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Re:	GRIDMAN Amendment Working Draft for 802.16.1
Abstract	Draft of 802.16.1a Amendment, based on 802.16.1 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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P802.16.1a AWD (Oct 2011)

WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems

Enhancements to Support Higher Reliability Operations

Contents

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 6.12 are in black and are not underlined.

1. Overview

2. Normative References

3. Definitions

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

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

3.149 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.

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

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

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

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

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

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

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

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

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

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

3.160 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.

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

3.162 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.

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

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

3.165 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. WirelessMAN-Advanced Air Interface

6.1 Introduction

6.2 Medium access control

6.2.1 Addressing

6.2.2 MAC PDU formats

6.2.3 MAC control messages

[Change Table 683 as indicated (renumbering may be required):]

Table 683 – MAC control messages

No.	Functional Areas	Message names	Message description	Secuirty	Connection
TBD	Multimode	AAI-MM-ADV	Multimode advertisement	N/A	Broadcast
TBD	Multimode	AAI-MMRS-REQ	Multimode Relay request	Encrypted/ICV	Unicast
TBD	Multimode	AAI-MMRS-RSP	Multimode Relay response	Encrypted/ICV	Unicast
TBD	Multimode	AAI-MMRL-REQ	Multimode release request	Encrypted/ICV	Unicast
TBD	Multimode	AAI-MMRL-RSP	Multimode release response	Encrypted/ICV	Unicast
TBD	Multimode	AAI-MMBS-REQ	Multimode Base station request	Encrypted/ICV	Unicast
TBD	Multimode	AAI-MMBS-RSP	Multimode Base station response	Encrypted/ICV	Unicast
TBD	Multimode	AAI-MMBS-CMD	Multimode Base station command	Encrypted/ICV	Unicast
TBD	Link Establishment	DM-LEST-REQ	Link Establishment Request		Unicast

TBD	Link Establishment	DM-LEST-RSP	Link Establishment Response		Unicast
TBD	Measurement	DM-MES-REP	Measurement Report		Unicast
TBD	Resource Management	DM-RCHG-REQ	Resource Change Request		Unicast
TBD	Resource Management	DM-RCHG-RSP	Resource Change Response		Unicast
TBD	Token Management	DM-TKN-REQ	Token Request		Unicast
TBD	Token Management	DM-TKN-RSP	Token Response		Unicast
TBD	Token Management	DM-TKN-HO	Token Handover		Unicast or Multicast
TBD	Link Establishment	DM-LEST-CMD	Link Establishment Command		Multicast
TBD	Link Release	DM-LREL-CMD	Link Release Command		Unicast or Multicast
TBD	Flow Management	DM-DSA-CMD	Dynamic Service Addition Command		Unicast or Multicast
TBD	Flow Management	DM-DSC-CMD	Dynamic Service Change Command		Unicast or Multicast
TBD	Flow Management	DM-DSD-CMD	Dynamic Service Delete Command		Unicast or Multicast
TBD	Measurement	DM-MES-CMD	Measurement Command		Unicast or Multicast
TBD	Resource Management	DM-RCHG-CMD	Resource Change Command		Unicast or Multicast
TBD	Token Management	DM-TKN-ADV	Token Advertisement		Multicast
TBD	Resource allocation	RTS	Request To Send		Unicast or Multicast or broadcast
TBD	Resource allocation	CTS	Clear To Send		Unicast

TBD	MCS Change	DM-MCHG-CMD	MCS Change Command		Unicast
TBD	Forwarding MS List	AAI-DMMS-ADV	MS list Advertisement		Broadcast or multicast or unicast
TBD	Forwarding MS list Update	AAI-DMLU-REQ	MS List Update Request		Unicast
TBD	Forwarding MS list Update	AAI-DMLU-RSP	MS List Update Response		Unicast
TBD	Backbone Enable	BBE-REQ	Backbone Enable Request		Unicast
TBD	Backbone Enable	BBE-RSP	Backbone Enable Response		Unicast
TBD	Backbone Disable	BBD-REQ	Backbone Disable Request		Unicast
TBD	Backbone Disable	BBD-RSP	Backbone Disable Response		Unicast
TBD	Backbone Enable	BBE-CMD	Backbone Enable Command		Broadcast
TBD	Backbone Disable	BBD-CMD	Backbone Disable Command		Broadcast
TBD	Multicast	AAI-MG-IND	Multicast Group Indication Message		Broadcast
TBD	Multicast	AAI-MT-IND	Multicast Traffic Indication Message		Broadcast or Multicast

6.2.3.1 AAI-RNG-REQ

[Change Table 684 in section 6.2.3.1 as indicated:]

Table 684.—AAI-RNG-REQ message Field Description

Field	Size (bits)	Value/Description	Condition
Ranging Purpose Indication	4	0b0000 = Initial network entry 0b0001 = HO reentry 0b0010 = Network reentry from idle mode 0b0011 = Idle mode location update 0b0100 = DCR mode extension 0b0101 = Emergency call setup (e.g., E911) 0b0110 = Location update for updating service flow management encodings of E-MBS flows 0b0111 = Location update for transition to DCR mode from idle mode 0b1000 = Reentry from DCR mode, coverage loss or detection of different ABS restart count. 0b1001 = Network reentry from a Legacy BS 0b1010 = Zone switch to MZONE from LZONE 0b1011 = Location update due to power down. 0b1100 = Interference mitigation request to a CSG Femto ABS when experiencing interference from the CSG Femto ABS 0b1101 = NS/EP call setup ~~0b1110–0b1111 = reserved~~ 0b1110 = HR multicast service flow update 0b1111 = reserved	-
…	…	…	…

6.2.3.2 AAI-RNG-RSP

[Change Table 685 in section 6.2.3.2 as indicated:]

Table 685—AAI-RNG-RSP message field description

Field	Size (bits)	Value/Description	Condition
Ranging Abort	1	Set to 1 when an ABS rejects the AMS.	Present when an ABS rejects an AMS.
If (Ranging Abort == 1) {			
Ranging Abort Timer	16	Timer defined by an ABS to prohibit the AMS from attempting network entry at this ABS, for a specific time duration. Value: 0 (Do not try ranging again at the ABS.) Value: 1–65534, in units of seconds Value: 65535 (When the received CSGID(s) from the AMS does not match any of the CSGID(s) of the Femto ABS. This value indicates the	

		Ranging Abort Timer is not to be used, and the AMS can range any time.)	
}else{			
…	…	…	…
Location Update Response	4	0x0= Success of Location Update 0x1= Failure of Location Update 0x2 = *Reserved* 0x3 = Success of location update and DL traffic pending 0x4 = Allow AMS's DCR mode initiation request or DCR mode extension request 0x5 = Reject AMS's DCR mode initiation request or DCR mode extension request 0x6~0xF: *Reserved*	Shall be included when this message is sent in response to an AAI-RNG-REQ message used to perform location update or DCR mode initiation from Idle Mode or DCR mode extension.

