for FTN discovery.

HR-MSs that are out of coverage of HR-BS/HR-RS scanning for DL preambles for possible network entry shall be able to differentiate between preambles transmitted by normal infrastructure stations (HR-BS/HR-RS) and those transmitted by a coverage-extending HR-MS.

After receiving the preamble and NCI, if HR-MS intends to start network entry process, it chooses an initial ranging code and shall transmit the ranging code on the specified ranging channel. Back-off is unnecessary for FTN initial ranging.

A subset of preambles shall be reserved for FTN discovery. The details are TBD.

16.3.2.1.2.2 Scheduling of Preamble and NCI

When HR-BS/HR-RS schedules some of HR-MSs to transmit the FTN discovery message, it shall reserve a zone at the end of uplink sub-frame for the transmission of preamble and NCI with UL_Zone_IE() as specified in Table 471. The zone shall have a minimum length of three symbols.

16.3.2.1.2 Synchronization

See 16.2.2.1.3.

16.3.2.1.3 Bandwidth Requests sent from Forwarded HR-MS

For use case 2, an out-of-coverage forwarded HR-MS can request bandwidth by transmitting some known sequences (Bandwidth Request (BR) preambles) toward the forwarding HR-MS.

The process can be described as follows.

- Serving HR-BS/RS schedules resources in an uplink subframe for forwarded HR-MSs to transmit BR messages to their corresponding forwarding HR-MS.
- The resource allocation information is conveyed to the forwarded HR-MS.
- The forwarding HR-MS listens to bandwidth requests at times and resources indicated by the HR-BS. The forwarded HR-MS may transmit bandwidth requests using these resources.
- The forwarding HR-MS, upon receiving BR messages from one of its forwarded HR-MS, forwards the requests to serving HR-BS/RS.
- Any resource assignment from the HR-BS is forwarded to the forwarding HR-MS.

16.3.2.1.4 Paging by HR-MS

The HR-BS may instruct an HR-MS or a group of HR-MS to broadcast a Paging Indicator (PI) message or IE. The PI contains ID's of paged HR-MSs or groups of HR-MSs. The resources for the PI are signaled in the S-NCI. PI format is TBD.

An HR-MS that receives its ID or an assigned group ID in the PI shall access the paging HR-MS as is done for HR-MS neighbor discovery.

16.3.2.2 Physical layer

16.3.2.2.1 Frame structure and resource allocation

See 16.2.2.2.1.

16.3.3 Talk-around HR-MS forwarding to network

16.3.3.1 Medium access control

16.3.3.2 Physical layer

16.4 Support for Standalone Network

For WirelessMAN HR-OFDMA air interface, when the HR-BS loses connectivity to the backbone network and the neighboring HR-BSs, the network stations under the coverage of this HR-BS shall form a standalone network. The local connectivity shall be provided for the HR-MS within the coverage of affected HR-BS. The established service flow between HR-MS within the coverage of the affected HR-BS shall be maintained.

16.4.1 Maintenance of Local Connectivity

For maintenance of local connectivity, all the HR-BSs shall maintain a network topology table of HR-MS/HR-RS within its coverage area. The network topology table shall be updated periodically by broadcasting STN-REQ message from HR-BS and receiving acknowledgement message STN-ACK from HR-MS or HR-RS within its coverage area.

16.4.2 Entry Process for Standalone Network

The HR standalone network with WirelessMAN HR-OFDMA air interface shall allow the entry of an unassociated HR-MS into the standalone network and establish the

connection with standalone network HR-BS. The unassociated HR-MS is referred to the HR-MS which is not associated with any Base Station.

16.4.3 Recovery Process of Standalone Network

When a standalone network HR-BS recovers the backbone connection, the standalone network shall be incorporated to the backbone connected network. Neighbor HR-BSs transmit information to the HR-BS which has recovered the backbone connection. The specification on how to transmit is out of scope of this standard. The subordinate stations may remain the association or re-associate with the HR-BS that has recovered the backbone connection.

16.5 Support for High Reliable Relaying

In order to provide great reliability in a degraded network, the relay function described in this subsection shall be supported.

In order to support local forwarding in an HR-Rs, the HR-Rs shall follow operation as defined in Section 16.6.

16.6 Support for Local Forwarding

16.7 Path Management against Degraded Network

To support high reliability and to recover SPOF, following operation may be supported:

- alternative path management described in 16.7.1
- reliable HO optimization described in 16.7.2
- forwarding between HR-infrastructure stations (using subordinate HR-station) described in 16.7.3

16.7.1 Alternative Path Management

Alternative path may be maintained in the following cases:

- before the SPOF occurs if SPOF is predicted or needed
- when the SPOF occurs with/without any preparing
- after the SPOF is recovered, to continue supporting high reliability

16.7.1.1 Alternative Path Preparing

To prepare alternative path, the MAC context information of HR-MS may be shared between following HR-stations:

- HR-infrastructure stations (i.e., serving and neighbor HR-infrastructure stations)
- An HR-MS capable of forwarding to the network and the HR-MS performing forwarding to the network

To support fast recovery in the event of SPOF, an indication of whether MAC context information of the subordinate HR-MS is being shared by infrastructure stations shall be transmitted to HR-MS.

To support fast network reentry to the neighbor HR-MSs, either HR-BS or HR-MS may prepare the alternative path using neighbor discovery described in 16.2.2.1.1.

To prepare the alternative path by an HR-BS, the HR-BS performs operation as follows:

a) neighbor discovery as described in 16.2.2.1.1
b) collecting HR-MS' neighbor information as described in 16.2.2.1.1
c) determining the alternative path for HR-MS
d) informing HR-MS about its alternative path information

To prepare the alternative path by an HR-MS, the HR-MS and its serving HR-BS perform operation as follows:

a) An HR-MS transmits AP-NBR-REQ to the HR-BS to initiate the neighbor discovery process
b) After the HR-BS receives the AP-NBR-REQ, the HR-BS performs the neighbor discovery as described in 16.2.2.1.1
c) The HR-BS collects the neighbor information of requesting HR-MS as described in 16.2.2.1.1
d) The HR-BS transmits AP-NBR-REP message to HR-MS, where the AP-NBR-REP includes the neighbor information of requesting HR-MS.
e) The HR-MS determines alternative path by itself based on its received neighbor information in the AP-NBR-REP message, but how to determine is out of scope of this specification

16.7.1.2 Alternative Path Switching

When the trigger condition specified in the TLV of the last MOB_BSHO-REQ described in 6.3.2.3.47 is met, the alternative path is activated by an HR-MS. If the action time is non-zero, the HR-MS shall perform the fast network reentry after the action time expires.

To support switching to alternative path with fast network reentry, the serving HR-BS transmits MOB_BSHO-REQ message with mode = 0b111 to the HR-MS.

The alternative path information may be updated with a new MOB_BSHO-REQ message.

The target HR-BS of the alternative path may share MS context information with the serving HR-BS and recommend a ranging code and slot from the ranging region to facilitate fast network reentry and reduce contention during ranging. However, how to request and recommend is out of this specification.

16.7.1.3 Alternative Path Maintaining

Alternative path may be selected during the role change or release the mode as described in 16.1.

16.7.2 Reliable HO Procedure

16.7.3 Forwarding between HR-Infrastructure stations

The HR-MS may transmit/receive data to/from any one infrastructure station at any given time. The HR-MS may forward previously received data to other infrastructure stations at other times.

16.8 Support for Priority Access Operation

16.9 Support for Multicast

Each HR-BS capable of providing multicast communication belongs to a certain multicast group zone. A multicast zone defined as a set of HR-BSs where the same HR Multicast CID is used for transmitting the content of certain service flow(s).

An HR-BS may provide the HR-MS with multicast content locally within its coverage and independently of other HR-BSs. The single HR-BS provision of multicast is therefore a configuration where a Multicast Zone is configured to consist of a single HR-BS only. In this case, the HR-BS uses any CID providing multicast service, independently of other HR-BSs, so the HR-MS received the multicast data from its serving HR-BS, and the HR-MS should not expect the service flow for this multicast connection to continue when the HR-MS leaves the serving HR-BS' coverage. However, if the HR-MS moves to an HR-BS that is transmitting the same multicast flow in another HR Multicast Group Zone, HR-MS may update its service flow management encodings to continue to receive the same multicast flows.

To ensure proper multicast operation on networks of HR-BS employing multicast, the HR Multicast CID used for common multicast content and service shall be the same for all HR-BSs within the same HR Multicast Group Zone. This allows the HR-MS which has already registered with a service to be seamlessly synchronized with multicast transmissions within an HR Multicast Group Zone without communicating in the UL or re-registering with other HR-BS within that HR Multicast Group Zone.

The Multicast Group Zone identifier shall not be "0."

When the Multicast Group Zone identifier list appears in DCD setting TLV in MOB_NBR-ADV message with only one value of "0," then the neighbor BS is not affiliated with any Multicast zone. An Multicast zone that is adjacent to another Multicast zone is a neighbor multicast zone to that multicast zone.

16.9.1 Multicast Communication Operation

An HR-BS establishes a DL multicast service by creating a multicast connection with each HR-MS to be associated with the service. Multicast service flows are not dedicated to the specific HR-MS and are maintained even though the HR-MS is either connected

mode or idle mode. When an HR-MS is registered at an HR-BS for receiving multicast service, multicast service flows shall be instantiated as multicast connections. An HR-MS regardless of what mode the HR-MS is currently in may receive data of multicast service flows transmitted from HR-BS. Any available HR Multicast CID is used for the multicast service (i.e., there are no dedicated CIDs for multicast transport connections). To ensure proper multicast operation, the HR multicast CID used for the service shall be the same for all HR-MSs on the same channel that participate in the connection in a multicast zone. Mapping of multicast service flows to corresponding HR multicast CIDs shall be known and be the same for all HR-BSs belonging to the same HR Multicast Group Zone.