If (Location Update Response ==
 	
0x0) {			

…	…	…	…
SMS	Variable	Short message contents up to the size of 140bytes	May be included when SMS contents is sent in idle mode.
New Multicast Group Zone ID	12	Indicates a Multicast Group Zone ID to update in target HR-BS.	Shall be included in HR-Network in response to the AAI-RNG-REQ message where ranging purpose indication is set to 0b1110.
New Multicast Indication cycle	8	Start of multicast indication cycle. The first superframe is the multicast available interval and rest superframes are the multicast unavailable interval. 8 LSB of superframe number	Shall be present if needed to update in HR-Network
For(j=1;j<=M;j++){		Number of Multicast Group ID and FID (M) to update in the target HR-BS[1..16]	Present if it needs to update in HR-Network.
Current Multicast Group ID	12		

Current FID	4		
New Multicast Group ID	12		
New FID	4		
}			
}//end of If (Location Update Response == 0x0)			
Reentry Process Optimization	5	Reentry process optimization bitmap indicates which MAC control message transactions may be omitted during an attempted reentry (i.e., reentry during HO (including zone switching), and reentry from idle mode) A value of 1 in the bitmap indicates that the corresponding MAC control message transaction may be omitted, while a 0 indicates that the corresponding MAC control message transaction shall be completed. The AMS shall only commence Connected State with the T-ABS after completing all the required MAC control message transactions. Bit 0: Omit AAI-SBC-REQ and AAI-SBC-RSP MAC control messages during reentry processing Bit 1: Omit PKM Authentication phase Bit 2: Omit AAI-REG-REQ and AAI-REG-RSP message during reentry processing. Bit 3: Omit higher layer protocol triggering for IP address refresh during reentry processing Bit 4: For the case of reentry during HO including zone switching, a 1 indicates to the AMS that the T-ABS has received the full service and operational states for static and dynamic context (including ARQ window parameters and state machines). For the case of reentry	

		from Idle mode, a 1 indicates to the AMS that the T-ABS has received the static context of the AMS. The static context includes SFIDs and related description (QoS descriptors and CS classifier information) for all service flows that the AMS has currently established as well as any SAs with their related keying information.	
…	…	…	…
If (it is under network reentry for HO){			
New Multicast Group Zone ID	12	Indicates a Multicast Group Zone ID to update in target HR-BS.	Shall be included in HR-Network in response to the AAI-RNG-REQ message where ranging purpose indication is set to 0b1110.
New Multicast Indication cycle	8	Start of multicast indication cycle. The first superframe is the multicast available interval and rest superframes are the multicast unavailable interval. 8 LSB of superframe number	Shall be present if needed to update in HR-Network
For (i = 0; i< M; i++) {		Number of Multicast Group ID and FID (M) to update in the T-ABS[1..16]. Mapping of current Multicast Group ID and FID and new Multicast Group ID and FID to be updated. Based on the value of Num of Multicast Group ID and FID to be updated.	Present if it needs to be updated.
Current Multicast Group ID	12		
Current FID	4		
New Multicast Group ID	12		
New FID	4		
}			
}//end of If (it is			

under network reentry for HO)			
For (*i* = 0; *i*<N_SFIDs; *i*++) {		N_SFIDs is Number of SFIDs supported in MZone when an AMS performs Zone Switching from LZone to MZone. Its maximal number is 24.	Present if CID to FID mapping is done through the AAI-RNG-RSP message during Zone Switching operation. If this field is not present, all FIDs for the transport connection should be reestablished through the AAI-DSA exchanges after completion of network reentry in MZone.
SFID	32	FID in MZone should be assigned as defined in 6.2.6.4.1.3.1 per each DL/UL connections	
}			
} //End of else (Ranging Abort==1)			

6.2.3.3 AAI-RNG-ACK

6.2.3.4 AAI-RNG-CFM

[Change section 6.2.3.5 as indicated:]

6.2.3.5 AAI-SBC-REQ

An AAI-SBC-REQ message, to which HARQ operation is applied, is transmitted by AMS to negotiate basic capability during network entry.

Table 688 – AAI-SBC-REQ message field description

Field	Size (bits)	Value/Description	Condition

If (AMS requests transmittal of
 	
NSP information) {			

SIQ (Service Information Query)	2	Bit 0: Indicates that the AMS requests transmittal of the NSP List for the list of NSP IDs supported by the Operator Network that includes the current ABS; Bit 1: Indicates that the AMS requests transmittal of the Verbose NSP Name List in addition to the NSP List; bit 1 shall not be set to a value of '1' unless bit 0 is set to 1	
} else {			
CAPABILITY_INDEX	5	It refers to the "Capability Class" that the AMS can support. Value: 0~31	
DEVICE_CLASS	5	It refers to the "Device Class" that the AMS can support. Value: 0~31	
CLC Request	*variable*	See Table 700	Present if AMS requests to activate one Type I or II CLC class for fast CLC class activation during initial network entry
Long TTI for DL	1	If Bit 0=1, it supports	Present as needed
UL sounding	2	If Bit 0=1, decimation separation based sounding (FDM) supports If Bit 1=1, cyclic shift separation based sounding (CDM) supports	Present as needed
OL Region	3	If Bit 0=1, OL Region type 0 supports If Bit 1=1, OL Region type 1, CDR and CoFIP supports If Bit 2=1, OL Region type 2 supports	Present as needed
DL resource metric for FFR	1	If Bit 0=1, it supports	Present as needed
Max. Number of streams for SU-MIMO in DL MIMO	3	The number in the range 1 through 8 that is higher by 1 than this field	Present as needed
Max. Number of streams for CL MU-MIMO (MIMO mode 4) in AMS point of view in DL MIMO	1	The number in the range 1 through 2 that is higher by 1 than this field	Present as needed
DL MIMO mode	6	If Bit 0 =1, mode0 supports If Bit 1 =1, mode1 supports	Present as needed