16.9.1.1 Multicast communication establishment

The procedure of multicast communication establishment includes capacity exchange, establishment multicast connection, transmission and receiving the HR-multicast control channel as shown in Figure 804. The procedure includes

- Capacity exchange using REG-REQ/RSP
- DSx procedure containing relevant multicast parameter to establish multicast connection
- Transmission and receiving the HR multicast control channel

To discover multicast service, HR-MS will inform HR-BS of support of multicast transmission by REG-REQ message and the HR-BS will indicate if it supports multicast for that HR-MS through REG-RSP message. The basic multicast capability exchange in REG-REQ/RSP message is described in 6.3.2.3.7 and 6.3.2.3.8.

When an HR-MS registers to receive multicast services, the serving HR-BS or the HR-MS may initiate the DSA procedure for multicast connections. The HR-MS' discovery and registration of multicast services with the HR-BS through upper layer signaling are outside the scope of this standard.

The DSA, DSC and DSD messages are used to establish, change, and delete multicast service flows respectively. The HR-BS shall send the DSA-REQ/RSP to the HR-MS with the relevant multicast parameters including Multicast Group ID.

To receive multicast data, an HR-MS receives the multicast allocation information in the multicast control channel (i.e., multicast assignment MAP).

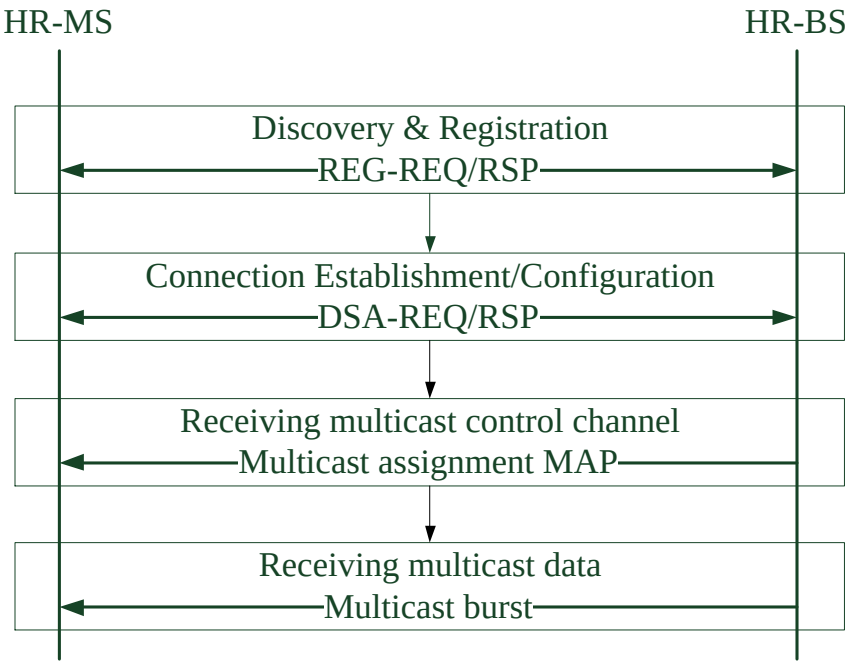


Figure 804 – Procedure of multicast communication establishment

16.9.1.2 Multicast communication in normal operation mode

When an HR-MS moves across Multicast zone boundaries in Active Mode or Sleep Mode, the HR-MS performs the handover procedure as described in 6.3.21.

When the HR-MS transits to a new Multicast Zone while in Active Mode or Sleep Mode, the HR-MS shall send RNG-REQ message described in 6.3.2.3.5 with Ranging Purpose Indication Bit 5 setting to 1 at the target HR-BS. In response to the request for multicast service flow update, the HR-BS shall transmit RNG-RSP message described in 6.3.2.3.6, which may include multicast service flow update mapping info to provide updated service flow management encodings for any affected multicast flow as part of the handover procedure.

16.9.1.3 Multicast communication operation in idle mode

When an HR-MS in Idle mode moves to an HR-BS which does not belong to HR-MS' previous Multicast Group Zone, the HR-MS is expected to update the multicast service flow management encodings at that HR-BS to provide continuous reception of multicast content. The HR-MS may obtain the multicast information in the target Multicast zone through MOB_NBR-ADV message described in 6.3.2.3.42 in the Multicast Zone of the service HR-BS. If the idle mode HR-MS has not received such information from the serving Multicast Zone, the HR-MS shall use location update procedure to acquire updated multicast service flow management encodings. In order to perform the multicast location update process, the HR-MS shall transmit RNG-REQ message described in 6.3.2.3.5 with the Ranging Purpose Indication Bit 5 setting to 1. In response to the request for multicast location update, the HR-BS shall transmit RNG-RSP message described in 6.3.2.3.6, which may include the Multicast Group Zone identifier and HR

Multicast CID to provide update service flow management encodings for any affected multicast flow(s).

16.9.2 Multicast Protocol Features and Functions

16.9.2.1 Downlink control channel for multicast communication

HR-multicast control channel (i.e., HR-Multicast DL MAP IE) carries configuration information (including allocation/change/releasement) for multicast communication for one multicast zone in an HR-BS. In HR-Multicast DL MAP, allocation period indicates a period of persistent allocation of multicast resource and Lifetime is a timer indicating the next instance of HR-Multicast DL MAP IE. Unless the Lifetime expires, this HR-Multicast DL MAP does not change during the allocation duration. At the time the Lifetime expires, the HR-Multicast DL MAP shall change or release the allocation.

Table 1022—HR-Multicast DL MAP IE

Syntax	Size (bit)	Notes
HR-Multicast DL MAP IE {		
Extended-2 DIUC	4	HR Multicast DL Map IE() = 0xF (Extended-3 DIUC)
Length	8	Length in bytes
Extended-3 DIUC	4	0x01
Region ID Indicator	1	0: not use Region_ID 1: use Region_ID
If (Region_ID use indicator == 0) {		
OFDMA symbol offset	8	Offset from the start of DL subframe
Subchannel offset	7	
Number of OFDMA symbols	7	
Number of subchannels	7	
Rectangular subburst Indication	1	Indicates subburst allocations are time-first rectangular. The duration field in each subburst IE specifies the number of subchannels for each rectangular allocation. This is only valid for AMC allocations and all allocations with dedicated pilots. When this field is clear, subbursts shall be allocated in frequency-first manner and the duration field reverts to the default operation.
Reserved	2	
} else		
Region_ID	8	Index to the DL region defined in DL region definition TLV in DCD
}		
HR_Multicast_DL_Subburst_IE()	*variable*	Table 1023
Padding	*variable*	Padding to byte for the unspecified portion of this IE (i.e. not including the first two fields,

		"Extended-2 DIUC" and "Length"); shall be set to 0.
}		

Table 1023—HR Multicast DL subburst IE format

Syntax	Size (bit)	Notes
HR_Multicast_DL_Subburst_IE() {		
N subburst	4	Number of subbursts in the 2D rectangular region is this field value plus 1.
Resource shifting indicator	1	0 = No Resource shifting 1= Resource shifting
For(j=0;j<Number of subbursts;j++){		
Allocation Flag	1	1 = allocate 0 = de-allocate
Group Indicator	1	TDD mode: *Reserved*, set to 0. Used for FDD/H-FDD case only; to indicate the group assignment of the MS (see 8.4.4.2 and 8.4.4.2.1) 0b0: Group #1 0b1: Group #2
If (Allocation Flag == 0) {		// deallocate
HR Multicast CID	16	
If (Resource shifting indicator == 1) {		
Duration	*variable*	Duration in slots. OFDMA Frame duration dependent 7 bits – 2.5 ms frame 8 bits – 5 ms frame 9 bits – 10 ms frame 10 bits – 20 ms frame
Slot Offset	*variable*	Indicates the start of this persistent allocation in OFDMA slots, with respect to the lowest numbered OFDM symbol and the lowest numbered subchannel in the region. OFDMA Frame duration dependent 7 bits – 2.5 ms frame 8 bits – 5 ms frame 9 bits – 10 ms frame 10 bits – 20 ms frame
}		
} else if (Allocation Flag == 1) {		// allocate
HR Multicast CID	16	
Persistent Flag	1	0 = Non-persistent 1 = Persistent
if(Power boost per subburst		

== 1){		
Boosting	1	0b000: Normal (not boosted) 0b001: +6dB 0b010: –6dB 0b011: +9dB 0b100: +3dB 0b101: –3dB 0b110: –9dB 0b111: –12dB; Note that if the Persistent flag is set, the boosting value applies to each instance of the persistent allocation
}		
Duration	*variable*	Duration in slots. OFDMA Frame duration dependent 7 bits – 2.5 ms frame 8 bits – 5 ms frame 9 bits – 10 ms frame 10 bits – 20 ms frame
Slot Offset	*variable*	Indicates the start of this persistent allocation in OFDMA slots, with respect to the lowest numbered OFDM symbol and the lowest numbered subchannel in the region. OFDMA Frame duration dependent 7 bits – 2.5 ms frame 8 bits – 5 ms frame 9 bits – 10 ms frame 10 bits – 20 ms frame
If (Persistent Flag == 1) {		
Allocation Period (ap)	5	Period of the persistent allocation is this field value plus 1 (unit is frame)
Lifetime(L)	4	Indicates the time to transmit the information of this allocation and the information does not change until lifetime expires. The next transmission of information is at the frame whose frame number, N_{frame}, satisfies the following condition. N_{frame} modulo L + 1 = 0
} else		
Next allocation offset	5	5LSBs of frame number and it indicates next allocation of the allocation of this field
}		
DIUC	4	
Repetition Coding Indication	2	0b00: No Repetition coding 0b01: Repetition coding of 2 used 0b10: Repetition coding of 4 used 0b11: Repetition coding of 6 used

}		
}		
Padding	*variable*	Padding to nibble; shall be set to 0.
}		

16.9.2.2 Feedback for multicast information

To ensure robust multicast and provide the network operator with specific or statistical information of its reception a feedback operation is defined between an HR-MS that is an addressee of a multicast transmission and its serving HR-BS or HR-RS.

The conditions for providing feedback are defined by the network per each multicast channel and include positive feedback only (logical ACK), negative feedback only (logical NAK) or both (logical ACK/NAK). It is expected that all intended recipients of a multicast channel obey the same rules but those can be changed by the network. UL resources for the feedback are also provided by the HR-BS. Feedback parameters may be unicast or multicast.

Feedback operation is supported by multicast addressees in connected as well as in idle states. Code-only feedback may be used to provide feedback for multicast. The procedure for providing the feedback is TBD.

16.9.3 Multicast Key Management

Multicast key is managed as described in **16.10.2**.

16.10 Support for Security

16.10.1 Security Procedure for Direct Communication Data Security

16.10.1.1 Security Procedure for BS-controlled Secure Direct Communication

16.10.1.1.1 BS-coordinated Key Management Procedure for Secure Direct Communication

In order to support BS-coordinated secure direct communication, the security procedure described in this subsection shall be executed between HR-MS, HR-BS, Authenticator, and AAA Server. Upon successful completion of the security procedure, HR-MSs received the security key from the HR-BS and use this security key for secure direct communication between/among HR-MSs. This security key may be used as the pre-established shared key for secure direct communications in Section 16.10.1.1.1.1.

The HR-BS/Authenticator is used to denote that the HR-BS may pass the messages to the AAA-server via the Authenticator for verification and the AAA-server may compute the

direct communication security key DMK and send it to the HR-BS via the Authenticator. The flow diagram is shown in Figure 805.

The BS-coordinated security procedure includes the following steps:

Step 1: Once it is determined that secure direct communications is allowed between HR-MS1 and HR-MS2, HR-BS/Authenticator generates the security key DMK, selects N_{HR-BS} and encrypts E_{HR-MS1_KEK}(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr) and computes$CMAC_{HR-BS} = MAC_{CMAC1}$("DC_REPLY_OK_BS"|$T_{HR-BS}$|$N_{HR-BS}$|$E_{HR-MS1\_KEK}$(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr)|HR-MS1Addr|HR-MS2Addr) and sends Key-Transfer-MSG#1 message to HR-MS1, where Key-Transfer-MSG#1 = "DC_REPLY_OK_BS"|T_{HR-BS}|N_{HR-BS}|E_{HR-MS1_KEK}(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr)|HR-MS1Addr|HR-MS2Addr|$CMAC_{HR-BS}$. HR-BS/Authenticator also encrypts E_{HR-MS2_KEK}(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr) and computes $CMAC_{HR-BS} = MAC_{CMAC2}$("DC_REPLY_OK_BS"|$T_{HR-BS}$|$N_{HR-BS}$|$E_{HR-MS2\_KEK}$(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr)|HR-MS2Addr|HR-MS1Addr) and sends Key-Transfer-MSG#2 message to HR-MS2, where Key-Transfer-MSG#2 = "DC_REPLY_OK_BS"|T_{HR-BS}|N_{HR-BS}|E_{HR-MS2_KEK}(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr)|HR-MS2Addr|HR-MS1Addr|$CMAC_{HR-BS}$.

Step 2a: If HR-MS1 received Key-Transfer-MSG#1 message from HR-BS/Authenticator, HR-MS1 first checks T_{HR-BS}, N_{HR-BS} for freshness and $CMAC_{HR-BS}$ for message authentication. If the verifications fail, then HR-MS1 shall ignore Key-Transfer-MSG#1 message. If the verifications are correct, then HR-MS1 decrypts E_{HR-MS1_KEK}(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr) and obtains the security key DMK and its lifetime key_lifetime.

Step 2b: Upon receiving the Key-Transfer-MSG#2 message, HR-MS2 first checks T_{HR-BS}, N_{HR-BS} for freshness and $CMAC_{HR-BS}$ for message authentication. If the verifications fail, HR-MS2 shall ignore the Key-Transfer-MSG#2 message. If the verifications are correct, then HR-MS2 decrypts E_{HR-MS2_KEK}(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr) and obtains the security key DMK and its lifetime key_lifetime.

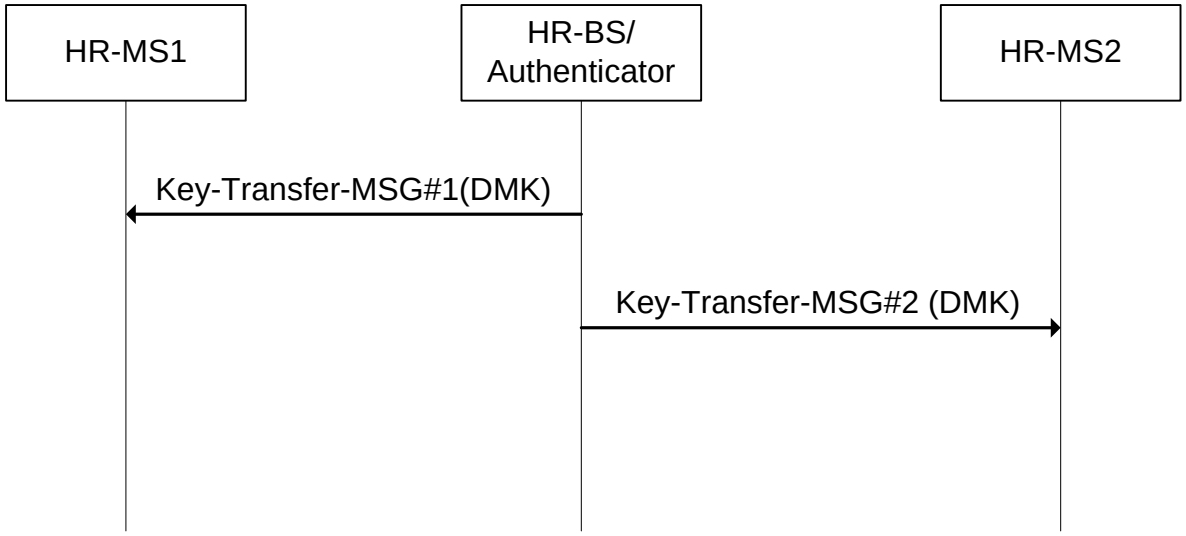


Figure 805—Flow Diagram of Authentication and Key Establishment of Network Aided Direct Communication scenario.

16.10.1.1.1.1 Message Type

Table 1024 —Message Type

Code	Message Type	MAC control message name
a	Key-Transfer-MSG#1	AAI-PKM-RSP
b	Key-Transfer-MSG#2	AAI-PKM-RSP

16.10.1.1.1.2 Message Attributes

Table 1025—Key-Transfer-MSG#1 message attribute

Attribute	Contents
"DC_REPLY_OK_BS"	HR-BS response to HR-MS1 that HR-MS2 accepted direct communications
T_{HR-BS}	Timestamp generated by HR-BS
N_{HR-BS}	Freshly generated random number of 64bits by HR-BS
E_{HR-MS1_KEK}(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr)	Encryption of DMK, key lifetime by HR-BS using HR-MS1's KEK
HR-MS1Addr	Address of HR-MS1
HR-MS2Addr	Address of HR-MS2
$CMAC_{HR-BS}$	Message digest calculated using CMAC key by HR-BS

Table 1026—Key-Transfer-MSG#2 message attribute

Attribute	Contents
"DC_REPLY_OK_BS"	HR-BS response to HR-MS1 that HR-MS2 rejected direct communications
T_{HR-BS}	Timestamp generated by HR-BS
N_{HR-BS}	Nonce generated by HR-BS
E_{HR-MS2_KEK}(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr)	Encryption of DMK, key lifetime by HR-BS using HR-MS2's KEK
HR-MS2Addr	Address of HR-MS2
HR-MS1Addr	Address of HR-MS1
$CMAC_{HR-BS}$	Message digest calculated using CMAC key by HR-BS

16.10.1.1.2 Autonomous Mutual Authentication of HR-MS and data security for Direct Communications

16.10.1.1.2.1 Secure direct communication using pre-established shared key

In order to support secure direct communication between two or among more HR-MSs, pre-established shared key is used.

The pre-established shared key is established prior to the start of this direct communications.

The pre-established shared key may be established using the procedure mentioned in Section 16.10.1.1.

The key agreement handshake procedure described below shall be used for HR-MSs to mutually authenticate themselves (without access to a security server) using the pre-established shared key and to derive data security keys for secure direct communications. Figure 806 shows the flow diagram while Figure 807 shows the flow chart for this scenario.

The key agreement handshake procedure using pre-established shared key includes the following steps:

Step 1: HR-MS1 selects nonce N_{HR-MS1} and uses the pre-established shared key DMK to compute DAK, DCMAC key and $CMAC_{HR-MS1} = MAC_{DCMAC}(N_{HR-MS1}|DMK\_Sequence\_No|DAKID|Key\_lifetime)$. Finally, HR-MS1 sends the DirectComms_KeyAgreement_MSG_#1 message to HR-MS2, where DirectComms_KeyAgreement_MSG_#1 = $N_{HR-MS1}|DMK\_Sequence\_No|DAKID|Key\_lifetime|CMAC_{HR-MS1}$.

Step 2: HR-MS2 first verifies the received nonce is fresh and uses the pre-established shared key DMK to compute DAK =Dot16KDF (DMK, HR-MS1Addr|HR-MS2Addr|"DAK", 160), the DCMAC key and uses DCMAC key to checks $CMAC_{HR-MS1}$. If the verification fails, HR-MS2 shall ignore the DirectComms_KeyAgreement_MSG_#1 message. If the verification is correct, HR-MS2 selects N_{HR-MS2} and computes $CMAC_{HR-MS2} = MAC_{DCMAC}(N_{HR-MS1}|N_{HR-MS2}|DAKID|DMK\_Sequence\_No|DC\_Security\_Parameters)$. Finally, HR-MS2 sends DirectComms_KeyAgreement_MSG_#2 message to HR-MS1, where DirectComms_KeyAgreement_MSG_#2 = $N_{HR-MS1}|N_{HR-MS2}|DAKID|DMK\_Sequence\_No|DC\_Security\_Parameters|CMAC_{HR-MS2}$.