Field	Size (bits)	Value/Description	Condition
		If Bit 2 =1, mode 2 supports If Bit 3 =1, mode 3 supports If Bit 4 =1, mode 4 supports If Bit 5=1, mode 5 supports	
feedback support for DL	11	If Bit 0 =1, differential mode supports If Bit 1 =1, MIMO feedback mode 0 supports If Bit 2 =1, MIMO feedback mode 1 supports If Bit 3=1, MIMO feedback mode 2 supports If Bit 4 =1, MIMO feedback mode 3 supports If Bit 5 =1, MIMO feedback mode 4 supports If Bit 6 =1, MIMO feedback mode 5 supports If Bit 7 =1, MIMO feedback mode 6 supports If Bit 8 =1, MIMO feedback mode 7 supports If Bit 9 =1, Long-term reporting disabling support for MFM 0,4,7 If Bit 10 =1, Short-term reporting disabling support for MFM 2,3,5,6	Present as needed
Subband assignment A-MAP IE support	1	If Bit 0=1, DL/UL Subband assignment A-MAP IE supports	Present as needed
DL pilot pattern for MU MIMO	2	If Bit 0 =1, DL 4 stream pilot pattern for DL MU MIMO support If Bit 1 =1, DL 8 stream pilot pattern for DL MU MIMO support	Present as needed
Number of Tx antenna of AMS	2	The number in the range {1, 2, 4} that is higher by 1 than this field	Present as needed
Max. Number of streams for SU-MIMO in UL MIMO(1/2/3/4)	2	The number in the range 1 through 4 that is higher by 1 than this field	Present as needed
Max. Number of streams for MU-MIMO in AMS point of view in UL MIMO(1/2/3/4)	2	The number in the range 1 through 4	Present as needed
UL pilot pattern for MU MIMO	3	If Bit 0 =1, UL 2 stream pilot pattern support If Bit 1 =1, UL 4 stream pilot pattern support If Bit 2 =1, UL 8 stream pilot pattern support	Present as needed
UL MIMO mode	5	If Bit 0 =1, mode0 supports	Present as needed

Field	Size (bits)	Value/Description	Condition
		If Bit 1 =1, mode1 supports If Bit 2 =1, mode 2 supports If Bit 3 =1, mode 3 supports If Bit 4 =1, mode 4 supports	
Modulation scheme	2	If Bit 0=1, DL 64 QAM supports If Bit 1=1, UL 64 QAM supports	Present as needed
UL HARQ buffering capability	7	Bit 0–6: The number that is higher by 1 than this field is the amount of information bits in 4800 bytes units the AMS can buffer in the UL.	Present as needed
DL HARQ buffering capability	7	Bit 0–6: The number that is higher by 1 than this field, is the steady amount of aggregated DL HARQ information bits per frame in units of 4800 bytes, at which the aimed combining gain or better is obtained in the benchmark scenario, as defined in 6.2.14.2.1.3.	Present as needed
AMS DL processing capability per subframe	7	Bit 0–6: The number that is higher by 1 than this field, is the steady amount of aggregated DL data information bits per subframe in units of 600 bytes that the AMS can process.	Present as needed
AMS UL processing capability per subframe	7	Bit 0–6: The number that is higher by 1 than this field, is the steady amount of aggregated UL data information bits per subframe in units of 600 bytes that the AMScan process.	Present as needed
FFT size(2048/1024/512)	3	If Bit 0 = 1, FFT 2048 supports If Bit 1 = 1, FFT 1024 supports If Bit 2 = 1, FFT 512 supports	Present as needed
Authorization policy support	1	If Bit 0 = 0, No authorization; If Bit 0 = 1, EAP-based authorization is supported.	Present as needed
Inter-RAT Operation Mode	2	0b00: single radio mode operation for inter RAT handover 0b01: multi radio mode operation for inter RAT handover 0b10–0b11: *Reserved*	Present as needed
Supported Inter-RAT type	8	1 indicates support, 0 indicates not supported: Bit 0: IEEE 802.11 Bit 1: GERAN(GSM/GPRS/EGPRS) Bit 2: UTRAN Bit 3: E-UTRAN	Present as needed

Field	Size (bits)	Value/Description	Condition
		Bit 4: CDMA 2000 Bit 5–7: *Reserved*, set to zero	
MIH Capability Supported	1	If Bit 0=1, the capability of IEEE 802.21 Media Independent Handover Services supports.	Present as needed
MAX Tx Power	24	The maximum available power of the carrier for initial network entry. Bit 0–7: Maximum transmitted power for QPSK. Bit 8–15: Maximum transmitted power for 16-QAM Bit 15–23: Maximum transmitted power for 64-QAM. Each unsigned 8-bit integer specifies the maximum transmitted power value in dBm. The maximum transmitted power is quantized in 0.5 dBm steps ranging from –64 dBm (encoded 0x00) to 63.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme. If AMS does not support 64-QAM, the AMS shall report the value of 0x00 for Bit 15–23.	Present as needed

If (ARS is a sender of AAI-SBC-
 	
REQ) {
			//only available during ARS network entry phase

Relay mode	1	0b0: TTR relay mode 0b1: STR relay mode	
if (Relay mode == 0b0){			
ARSTTG	6	ARSTTG value (μs). It shall be less than 50 μs.	
ARSRTG	6	ARSRTG value (μs). It shall be less than 50 μs.	
}			
}			
Visited NSP ID	24	NSP ID of the Network Service Provider the AMS intends to be the conduit for authentication to the AMS home network	Present as needed
Multimode capability supported	3	If bit0 = 1, the capability of TTR relay mode supports If bit1 = 1, the capability of STR relay mode supports If bit2 = 1, the capability of base station function supports	Present as needed in HR-Network
}			

6.2.3.12 AAI-HO-CMD

[Change Table 695 in section 6.2.3.12 AAI-HO-CMD as indicated:]