Step 3: HR-MS1 receives the DirectComms_KeyAgreement_MSG_#2 message from HR-MS2 and checks the received nonces for freshness and also checks DAKID and $CMAC_{HR-MS2}$. If the verifications fail, HR-MS1 shall ignore the DirectComms_KeyAgreement_MSG_#2 message. If the verifications are correct, HR-MS1 computes $CMAC_{HR-MS1}' = MAC_{DCMAC}(N_{HR-MS1}|N_{HR-MS2}|DMK\_Sequence\_No|DC\_SAID|DC\_Security\_Parameters)$. Finally, HR-MS1 sends DirectComms_KeyAgreement_MSG_#3 message to HR-MS2, where DirectComms_KeyAgreement_MSG_#3 = $N_{HR-MS1}|N_{HR-MS2}|DMK\_Sequence\_No|DC\_SAID|$ $DC\_Security\_Parameters|CMAC_{HR-MS1}'$. If HR-MS1 does not receive DirectComms_KeyAgreement_MSG_#2 message from HR-MS2 within DirectComms_KeyAgreement_MSG_#1 Timeout, it shall resend the DirectComms_KeyAgreement_MSG_#1 message up to DirectComms_KeyAgreement_MSG_#1 MaxResends times. If HR-MS1 reaches its maximum number of resends, it shall initiate another authentication or drop the request.

Step 4: Upon receiving the DirectComms_KeyAgreement_MSG_#3 message, HR-MS2 checks the received nonces for freshness and $CMAC_{HR-MS1}'$. If the verifications are invalid, then HR-MS2 shall ignore the DirectComms_KeyAgreement_MSG_#3 message. If the verifications are correct, HR-MS2 applies the negotiated security parameters. Otherwise, if $CMAC_{HR-MS1}'$ is invalid, then HR-MS2 shall ignore the DirectComms_KeyAgreement_MSG_#3 message. If HR-MS2 does not receive DirectComms_KeyAgreement_MSG_#3 message from HR-MS1 within DirectComms_KeyAgreement_MSG_#2 Timeout, it shall resend the DirectComms_KeyAgreement_MSG_#2 message up to DirectComms_KeyAgreement_MSG_#2 MaxResends times. If HR-MS2 reaches its maximum number of resends, it shall initiate another authentication or drop the request. HR-MS1 and HR-MS2 can now derive DTEK and commence secure direct communications.

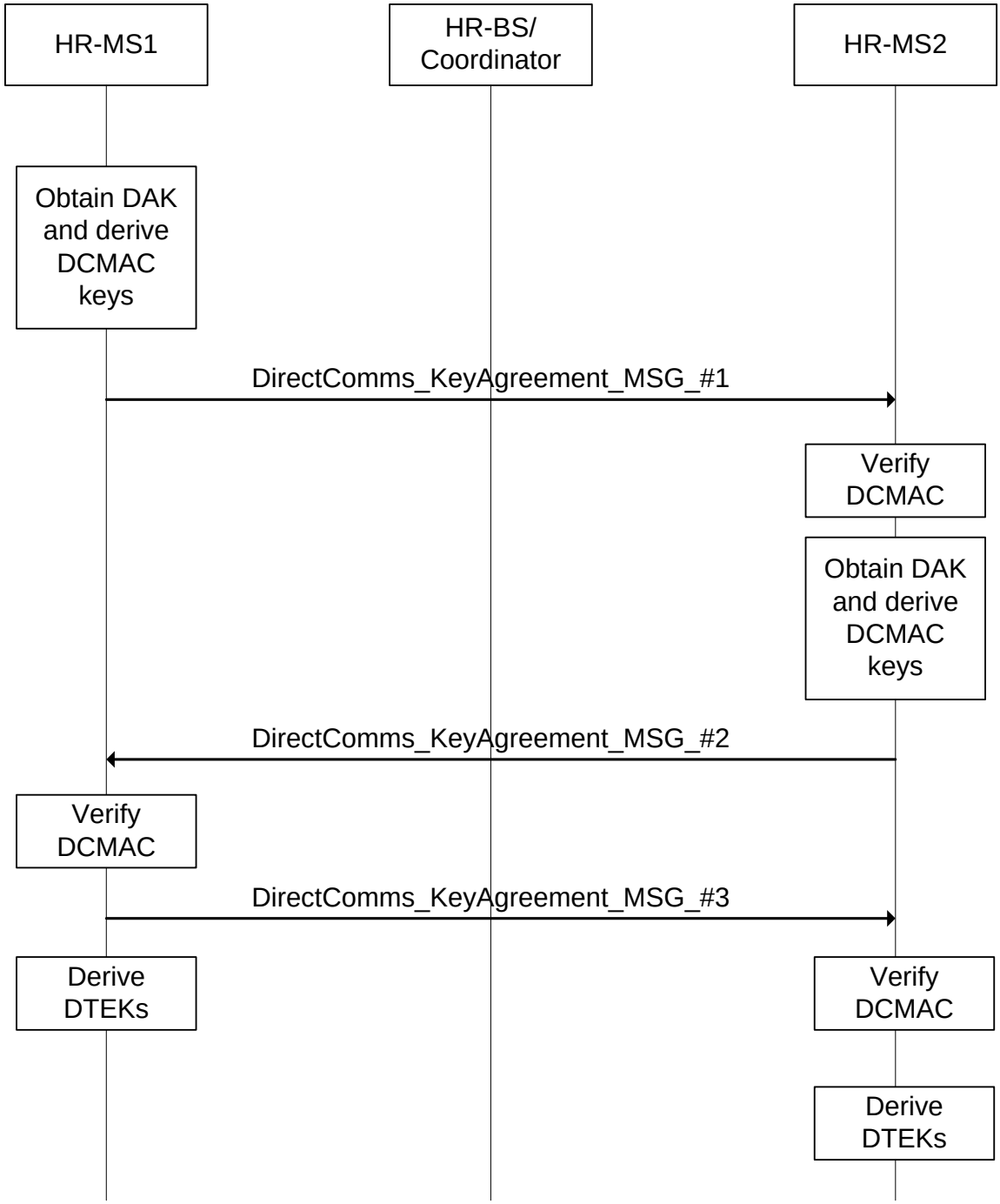


Figure 806—Flow Diagram of Authentication and Key Establishment of Direct Communication without Infrastructure (Pre-shared key case).

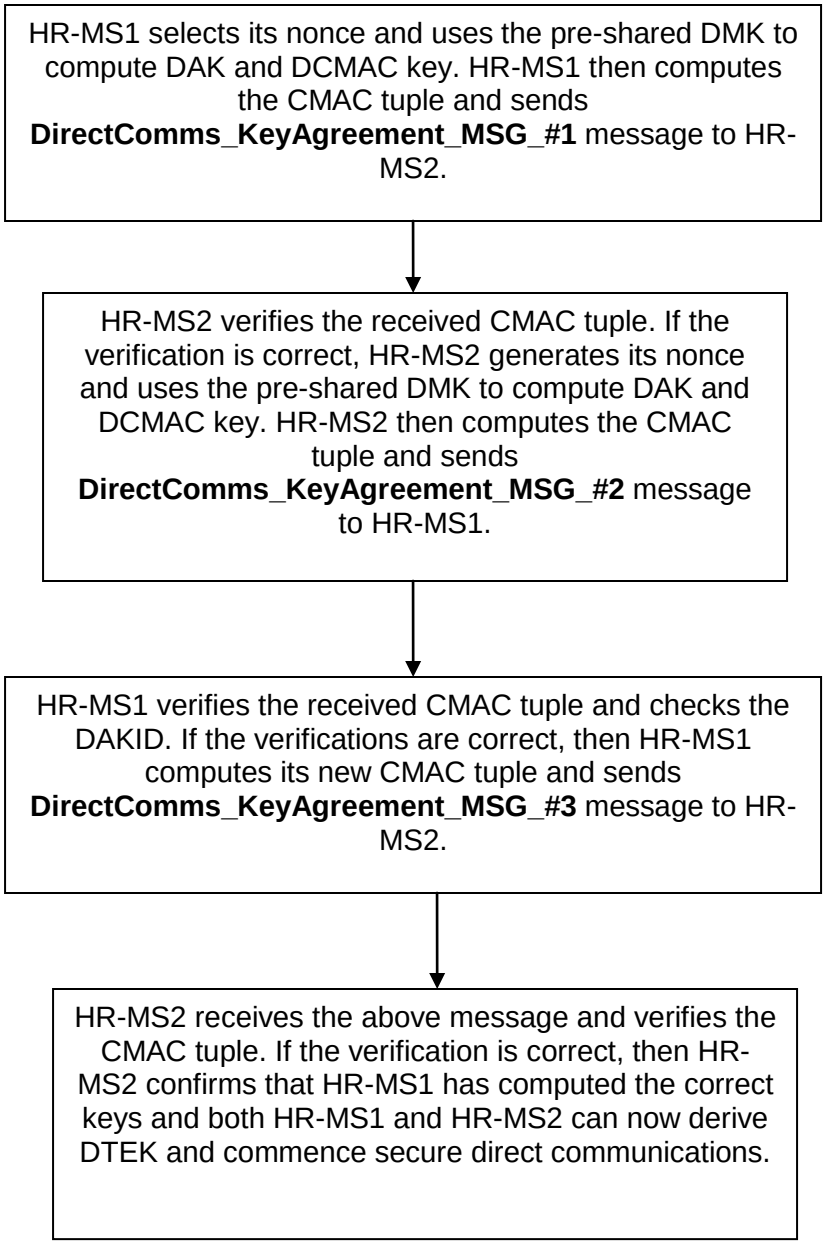


Figure 807—Flow Chart of Pre-shared key-based Autonomous Direct Communication Authentication and Key Establishment Security Procedure.

16.10.1.1.2.1.1 Message Type

Table 1027—DC_Request_MSG#1 message attribute

Code	Message Type	MAC control message name
	DirectComms_KeyAgreement_MSG #1	AAI-PKM-RSP

	DirectComms_KeyAgreement_MSG #2	AAI-PKM-REQ
	DirectComms_KeyAgreement_MSG #3	AAI-PKM-RSP

16.10.1.1.2.1.2 Message Attributes

Table 1028—DirectComms_KeyAgreement_MSG_#1 message attribute

Attribute	Contents
N_{HR-MS1}	Freshly generated random number of 64bits by HR-MS1
DMK_Sequence_No	new DMK sequence number
DAKID	identifies the direct communications authorization key
Key_lifetime	DMK key lifetime
$CMAC_{HR-MS1}$	Message digest calculated using DCMAC key

Table 1029—DirectComms_KeyAgreement_MSG_#2 message attribute

Attribute	Contents
N_{HR-MS1}	Nonce generated by HR-MS1 in DirectComms_KeyAgreement_MSG_#1 message
N_{HR-MS2}	Freshly generated random number of 64bits by HR-MS2
DAKID	identifies the direct communications authorization key
DMK_Sequence_No	new DMK sequence number
DC_Security_Parameters	The requesting HR-MS's security capabilities
$CMAC_{HR-MS2}$	Message digest calculated using DCMAC key

Table 1030 —DirectComms_KeyAgreement_MSG_#3 message attribute

Attribute	Contents
N_{HR-MS1}	Nonce generated by HR-MS1 in DirectComms_KeyAgreement_MSG_#1 message
N_{HR-MS2}	Nonce generated by HR-MS1 in DirectComms_KeyAgreement_MSG_#2 message
DMK_Sequence_No	new DMK sequence number

DC_SAID	identifies the direct communications authorization key for protecting this message
DC_Security_Parameters	The supporting HR-MS's security capabilities
$CMAC_{HR\text{-}MS1}$'	Message digest calculated using DCMAC key

1
2

3 **16.10.1.1.2.2 Secure direct communication using Public Key Infrastructure**

4

5 When pre-established shared key is not used for direct communication, Public Key
6 Infrastructure shall be used.

7 Each HR-MS has a public/private key pair and digital certificate (e.g. X.509) issued by a
8 certification authority for mutual authentication and key exchange prior to the start of this
9 direct communications.

10

11 The key agreement handshake procedure described below shall be used for HR-MSs to
12 mutually authenticate themselves (without access to a security server) using Public Key
13 Infrastructure and to derive data security keys for secure direct communications. The
14 flow diagram for this scenario is depicted in Figure 808 and the Flow Chart for this
15 scenario is shown in Figure 809.

16

17 The key agreement handshake procedure using Public Key Infrastructure includes the
18 following steps:

19

20 **Step 1:** HR-MS1 first generates nonce $N_{HR\text{-}MS1}$. Next, HR-MS1 computes the signature
21 $signature_{HR\text{-}MS1} = SIGN(T_{HR\text{-}MS1}|N_{HR\text{-}MS1}|HR\text{-}MS2Addr|HR\text{-}MS1Addr)$ and sends
22 DirectComms_KeyAgreement_MSG_#1 message to HR-MS2, where
23 $DirectComms\_KeyAgreement\_MSG\_\#1 = T_{HR\text{-}MS1}|N_{HR\text{-}MS1}|HR\text{-}MS2Addr|HR\text{-}$
24 $MS1Addr|signature_{HR\text{-}MS1}|Cert(HR\text{-}MS1)$.

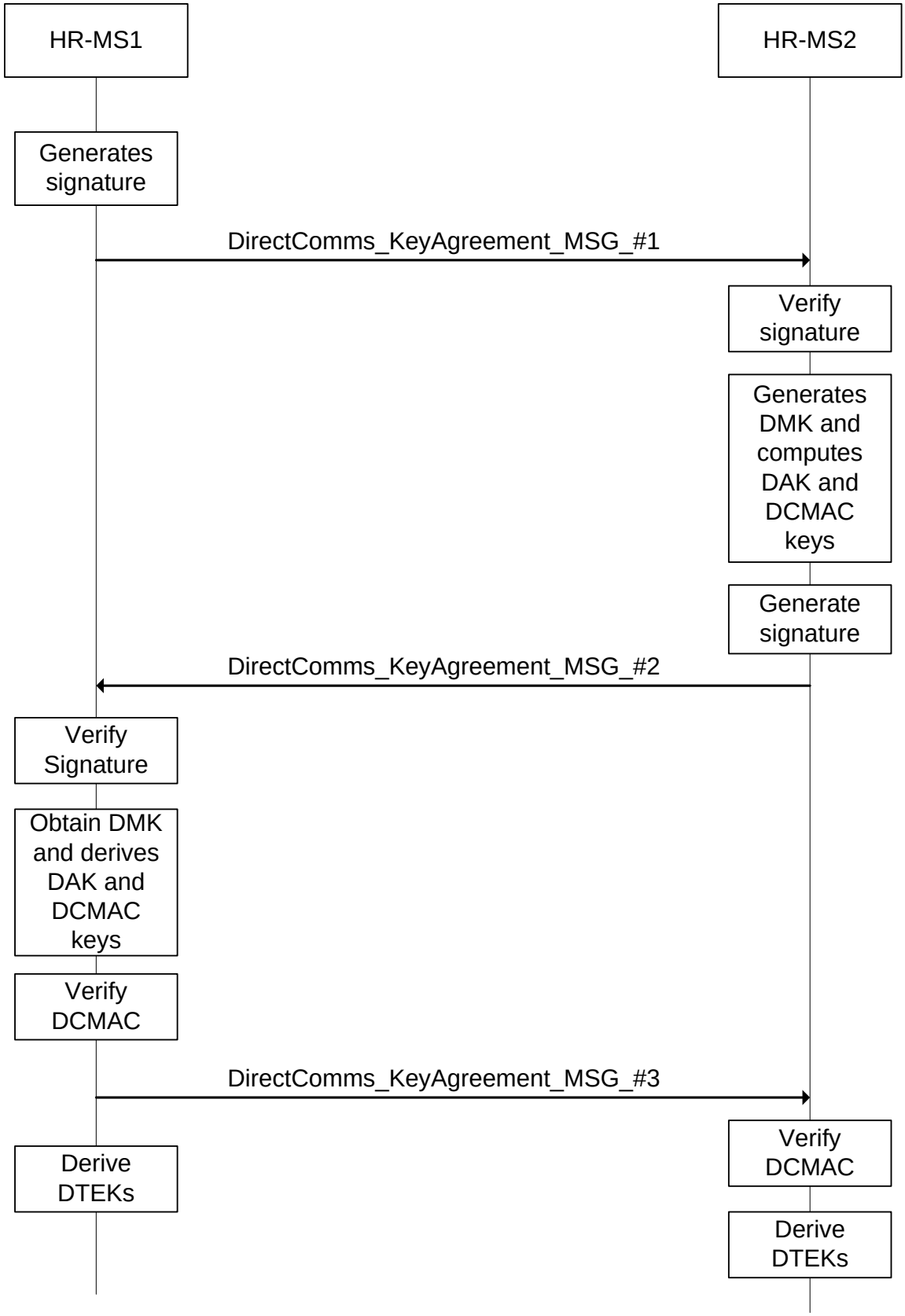
25

26 **Step 2:** HR-MS2 first verifies the received timestamp and nonce for freshness and the
27 certificate Cert(HR-MS1) and signature $signature_{HR\text{-}MS1}$. If the verifications fail, then HR-
28 MS2 ignores the DirectComms_KeyAgreement_MSG_#1 message. If the verifications
29 are correct, then HR-MS2 generates nonce $N_{HR\text{-}MS2}$ and security key DMK and computes
30 DAK =Dot16KDF (DMK, HR-MS1Addr|HR-MS2Addr| "DAK", 160) and the DCMAC
31 key and $CMAC_{HR\text{-}MS2} = MAC_{DCMAC}(N_{HR\text{-}MS2}|N_{HR\text{-}MS1}|HR\text{-}MS2Addr|HR\text{-}MS1Addr)$.
32 HR-MS2 then uses HR-MS1's public key to encrypt and obtain $E_{HR\text{-}MS1\_PK}$(DMK,
33 key_lifetime, HR-MS1Addr, HR-MS2Addr). Finally, HR-MS2 computes signature
34 $signature_{HR\text{-}MS2} = SIGN(T_{HR\text{-}MS2}|N_{HR\text{-}MS2}|HR\text{-}MS1Addr|HR\text{-}MS2Addr|N_{HR\text{-}MS1}|E_{HR\text{-}}$
35 $_{MS1\_PK}(DMK, key\_lifetime, HR\text{-}MS1Addr, HR\text{-}MS2Addr)|CMAC_{HR\text{-}MS2})$ and sends
36 DirectComms_KeyAgreement_MSG_#2 message to HR-MS1, where
37 $DirectComms\_KeyAgreement\_MSG\_\#2 = T_{HR\text{-}MS2}|N_{HR\text{-}MS2}|HR\text{-}MS1Addr|HR\text{-}$
38 $MS2Addr|N_{HR\text{-}MS1}|E_{HR\text{-}MS1\_PK}(DMK, key\_lifetime, HR\text{-}MS1Addr, HR\text{-}$

MS2Addr)|$CMAC_{HR\text{-}MS2}$|$signature_{HR\text{-}MS2}$|Cert({HR-MS2).

Step 3: HR-MS1 first verifies the received timestamp and nonces for freshness and the certificate Cert(HR-MS2) and signature $signature_{HR\text{-}MS2}$. If the verification is invalid, then HR-MS1 ignores the DirectComms_KeyAgreement_MSG_#2 message. If the verifications are correct, then HR-MS1 decrypts $E_{HR\text{-}MS1\_PK}$(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr) and obtains security key DMK and key_lifetime. Next, HR-MS1 computes DAK and DCMAC keys and verifies $CMAC_{HR\text{-}MS2}$. If the verification is invalid, then HR-MS1 ignores the DirectComms_KeyAgreement_MSG_#2 message. If the verification is correct, then HR-MS1 computes $CMAC_{HR\text{-}MS1} = MAC_{DCMAC}(N_{HR\text{-}MS1}|N_{HR\text{-}MS2}|$HR-MS1Addr|HR-MS2Addr) and sends DirectComms_KeyAgreement_MSG_#3 message to HR-MS2, where DirectComms_KeyAgreement_MSG_#3 = $N_{HR\text{-}MS2}$|HR-MS2Addr|HR-MS1Addr| $CMAC_{HR\text{-}MS1}$. If HR-MS1 does not receive DirectComms_KeyAgreement_MSG_#2 message from HR-MS2 within DirectComms_KeyAgreement_MSG_#1 Timeout, it shall resend the DirectComms_KeyAgreement_MSG_#1 message up to DirectComms_KeyAgreement_MSG_#1 MaxResends times. If HR-MS1 reaches its maximum number of resends, it shall initiate another authentication or drop the request.