Table 695—AAI-HO-CMD message field description

Field	Size (bits)	Value/Description	Condition
Mode	2	0b00: HO command; 0b01: Zone switch command from MZone to LZone; 0b10: AMS HO request rejected (ABS in list unavailable). In this case, AAI-HO-CMD message shall not include any T-ABS. However, if the requested ABSs in list available but MAC information is not shared, those ABSs may be included candidate T-ABS and serving ABS transfers MS information via backbone network or relay link in HR-Network ~~0b11: *Reserved.*~~ 0b11: Alternative Path (only for HR-Network).	N/A
If (Mode == 0b00 or 0b11) {			
……	…	……	…
Resource_Retain_Time	16	The duration in units of 100 ms to which the T-ABD set the ABS-Resource-Retain-Timer	Present if needed
If (HO Reentry Mode == 0b11) {			
Role	1	0b0: Stay as HR-MS; 0b1: Change to HR-RS;	
} //end of If (HO Reentry Mode == 0b11)	-	-	
…			
Action Time	8	If HO Reentry Mode is 0b11, it is the wait time in units of 1 ms before the HR-MS starts to perform fast network reentry. Otherwise, it is ~~T~~the 8 least significant bits of the absolute frame number at the TABS where the AMS starts to perform network reentry. When CDMA_RNG_FLAG is set to 1, it indicates the frame whereafter the AMS starts a CDMA ranging process. The action time should be set to a frame that includes either a nondynamic ranging channel or a dynamic ranging channel. When CDMA_RNG_FLAG is set to 0, it indicates the frame where the AMS starts to expect the UL	

		bandwidth allocation for transmission of RNG-REQ at target R1 BS or LZone (i.e., Fast ranging opportunity) or AAI-RNG-REQ at T-ABS.	
……	…	……	…
}else if (Mode == 0b01) {			
……	…	……	…
}else if (Mode==0b10) {			
REQ-Duration	8	The 8 least significant bits of the absolute superframe number where the AMS may perform handover again (i.e., allowing the AMS to transmit AAI-HO-REQ after REQ-Duration).	Shall be present in HR-Network
for(*i*=0; *i* < N_Target_BS; *i*++) {		N_Target_BS is the number of T-ABSs or target legacy BSs included in this message in HR-Network.	
targetBSID	48	BSID of the T-ABS or target legacy BS.	Shall be included
SA-Preamble Index	10	Indicate the SA-Preamble index of the carrier.	Shall be included if the BS is T-ABS
Preamble Index	7	Indicate the preamble index of the neighbor BS.	Shall be included if the BS is target legacy BS
Center Frequency	32	Indicates center frequency (in unit of Hz) of the carrier.	Shall be included
}			
}			

6.2.3.13 AAI-NBR-ADV

[Change the last paragraph in page 142 as indicated:]

Within each cell type, if S-ABS chooses to broadcast configuration information for each individual ABS instead of specifying SA-Preamble Index range and Physical carrier range, a list of ABSs are provided and the following parameters are carried for each ABS:

- 48-bit BS-ID
- ABS SA-Preamble Index
- Indication whether full system information or partial information is carried for this ABS, which includes the following:
  - SFH information
  - Physical carrier index (6 bits, refer to the “physical carrier index” defined in AAI-Global-CFG)

- MAC protocol versions (8 bits)
- Paging carrier indication (1 bit, refer to specify if a carrier is a paging carrier or not)

— Multicast service flow mapping list (for HR-Network)

- Neighbor Multicast Group Zone ID
- Mapping of Multicast Group ID + FID and neighbor Multicast Group ID + FID

— Indication whether the neighbor infrastructure station is HR multimode station (i.e., acting as BS or RS) for HR-Network.

where for ABS of macrocell type, all the necessary system information shall be included, and the format may only carry delta information fields with respect to the reference ABS (e.g., the S-ABS or the preceding neighbor BS/ABS of this cell type); and for Wireless-MAN-OFDMA reference system, only 48-bit BS-ID and Preamble index are included in AAI-NBR-ADV.

…

[Change Table 696 in section 6.2.3.13 as indicated:]

Table 696—AAI-NBR-ADV message field description

Field	Size (bits)	Value/Description	Condition
……	……	.....	.....
For (*i*=0; *i*<N-NBR-ABSs; *i*++) {		N-NBR-ABSs is the number of neighbor ABSs included in this message, and has the range of [1..64].	
BSID	48	Neighbor ABS ID	
MAC protocol version	8	MAC protocol version of the BS Consistent with IEEE Std 802.16-2009 definition, with new MAC protocol version 10 defined for AAI.	
CP time	2	CP time of the BS 0b00: 1/8 0b01: 1/16 0b10: 1/4	
HR Multimode indication	2	Indicates whether neighbor BR/RS is HR-MS acting as BS/RS or HR-BS acting as RS 0b00: neighbor BS is neither HR-MS acting as BS/RS nor HR-BS acting as RS 0b01: neighbor BS is HR-MS acting	Shall be present in HR-Network

		as BS/RS 0b10: neighbor BS is HR-BS acting as RS 0b11: *reserved*	
Neighbor Multicast Group Zone ID	12	Indicates a Multicast Group Zone ID provided by neighbor BS.	Present in HR-Network
For(j=1;j<=M;j++){		Number of Multicast Group ID and FID (M) mapping between serving BS and neighbor BS[1..16]	Present if needed
Multicast Group ID	12		
FID	4		
Neighbor Multicast Group ID	12		
Neighbor FID	4		
}			

For(*j*=0; *j*<N-Carrier-Info; *j*++)
 	
{
		N-Carrier-Info is the number of carrier
		
		information listed here for the *ABSi*	

.....	……	.....	.....

6.2.3.31 AAI-System Configuration Descriptor (SCD) message

[Add following rows in the end of Table 714 in 6.2.3.31 as indicated:]

Multicast Group Zone ID	12	Indicates a Multicast Group Zone ID provided by this BS. Shall not be set to "0."	In HR-Network
Multicast Indication cycle	8	Start of multicast indication cycle. The first superframe is the multicast available interval and rest superframes are the multicast unavailable interval. 8 LSB of superframe number	Shall be present unless Multicast Group Zone is set to "0" in HR-Network
HR Multimode indication	2	Indicates whether current BR/RS is HR-MS acting as BS/RS or HR-BS acting as RS 0b00: current BS/RS is neither HR-MS acting as BS/RS nor HR-BS acting as RS 0b01: current BS/RS is HR-MS acting as BS/RS 0b10: current BS/RS is HR-BS acting as RS	HR Multimode indication Shall be present in HR- Networks

		0b11: reserved	

6.2.3.47 DSx MAC control messages

6.2.3.47.1 AAI-DSA-REQ

[Change last paragraph in section 6.2.3.47.1 AAI-DSA-REQ as indicated:]

When an ABS commences multicast service, the following parameters shall be included in the AAI-DSA-REQ message.

- Multicast Group Zone ID: Indicates multicast group zone IDs for the connection that is associated with the service flow in AAI-DSA-REQ in HR-Network.
- Multicast Indication cycle: Indicates multicast indication cycle for the multicast in HR-Network
- Multicast Group ID: Indicates multicast group for the connection that is associated with the service flow in AAI-DSA-REQ.

[Change Table 740 as indicated:]

Table 740—AAI-DSA-REQ message field description

Field	Size (bits)	Value/Description	Condition
……	……	.....	.....

For(*i*=0; *i*<N-FIDs-Coupled-
 	
Noncommon; *i*++) {
		N-FIDs-Coupled-Noncommon is the number of non-common coupled service flow IDs
		
		The maximum value of N-FIDs-Coupled-Noncommon is 32.	

FID	4		Shall be present if NFIDs-Coupled-Noncommon is not zero
Non-common for Coupled Group	*variable*	Non-common service flow encodings that are specific to individual service flows specified in Coupled FID Parameter List Service flow/convergence sublayer parameters in Table 788,	Shall be present if NFIDs-Coupled-Noncommon is not zero

		except FID, SFID, E-MBS service related information, Group Parameter Create/Change related information and Coupled Group Create/Change related information, may be encapsulated in this field.	
}			
}			
Multicast Group Zone ID	12	Indicates a multicast group zone to add where the connection for associated service flow is valid.	Present if needed in HR-Network
Multicast Indication cycle	8	Start of multicast indication cycle. The first superframe is the multicast available interval and rest superframes are the multicast unavailable interval. 8 LSB of superframe number	Shall be present if Multicast Group Zone is included in this message and the Multicast indication cycle is different from that in AAI-SCD in HR-Network. If the value is the same as that in AAI-SCD, this may not be included in this message
For (*i*=0; *i*<Num of Multicast Group ID and FID (M); *i*++) {		Num of Multicast Group ID and FID (M) ~~is the number of Multicast Group IDs~~ to add [1..16]	Present when ABS initiates AAI-DSA-REQ
Multicast Group ID	12	ID of a group to which the flow is added	Present only if Num of Multicast Group ID and FID (M)> 0
FID	4	Multicast specific FID that is associated with Multicast Group ID	Present only if Num of Multicast Group ID and FID (M)> 0

}			
If (sleep cycle setting is included) {			
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	
.....	.....	.....	.....
.....	.....	.....	.....
DC	2	00 – normal request 01 – DC request 10, 11 reserved	When direct communication is turned on
Reserved	6	--	--
if (DC == 01) {			
STID	12	STID of the direct communication link	When direct communication is turned on
}			

6.2.3.47.2 AAI-DSA-RSP

[Change last paragraph in section 6.2.3.47.2 AAI-DSA-RSP as indicated:]

When an AMS commences multicast service, the ABS shall include the following parameters in the AAI-DSA-RSP message:

- Multicast Group Zone ID: Indicates multicast group zone IDs for the connection that is associated with the service flow in AAI-DSA-RSP in HR-Network.
- Multicast Indication cycle: Indicates multicast indication cycle for the multicast in HR-Network
- Multicast Group ID: Indicates multicast group for the connection that is associated with the service flow in AAI-DSA-RSP.

[Change Table 741 in section 6.2.3.47.2as indicated:]

Table 741—AAI-DSA-RSP message field description

Field	Size (bits)	Value/Description	Condition
……	……	.....	.....
Carrier Switching Mode	1	0b0: carrier switching method based on Unicast Available Interval in the AAI-DSA message 0b1: carrier switching method using AAI-E-MBS-REP/RSP message	Present if ABS indicates carrier switching when receiving AMS-initiated DSA
If(Carrier Switching Mode == 0b0) {			
Unicast Available Interval Bitmap	*variable*	Indicates when the AMS should be available in the primary carrier using *N* bits *b0b1b2...bN-1* If *bi*==0, then AMS is available for E-MBS data scheduling in secondary carrier If *bi*==1, then AMS is available for unicast scheduling in primary carrier *NMSI* = 4 superframes: *N* = 4 bits *NMSI* = 8 superframes: *N* = 8 bits *NMSI* = 16 superframes: *N* = 16 bits *NMSI* = 32 superframes: *N* = 32 bits Depending on the *NMSI*, the number of bits per subframe changes, 4 frames per bit	
}			
Multicast Group Zone ID	12	Indicates a multicast group zone to add where the connection for associated service flow is valid.	Present if needed in HR-Network
Multicast Indication	8	Start of multicast indication cycle.	Shall be present if Multicast Group

cycle		The first superframe is the multicast available interval and rest superframes are the multicast unavailable interval. 8 LSB of superframe number	Zone is included in this message and the Multicast indication cycle is different from that in AAI-SCD in HR-Network. If the value is the same as that in AAI-SCD, this may not be included in this message
For (*i*=0; *i*<Num of Multicast Group ID and FID (M); *i*++) {		Num of Multicast Group ID and FID (M) ~~is the number of Multicast Group IDs~~ to add [1..16]	
Multicast Group ID	12	ID of a group to which the flow is added	Present only if Num of Multicast Group ID and FID (M)> 0
FID	4	Multicast specific FID that is associated with Multicast Group ID	Present only if Num of Multicast Group ID and FID (M)> 0
}			
If (sleep cycle setting is included) {			May be present when sleep cycle setting needs to be changed or switched
Response_Code	2	This indicates response type of AAI-SLP-RSP message. 0b00: Request by ABS in Unsolicited manner 0b01: Approval of AAI-SLP-REQ	This parameter shall be included only when ABS transmit this

		0b10: Rejection of AAI-SLP-REQ 0b11: *Reserved*	control message.
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	
.....	……	.....	.....

6.2.3.47.3 AAI-DSA-ACK

6.2.3.47.4 AAI-DSC-REQ

[Change Table 743 in section 6.2.3.47.4 as indicated:]