Step 4: HR-MS2 receives the DirectComms_KeyAgreement_MSG_#3 message and verifies received nonce and the CMAC tuple. If the verification fails, then HR-MS2 ignores DirectComms_KeyAgreement_MSG_#3 message. If the verification is correct, then HR-MS2 confirms that HR-MS1 has computed the correct keys and commence secure direct communications. If HR-MS2 does not receive DirectComms_KeyAgreement_MSG_#3 message from HR-MS1 within DirectComms_KeyAgreement_MSG_#2 Timeout, it shall resend the DirectComms_KeyAgreement_MSG_#2 message up to DirectComms_KeyAgreement_MSG_#2 MaxResends times. If HR-MS2 reaches its maximum number of resends, it shall initiate another authentication or drop the request. HR-MS1 and HR-MS2 can now derive DTEK and commence secure direct communications.


HR-MS1
HR-MS2
Generates signature
DirectComms_KeyAgreement_MSG_#1
Verify signature
Generates DMK and computes DAK and DCMAC keys
Generate signature
DirectComms_KeyAgreement_MSG_#2
Verify Signature
Obtain DMK and derives DAK and DCMAC keys
Verify DCMAC
DirectComms_KeyAgreement_MSG_#3
Verify DCMAC
Derive DTEKs
Derive DTEKs

1

Figure 808—Flow Diagram of Authentication and Key Establishment of Direct Communication without Infrastructure (HR-MS becomes HR-BS*case).

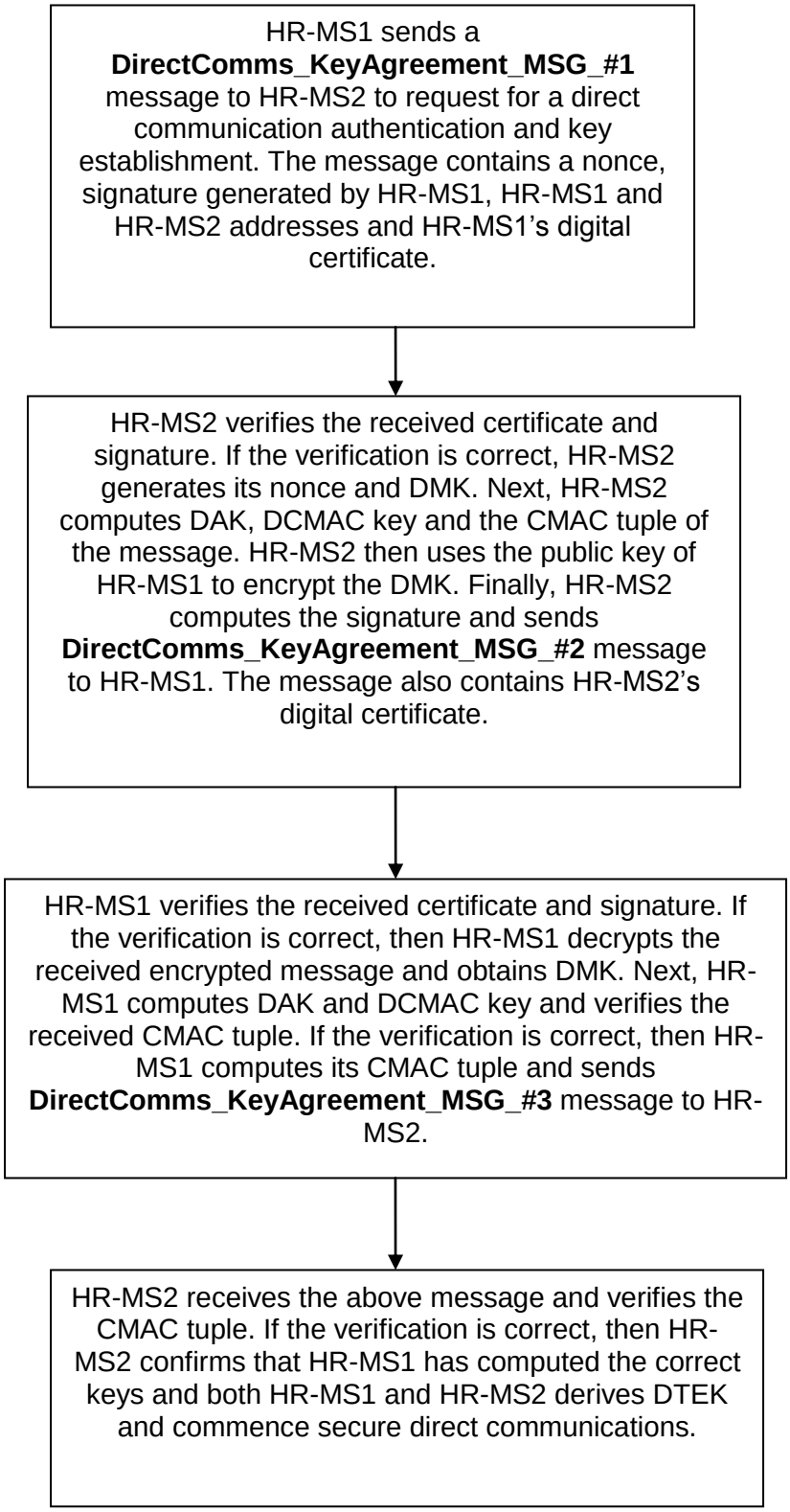


Figure 809—Flow Chart of PKI-based Autonomous Direct Communication Authentication and Key Establishment Security Procedure.

16.10.1.1.2.2.1 Message Type

Table 1031—DC_Request_MSG#1 message attribute

Code	Message Type	MAC control message name
	DirectComms_KeyAgreement_ MSG #1	AAI-PKM-RSP
	DirectComms_KeyAgreement_ MSG #2	AAI-PKM-REQ
	DirectComms_KeyAgreement_ MSG #3	AAI-PKM-RSP

16.10.1.1.2.2.1 Message Attribute

Table 1032—DirectComms_KeyAgreement_MSG_#1 message attribute

Attribute	Contents
$T_{HR\text{-}MS1}$	Timestamp generated by HR-MS1
$N_{HR\text{-}MS1}$	Freshly generated random number of 64bits by HR-MS1
HR-MS2Addr	Address of HR-MS2
HR-MS1Addr	Address of HR-MS1
$signature_{HR\text{-}MS1}$	Signature of message generated by HR-MS1 using its RSA private key
Cert(HR-MS1)	Digital certificate of HR-MS1

Table 1033—DirectComms_KeyAgreement_MSG_#2 message attribute

Attribute	Contents
$T_{HR\text{-}MS2}$	Timestamp generated by HR-MS2
$N_{HR\text{-}MS2}$	Freshly generated random number of 64bits by HR-MS2
HR-MS1Addr	Address of HR-MS1
HR-MS2Addr	Address of HR-MS2
$N_{HR\text{-}MS1}$	Nonce generated by HR-MS1 in DirectComms_KeyAgreement_MSG_#1 message
$E_{HR\text{-}MS1\_PK}$(DMK, key_lifetime, HR-	Public key encryption using HR-MS1's Public

MS1Addr, HR-MS2Addr)	key where DMK = DirectComms Master Key generated by HR-MS and key_lifetime = lifetime of DMK
$CMAC_{HR-MS2}$	Message digest calculated using DCMAC key by HR-MS2
$signature_{HR-MS2}$	Signature of message generated by HR-MS2 using its RSA private key
Cert(HR-MS2).	Digital certificate of HR-MS2

Table 1034—DirectComms_KeyAgreement_MSG_#3 message attribute

Attribute	Contents
N_{HR-MS2}	Nonce generated by HR-MS2 in DirectComms_KeyAgreement_MSG_\#2 message
HR-MS2Addr	Address of HR-MS2
HR-MS1Addr	Address of HR-MS1
$CMAC_{HR-MS1}$	Message digest calculated using DCMAC key by HR-MS1

16.10.1.1.3 Security Context for BS-coordinate Secure Direct Communication

The direct communications security context describes the set of parameters that links the direct communication security keys for BS-coordinate secure direct communications.

signature

16.10.1.1.3.1 DMK context

The DMK context includes all parameters associate with the DMK. This context is created when the DMK is derived.

The DMK context is described in Table 1035.

Table 1035—The DMK context

Parameter	Size (bit)	Usage
DMK	160	Multicast Master Key shared by HR-BS and HR-MSs in a multicast group
DMK SN	4	DMK sequence number
DMK Lifetime	32	MMK Lifetime
DAK_COUNT	16	Counter to ensure freshness of computed CMAC key and prevent replay attacks.

16.10.1.1.3.2 DAK context

The DAK context includes all parameters associate with the DAK. This context is created

whenever a new DAK is derived. This context shall be deleted when the DAK is not in used.

The DAK context is described in Table 1036.

Table 1036—The DAK context

Parameter	Size (bit)	Usage
DAK	160	Direct Communications Authentication Key derived from DMK.
DAK Lifetime	32	DAK Lifetime
DAKID	64	Identifies the DAK key.
DCMAC_KEY	128	Key which is used for signing Direct Communications MAC control messages.
DCMAC_PN	24	Used to avoid multicast replay attack on the control connection. The initial value of DCMAC_PN is zero.
DAK_COUNT	16	Counter to ensure freshness of computed CMAC key and prevent replay attacks.

16.10.1.1.3.3 DSA context

The DSA context is the set of parameters managed by each DSA in order to ensure DTEK management and usage in a secure way for BS-coordinated secure direct communications.

The DSA holds the DTEK context and additional information that belongs to the DSA itself.

16.10.1.1.3.4 DTEK context

The DTEK context includes all parameters of the DTEK and is described in Table 1037.

Table 1037—The DTEK context

Parameter	Size (bit)	Usage
DTEK	128	Key used for encryption or decryption of direct communications messages
DMK SN	4	DMK sequence number
COUNTER_DTEK	16	The counter used to derive this DTEK
DTEK lifetime	32	DTEK lifetime=DMK lifetime
DTEK_PN	22	The PN used for encrypting multicast packets. After each Multicast MAC PDU transmission, the

		value shall be increased by 1. (0x000000-0x1FFFFF)

16.10.1.1.3.5 DSA context

The DSA context is described in Table 1038.