Table 743—AAI-DSC-REQ message field description

Field	Size (bits)	Value/Description	Condition
……	……	.....	.....
For(*i*=0; *i*<N-FIDs-Coupled-Noncommon; *i*++) {		N-FIDs-Coupled-Noncommon is the number of non-common coupled service flow IDs. The maximum value of N-FIDs-Coupled-Noncommon is 32.	
FID	4	Flow identifier	Present when N-FIDs-Coupled-Noncommon >0
Non-common for Coupled Group	*variable*	Non-common service flow encodings that are specific to individual service flows specified in Coupled FID Parameter List. Service flow/convergence sublayer parameters in Table 788, except FID, SFID, E-MBS	Present when N-FIDs-Coupled-Noncommon >0

		service-related information, Group Parameter Create/Change related information and Coupled Group Create/Change related information, may be encapsulated in this field.	
}			
}			
New Multicast Group Zone ID	12	Indicates a multicast group zone to overwrite where the connection for associated service flow is valid.	Present when ABS initiates AAI-DSC-REQ in HR-Network
Multicast Indication cycle	8	Start of multicast indication cycle to overwrite. The first superframe is the multicast available interval and rest superframes are the multicast unavailable interval. 8 LSB of superframe number	Shall be present if needed to update
For (*i*=0; *i*<Num of Multicast Group ID and FID (MC); *i*++) {		Num of Multicast Group ID and FID (MC) ~~is the number of Multicast Group IDs~~ to add [1..16]	Present when ABS initiates AAI-DSA-REQ
Multicast Group ID	12	ID of a group to which the flow is added	Present only if Num of Multicast Group ID and FID (M)> 0
FID	4	Multicast specific FID that is associated with Multicast Group ID	Present only if Num of Multicast Group ID > 0
}			
For (*i* = 0; *i*< MU; *i*++) {		Number of Multicast Group ID and FID (MU) to update [1..16]. Mapping of current Multicast Group ID and FID and new	Present if it needs to update in HR-network.

		Multicast Group ID and FID to update. Based on the value of Num of Multicast Group ID and FID to update.	
Current Multicast Group ID	12		
Current FID	4		
New Multicast Group ID	12		
New FID	4		
}			
For (*i*=0; *i*<Num of Multicast Group ID and FID (MA); *i*++) {		Num of Multicast Group ID and FID (MA) ~~is the number of Multicast Group IDs~~ to add [1..16]	Present when ABS initiates AAI-DSC-REQ Present only if Multicast Group ID to be added exists
Multicast Group ID to be added	12	Multicast Group ID to be added	Present only if Num of Multicast Group ID and FID (M)> 0
FID	4	Multicast specific FID which is associated with newly added Multicast Group ID	Present only if Num of Multicast Group ID and FID (M) > 0
}			
For (*i*=0; *i*<Num of Multicast Group ID and FID (MD); *i*++) {		Num of Multicast Group ID and FID (MD) ~~is the number of Multicast Group IDs~~ to delete [1..16]	Present when ABS initiates AAI-DSC-REQ Present only if Multicast Group ID to be deleted exists
Multicast Group ID to be deleted	12	Multicast Group ID to be deleted	Present only if Num of Multicast Group ID and FID (M) > 0
FID		Multicast specific FID which is associated with newly deleted Multicast Group ID	Present only if Num of Multicast Group ID

			and FID (M)> 0
}			
If (sleep cycle setting is included) {			May be present when sleep cycle setting needs to be changed or switched
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	
.....	.....	.....	.....

[Change the text in section 6.2.3.57 as indicated:]

6.2.3.57 AAI-ARS-CONFIG-CMD message format

An ABS shall use AAI-ARS-CONFIG-CMD message to configure the TTR mode ARS PHY layer operational parameters.

An HR-BS shall use AAI-ARS-CONFIG-CMD message to configure the multimode HR-MS acting as HR-RS PHY layer operational parameters.

[Change the table 757 in 6.2.3.57 as indicated:]

Table 757—AAI-ARS-CONFIG-CMD message field description

Field	Size (bits)	Value/Description	Conditions
If(subordinate RS (including HR-MS acting as RS) is TTR relay mode in HR-Network) {			// TTR mode
AAI_Relay_zone_AMS_ allocation_indicator	1	0b0: The ABS does not allocate resources to the AMS in the AAI DL Relay zone; 0b1: The ABS may allocate resources to the AMS in the AAI DL Relay zone	Always present

Field	Size (bits)	Value/Description	Conditions
MIMO Midamble indication in AAI DL Relay zone	1	0b0: MIMO midamble is not transmitted in AAI DL Relay zone 0b1: MIMO midamble is transmitted in AAI DL Relay zone If AAI_Relay_zone_AMS_allocation_indicator == 0b0, this field is set to 0b1.	Always present
Superframe Number Action	4	LSBs of the superframe number when ARS start ARS operation and apply the PHY operational parameters.	Always present
R_IdleTime	11	Unit is 0.1 μs	Always present
If(ABS allocates resource for periodic ranging in AAI UL Relay zone) {			
Allocation periodicity of the S-RCH	2	Indicates the periodicity of the S-RCH allocation. 0b00: Every frame 0b01: The second frame in every superframe 0b10: The second frame in every 4^{th} superframe, i.e., mod(superframe number, 4) = 0 0b11: The second frame in every 8^{th} superframe, i.e., mod(superframe number, 8) = 0	Present when ABS allocates resource for periodic ranging in AAI UL Relay zone
Subframe offset of the S-RCH	2	Indicates the subframe offset (O_{SF}) of the S-RCH allocation. The range of values is $0 \le O_{SF} \le 3$. S-RCH is allocated in the (O_{SF} +UAZ) subframe.	Present when ABS allocates resource for periodic ranging in AAI UL Relay zone
Start RP code information of the S-RCH	4	Indicates the ks which is the parameter controlling the start root index of the RP codes (r_{s0}). $r_{s0}=6k_s+1$ The range of values is $0 \le k_s \le 15$.	Present when ABS allocates resource for periodic ranging in AAI UL Relay zone
N_{PE}	2	Indicates the number of periodic code (N_{PE}) according to the Table 917.	Present when ABS allocates resource for periodic ranging in AAI UL Relay zone
}			

Field	Size (bits)	Value/Description	Conditions
If(ABS allocates resource for BR channel in AAI UL Relay zone) {			
UL BW REQ channel information	2	Indicates the number and the location of UL AAI subframe where the UL BW REQ channels are allocated. 0b00: *i*-th UL AAI subframe of UL relay zone in the first frame in every superframe 0b01: *i*-th UL AAI subframe of UL relay zone in the first and second frame in every superframe 0b10: *i*-th UL AAI subframe of UL relay zone in every frame 0b11: *i*-th and (*i*+1)-th UL AAI subframes of UL relay zone in every frame Where *i*-th is "first" if UL R-RTI = 0, and *i*-th is "second" if UL R-RTI=*Ts*.	Present when ABS allocates resource for BR channel in AAI UL Relay zone
UL BW REQ channel allocation	4	The DRU index for UL BW REQ channel within FPi defined by "Frequency partition location for UL control channels" in S-SFH SP1.	Present when ABS allocates resource for BR channel in AAI UL Relay zone
Bandwidth request backoff start	4	Initial backoff window size for contention BRs, expressed as a power of 2. Values of n range 0–15 (the highest order bits shall be unused and set to 0)	Present when ABS allocates resource for BR channel in AAI UL Relay zone
Bandwidth request backoff end	4	Final backoff window size for contention BRs, expressed as a power of 2. Values of n range 0–15	Present when ABS allocates resource for BR channel in AAI UL Relay zone
}			
If(AAI_Relay_zone_AMS_allocation_indicator == 0b0){			
R_DCAS_{SB0}	5/4/3	Indicates the number of subband-based CRUs in FP0 for AAI DL Relay zone. See 6.6.3.3.2 Cell-specific resource mapping For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits	Present when AAI_Relay_zone_AMS_allocation_indicator ==0b0
R_DCAS_{MB0}	5/4/3	Indicates the number of miniband-based CRUs in FP0	Present when

Field	Size (bits)	Value/Description	Conditions
		for AAI DL Relay zone. See 6.6.3.3.2 Cell-specific resource mapping For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits	AAI_Relay_zone_AMS_allocation_indicator ==0b0
R_DCAS$_i$	3/2/1	Indicates the number of total allocated CRUs, in a unit of a subband, for FPi (i > 0) for AAI DL Relay zone. See 6.6.3.3.2 Cell-specific resource mapping For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit	Present when AAI_Relay_zone_AMS_allocation_indicator ==0b0
R_UCAS$_{SB0}$	5/4/3	Indicates the number of total allocated CRUs, in a unit of a subband, for FPi (i > 0) for AAI DL Relay zone. See 6.6.3.5.1 Cell-specific resource mapping For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits	Present when AAI_Relay_zone_AMS_allocation_indicator ==0b0
R_UCAS$_{MB0}$	5/4/3	Indicates the number of miniband-based CRUs in FP0 for AAI UL Relay zone. See 6.6.3.5.1 Cell-specific resource mapping For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits	Present when AAI_Relay_zone_AMS_allocation_indicator ==0b0
R_UCAS$_i$	3/2/1	Indicates the number of total allocated CRUs, in a unit of a subbands, for FPi (i > 0) for AAI UL Relay zone. See 6.6.3.5.1 Cell-specific resource mapping For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit	Present when AAI_Relay_zone_AMS_allocation_indicator ==0b0
}			
}			// TTR mode only
If (subordinate HR-MS is multimode MS acting as HR-RS in HR-			

Field	Size (bits)	Value/Description	Conditions
Network) {			
SA-PREAMBLE index	10		Always present
MS functionality maintenance indication	1	0b0: MS functionality is maintained after role change 0b1: MS functionality is not maintained	Always present
Cell bar information	1	If Cell bar bit == 0b1, this cell shall not be allowed for network entry or reentry	Always present
If (subordinate HR-MS is acting as STR relay mode) {			
Frame configuration index	6	The mapping between value of this index and frame configuration is listed in Table 806, Table 807, and Table 808.	Always present
FFT size indication	2	0b00: 2048 FFT 0b01: 1024 FFT 0b10: 512 FFT 0b11: reserved	Always present
DL carrier frequency for BS and RS (F_{BR_DL})	10	Indicates the DL carrier frequency in unit of 100KHz for MS acting as RS. Used to receive from HR-BS in the DL relay zone.	Present if needed
UL carrier frequency for BS and RS (F_{BR_UL})	10	Indicates the UL carrier frequency in unit of 100KHz for MS acting as RS. Used to transmit to HR-BS in the UL relay zone.	Present if needed
DL carrier frequency for RS and MS (F_{RM_DL})	10	Indicates the DL carrier frequency in unit of 100KHz for MS acting as RS in FDD. If the duplex mode is TDD, this carrier is used for DL/UL Used to transmit to subordinate HR-MS in the DL in FDD. Used to transmit/receive to/from subordinate HR-MS in TDD.	Shall be present if F_{RM_DL} is different from that of HR-BS' DL access zone
UL carrier frequency for RS and MS (F_{RM_UL})	10	Indicates the UL carrier frequency in unit of 100KHz for MS acting as RS in FDD. Used to transmit to subordinate HR-MS in the UL in FDD.	Shall be present if F_{RM_UL} is different from that of HR-BS' UL access zone
Superframe Number Action	4	LSBs of the superframe number when HR-RS start RS operation and apply the PHY operational parameters.	Always present
}			
}			

Field	Size (bits)	Value/Description	Conditions
}			

[Insert the following new sections:]

6.2.3.65 MAC control messages for HR-Networks

6.2.3.65.1 AAI-MM-ADV message

Infrastructure stations and HR-MS acting as HR-BS or HR-RS may transmit AAI-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

Table 763mm1 – Parameters for AAI-MM-ADV message

Field	Size (bits)	Value/Description	Condition
Action Type	3	Used to indicate the purpose of this message 0b000: Reconfiguration of HR-BS/RS including multimode BS/RS 0b001: Restart of HR-BS/RS including multimode BS/RS 0b010: Power down (including FA down) of HR-BS/RS including multimode BS/RS 0b011: Power reduction of HR-BS/RS including multimode BS/RS 0b100: Backhaul link down of HR-BS 0b101: Backhaul link up of HR-BS 0b110: FA change of HR-BS/RS including multimode BS/RS 0b111: Multimode service end of HR-MS	Mandatory

Field	Size (bits)	Value/Description	Condition
If (Action Type == 0b000) {			// reconfiguration
New IDcell	10	New IDcell that the ABS will use after the reconfiguration process.	Optional
Frame configuration index	6	New mapping between value of this index and frame configuration is listed in Table 806, Table 807, and Table 808.	Optional
Unavailable Start Time (UST)	8	Start of unavailable time in unit of frame	Mandatory
Unavailable Time Interval (UTI)	8	Interval of unavailable time in unit of superframe	Mandatory
} else if (Action Type == 0b001) {			// restart
Unavailable Start Time (UST)	8	Start of unavailable time in unit of frame	Mandatory
Unavailable Time Interval (UTI)	8	Interval of unavailable time in unit of superframe	Mandatory
} else if (Action Type == 0b010) {			// power down
Time of Power Down	8	Expected time when the HR-BS will be powered down in units of frame	Mandatory
Expected uptime of BS	8	Expected uptime of BS in units of superframe	Optional
} else if (Action Type == 0b011) {			// power reduction
Tx Power Reduction	10	dB value of Tx power reduction	Mandatory
Expected time of power reduction	8	Expected resource adjustment time in units of frame	
} else if (Action Type == 0b100) {			// backhaul link down
Time of backhaul link down	8	Expected time when the backhaul link will be down in units of superframe	Optional
Expected time of backhaul link available	8	Expected time in unit of LSB of superframe when backhaul link will be available of HR-BS either itself or via neighbor HR-BS	Optional
} else if (Action Type == 0b101) {			// backhaul link up
Expected time of backhaul link up	8	Expected time in unit of LSB of superframe when the HR-BS restarts service without any help of neighbor BS using relay link but the HR-BS' backhaul link	Optional
} else if (Action Type == 0b011) {			// power reduction