Table 1038—The DSA context

Parameter	Size (bit)	Usage
DSAID	8	The identifier of this DSA, which decribes the applied encryption/decryption method and DTEK contexts.
DTEK context	Sizeof(DTEK context)	DTEK context for encryption and decryption

16.10.1.1.4 Key Derivation for BS-coordinated Secure Direct Communication

The key hierarchy defines what keys are present in the system for BS-coordinated secure direct communication and how the keys are generated.

16.10.1.1.4.1 DMK Derivation

The DMK is the security key/pre-established shared key that is randomly generated by HR-BS or HR-MS or a network entity (e.g. an AAA Server etc). The DMK is a 160-bit key.

The DMK may be used as a source for keying materials required by upper layers.

The DMK is used to derive the Direct Communication Authentication Key (DAK).

16.10.1.1.4.2 DAK Derivation

DAK is derived from DMK and belongs to a pair of HR-MSs. The DAK is used for BS-coordinated Direct Communications in the event of failure in the backbone.

The DAK derivation is as follows:

DAK =Dot16KDF (DMK, HR-MS1Addr|HR-MS2Addr|”DAK”, 160)

where: HR-MS1Addr and HR-MS2Addr are the addresses of HR-MS1 and HR-MS2

respectively.

The DCMAC-DTEK prekey is derived from DAK and is used to derive other keys:

- Direct Communication Cipher-based Message Authentication Code (DCMAC) key
- Direct Communication Traffic Encryption (DTEK) Key

The DCMAC-DTEK prekey derivation is done as follows:

DCMAC-DTEK prekey = Dot16KDF (DAK, DAK_COUNT|"DCMAC-DTEK prekey", 160)

16.10.1.1.4.3 DCMAC Key Derivation

DCMAC key is derived from DAK and used for message authentication for the messages sent during BS-coordinated secure direct communications.

DCMAC key is derived as follows:

DCMAC key = Dot16KDF(DCMAC-DTEK prekey, "DCMAC_KEYS", 128)

16.10.1.1.4.4 DTEK Derivation

DTEK is the transport encryption key used to encrypt data in BS-coordinated secure direct communications.

DTEK is derived as follows:

DTEK = Dot16KDF(DCMAC-DTEK prekey,
DSAID|COUNTER_DTEK|"DTEK_KEY", 128)

Where

SAID is the security association to which the TEK belongs.

COUNTER_DTEK is a counter used to derive different TEKs for the same SAID, the value of the counter is changed everytime a new DTEK needs to be derived within the same AK and AK_COUNT pair is valid. Everytime a new DCMAC-DTEK prekey is derived, this counter is reset.

16.10.1.2 Security Procedure for Secure Talk-around Direct Communication

In order to support secure direct communication between two or among more HR-MSs, pre-established shared key is used.

PKMv3 provides HR-MSs with strong protection from theft of service by encrypting talk-around direct connections between two or among HR-MSs.

If a talk-around direct communication connection is to be encrypted, each HR-MS participating in the connection shall have an additional security association (SA) (i.e., talk-around direct communication SA), allowing that connection to be encrypted using keys that are independent of those used for other encrypted transmissions between HR-MSs.

Talk-around direct communication traffic can be encrypted using talk-around direct communication specific key management based on PKMv3.

16.10.2 Security Procedure for Multicast Operation

16.11 Support for Self-Coexistence

16.11.1 Self-coexistence cycle

A self-coexistence cycle (SCC) consists of 4frames as shown in Figure 810. A frame is identified by frame identification number (FIN), which is in range between 0 to 3.

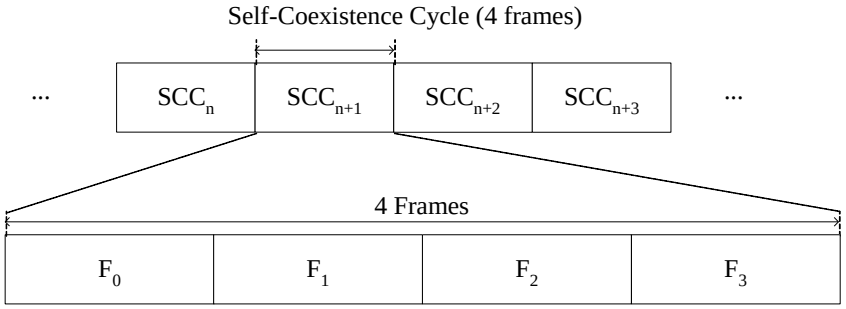


Figure 810—Self-coexistence cycle of HR OFDMA network..

16.11.2 Frame structure

A self-coexistence zone can be allocated in a frame for transmission preamble and self-coexistence beacons for self-coexistence of multiple HR cells overlapped in coverage and have to operate on the same frequency channel.

As shown in Figure 811, a self-coexistence zone occupies the last 3 symbols of a frame. The first symbol is used as guard time. In the second symbol, preamble shall be transmitted, and in the last symbol self-coexistence beacon protocol (SCBP) MAC PDU shall be transmitted.

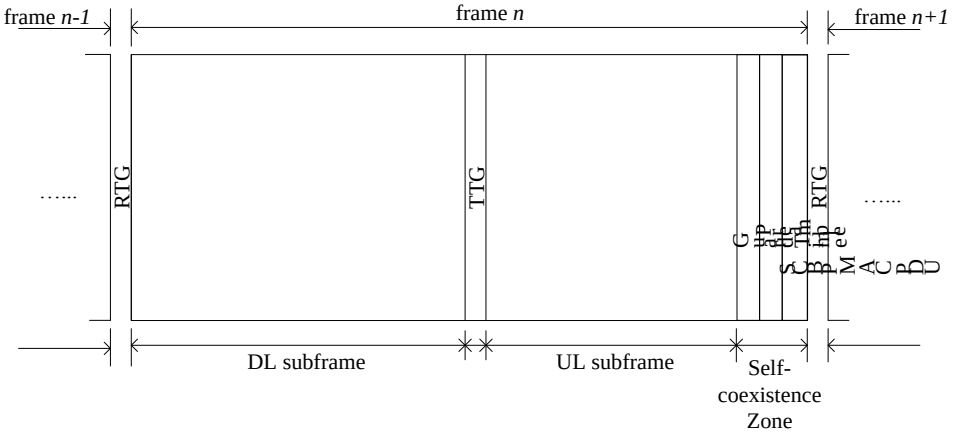


Figure 811—TDD frame structure with self-coexistence zone.

16.11.3 Operation modes

HR network can operate in two modes: normal mode and self-coexistence mode. In normal mode, a HR network occupies one frequency channel and operates on all frames of a self-coexistence cycle. In self-coexistence mode, multiple HR cells share the same frequency channel and operate on different frames. A HR cell operates in normal mode by default and transits to self-coexistence mode when the HR cell receives self-coexistence beacon from an adjacent HR cell on its operating channel.

16.11.4 Self-coexistence Beacon Protocol (SCBP)

16.11.4.1 SCBP Burst Structure

Figure 812 shows the structure of SCBP burst. It consists of two symbols. In the first symbol, frame preamble shall be transmitted. In the second symbol, SCBP MAC PDU as described in TBD shall be transmitted.

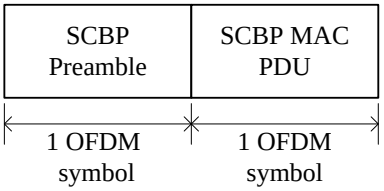


Figure 812—SCBP burst structure of WirelessMAN HR-OFDMA network.

16.11.4.2 Transmission of SCBP Burst

Transmission of SCBP can be reservation based or contention based. Details are described in TBD.

16.11.4.3 Detecting and Receiving SCBP Burst

An HR-infrastructure station may request its subordinate HR station to detect and receive SCBP burst from neighbor HR networks on its operating frequency channel or other

frequency channels.

16.11.5 Mechanism for self-coexistence of multiple HR cells

16.11.5.1 Execution Flow of Self-coexistence of Multiple HR cells

HR network shall follow the operation procedure shown in Figure 813 and description below for self-coexistence:

<s1> Neighboring HR cell is discovered by an HR station.

An HR station discovers an adjacent HR cell with the method described in 16.11.4.3. The network discovery includes discovering:

(s1.1) Self-coexistence zone reservation of a neighboring HR cell;

(s1.2) Frame reservation patterns of the neighboring HR cells on specific channels (this information can be obtained from received coexistence beacon packets).

In above, in the case that an HR-MS or HR-RS discovers neighboring HR cell, it reports the network discovery information to its serving HR-BS, by using messaged described in TBD.

<s2> The serving HR-BS performs channel acquisition.

<s3> If the serving HR-BS successfully acquires another frequency channel, it goes to the normal mode of data service operations on the acquired channel. Otherwise, it performs frame contention.

<s4> The serving HR-BS enters the normal mode of data service operations.

During operation of normal mode, a serving HR-BS may receive demands from a neighboring HR cell for sharing channel. When this happens, it tries to find an empty frequency channel. If it finds an empty channel, it moves its service to the channel and operates in normal mode of data service. Otherwise, the serving HR-BS performs frame contention on its operation channel.

<s5> The serving HR-BS performs frame contention with a neighboring HR cell on the selected frequency channel, and then goes to the self-coexistence mode.

<s6> The serving HR-BS enters self-coexistence mode.

In self-coexistence mode, a serving HR-BS may need to re-initiate wireless medium scanning for channel acquisition if it receives internal demand for more spectrum resource or external demand for sharing channel. In this case, it goes to step s2.

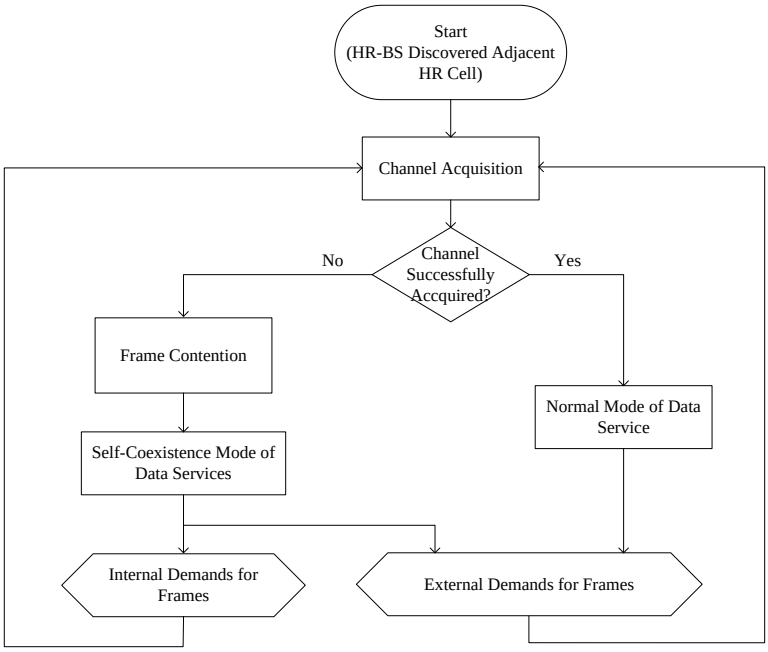


Figure 813—Execution flow of self-coexistence mechanism of WirelessMAN HR OFDMA air interface.

16.11.5.2 Frame Contention

16.11.5.2.1 Control Messages

Four control messages are used in frame contention, i.e.,

- Frame Contention Request (HR-FC-REQ) – carries request information of a requesting HR-BS, including index of the targeted frames within a self-coexistence cycle;
- Frame Contention Response (HR-FC-RSP) – carries contention result information of each requested frame;
- Frame Contention Acknowledgement (HR-FC-ACK) – carriers confirmation or not of acquisition of each of the requested frame;
- Frame Contention Release (HR-FC-REL) – carries information of release or not of each frame within a self-coexistence cycle.

16.11.5.2.2 Message Flow

Figure 814 shows message flow of frame contention in self-coexistence of HR cells. If the two HR-BSs cannot communicate directly, exchange of the messages can go through middle subordinate HR stations.

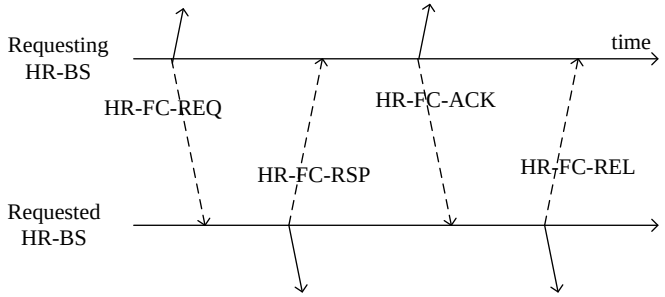


Figure 814—Message flow of frame contention. Messages may be exchanged through middle subordinated HR stations.

16.11.5.2.3 Frame Contention Protocol

16.11.5.2.3.1 Frame contention procedure at the frame contention source

Frame contention source (FCS) is an HR cell that intends to acquire frames by contention.

An FCS monitors frame occupancies by analyzing received self-coexistence beacons. When it needs to contend for frames, it identifies target Frame Contention Destinations (FCDs), which are HR cells around it and carries out the procedure of frame contention based on flow shown in Figure 815.

In above, once an FCS receives an HR-FC-REL addressed to it, it occupies the frames granted to it from next self-coexistence cycle and updates its frame occupancy MAP.

16.11.5.2.3.2 Frame contention procedure at the frame contention destination

Frame contention destination (FCD) is an HR cell that is acquired by a frame contention source for frames.

An FCD follows procedure shown in Figure 816. When an FCD receives an HR-FC-REQ, it checks the number of frames it occupied. If the number is not more than a minimum number it requires, it doesn't carry out frame contention. Otherwise, it identifies all FCSs of the first frame in contention. It randomly selects one from the set {all FCSs of this frame in contention, FCD itself}. If the selected one is not FCD itself, it grants the frame to the selected FCS. Otherwise, it continues to randomly select one from the set {all FCSs of this frame in contention, FCD itself}. And then it checks number of remained frames, it continues the process until all frames in contention are processed, or it has no more frames for contention.

When an FCD receives HR-FC-ACK from an FCS, it releases the corresponding frames by sending out HR-FC-REL, and it updates its frame occupancy MAP from next self-coexistence cycle.

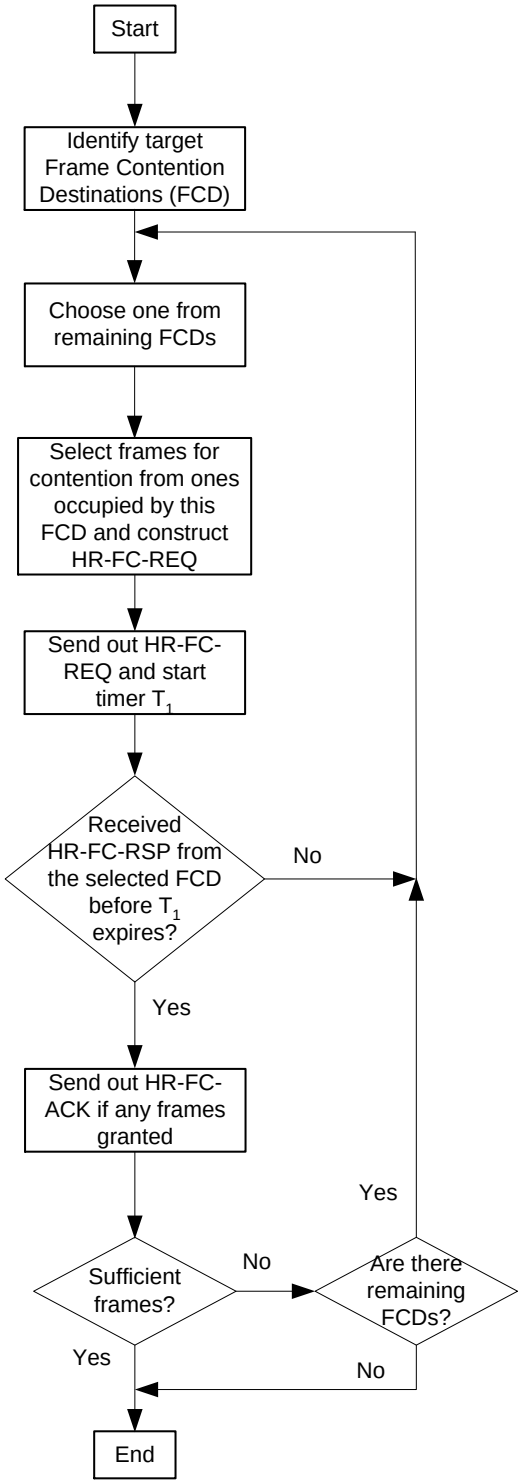


Figure 815—Procedure of frame contention at an FCS.

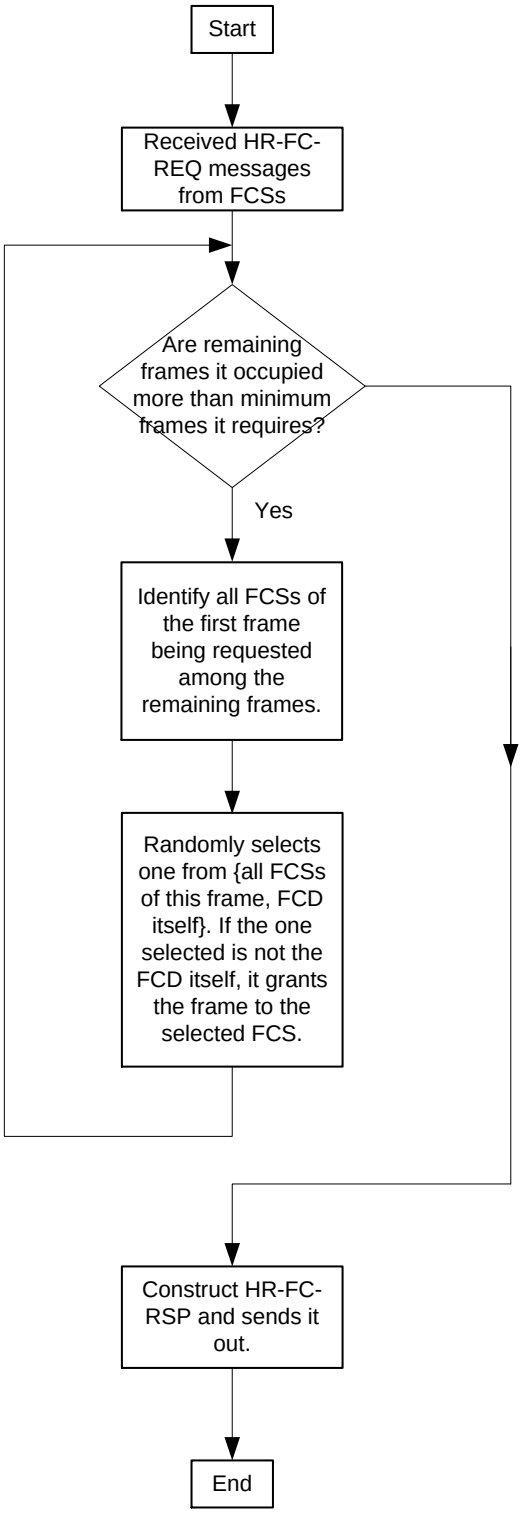


Figure 816—Procedure of frame contention at an FCD.

16.11.6 Inter-HR-BS Synchronization

Inter-HR-BS synchronization is needed for self-coexistence.

HR-RS or HR-MS may be instructed to report the time difference between a neighboring HR-BS and its serving HR-BS to the serving HR-BS.

16.12 Support for Downlink High Reliability and Uplink Heavy Data Service

For HR-network operating in VHF band, it may use VHF mode of HR OFDMA air interface to support uplink heavy data service.

VHF mode of HR OFDMA air interface is OFDMA PHY-based with operating frequency in VHF band. The DL and UL tile structure specified in Figures 332a and 334a may be used in VHF mode. The modified DL tile structure is able to provide higher reliability of data link compared to DL PUSC cluster structure specified in 8.4.6.1.2.1. The modified tile structure for UL has lower pilot occupation rate which allows higher data rate compared to UL PUSC cluster structure specified in 8.4.6.2.1.

Annexes