Field	Size (bits)	Value/Description	Condition
Tx Power Reduction	10	dB value of Tx power reduction	Mandatory
Expected time of power reduction	8	Expected resource adjustment time in units of frame	
} else if (Action Type == 0b111) {			// multimode service end
Expected time of backhaul link up	8	Expected time in unit of LSB of superframe when the HR-MS release the multimode service and to allow subordinate MS to perform handover to other infrastructure	Optional
}			

6.2.3.65.2 AAI-MMRS-REQ

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

Table 763mm2 – AAI-MMRS-REQ message field description

Field	Size (bits)	Value/Description	Condition
Request Relay mode	1	0b0: TTR relay mode 0b1: STR relay mode	Always present
If(this request is subordinate station initiated request) {			Shall be present when subordinate station initiates AAI-MMRS-RSP
If (request relay mode == 0b0) {			// TTR
ST-TTG	6	Transmit-to-receive turnaround gap of subordinate station, i.e., HR-MS or HR-BS, in units of µs. It shall be less than 50 µs.	
ST-RTG	6	Receive-to-transmit turnaround gap of subordinate station, i.e., HR-MS or HR-BS, in units of µs. It shall be less than 50 µs.	
If (subordinate station is HR-BS) {			
T_a	11	Proposed value of timing advance T_a , in units of 0.1 µs	
T_{bs}	5	Proposed duration of the BS Operation	

		mode, in units of frames	
T_{rs}	5	Proposed duration of the RS Operation mode, in units of frames	
}			
} else if (request relay mode == 0b1) {			// STR
Duplex mode support indication	2	If bit0 = 1, FDD supports If bit1 = 1, TDD supports	
for(i=1; i<=N-frequency; i++) {		N-frequency is the number of available frequency to communicate[1..16]	
Carrier frequency	10	Indicates the carrier frequency in unit of 100KHz.	
}			
}			
}			
If (this request is superordinate station initiated request && received subordinate station is HR-BS) {			Shall be present when Superordinate HR-BS initiates AAI-MMRS-REQ
If (request relay mode == 0b0) {			// TTR
T_a	11	Proposed value of timing advance T_a , in units of 0.1 μs	
T_{bs}	5	Proposed duration of the BS Operation mode, in units of frames	
T_{rs}	5	Proposed duration of the RS Operation mode, in units of frames	
}			
}			

6.2.3.65.3 AAI-MMRS-RSP

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

Table 763mm3 – AAI-MMRS-RSP message field description

Field	Size (bits)	Value/Description	Condition

Field	Size (bits)	Value/Description	Condition
If(the response is transmitted by superordinate HR-BS) {			Present when superordinate HR-BS responds the subordinate station initiated request
Response code	2	0b00: in response to the AAI-MMRS-REQ message to accept the request 0b01: in response to the AAI-MMRS-REQ message to allow to transmit subordinate station initiated AAI-ARE-REQ after action time expires 0b10: in response to the AAI-MMRS-REQ message to reject the request 0b11: *reserved*	
If(Response code == 0b00 and the request was sent by an HR-BS wishing to establish TTR relay link){			
T_a	11	Confirmed value of timing advance T_a, in units of 0.1 μs	
T_{bs}	5	Confirmed duration of the BS Operation mode, in units of frames	
T_{rs}	5	Confirmed duration of the RS Operation mode, in units of frames	
}			
If(Response code == 0b01) {			
Action time	4	LSBs of the superframe number when the subordinate station transmits AAI-MMRS-REQ message.	Always present
}			
} else {			Present when subordinate station responds to the superordinate HR-BS initiated request
If(received request relay mode == 0b0) {			// TTR mode
ST-TTG	6	Transmit-to-receive turnaround gap of subordinate station, i.e., HR-MS or HR-BS, in units of μs. It shall be less than 50 μs.	Shall be present if action code == 0b0 in AAI-MMRS-REQ.
ST-RTG	6	Receive-to-transmit turnaround gap of subordinate station, i.e., HR-MS or HR-BS, in units of μs. It shall be less than 50 μs.	Shall be present if action code == 0b0 in AAI-MMRS-REQ.
If (requested subordinate station is HR-BS) {			Shall be present if the

Field	Size (bits)	Value/Description	Condition
			subordinate station is HR-BS and action code == 0b0 in AAI-MMRS-REQ.
T_a	11	Confirmed value of timing advance T_a, in units of 0.1 μs	
T_{bs}	5	Confirmed duration of the BS Operation mode, in units of frames	
T_{rs}	5	Confirmed duration of the RS Operation mode, in units of frames	
}			
} else if (received request relay mode == 0b1) {			// STR mode
Duplex mode support indication	2	If bit0 = 1, FDD supports If bit1 = 1, TDD supports	Always present
for(i=1; i<=N-frequency; i++) {		N-frequency is the number of available frequency to communicate[1..16]	
Carrier frequency	10	Indicates the carrier frequency in unit of 100KHz.	
}			
}			
}			

6.2.3.65.4 AAI-MMRL-REQ message

HR-MS transmits AAI-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 AAI-MMRL-RSP message by the HR-BS

Table 763mm4 – AAI-MMRL-REQ message field description

Field	Size (bits)	Value/Description	Condition
Release_Request_Code	2	Used to indicate the purpose of this message 0b00: multimode release 0b01: response for the unsolicited AAI-MMRL-RSP message by the HR-BS 0b10: reject for the unsolicited AAI-MMRL-RSP message by the HR-BS. This code is applicable only when UL data is	Always present

Field	Size (bits)	Value/Description	Condition
		pending to transmit. 0b11: *reserved*	

6.2.3.65.5 AAI-MMRL-RSP message

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

Table 763mm5 – AAI-MMRL-RSP message format

Field	Size (bits)	Value/Description	Condition
Action code	2	Used to indicate the purpose of this message 0b00: HR-MS shall immediately terminate multimode service and return its original HR-MS mode. 0b01: HR-MS shall terminate multimode service and return its original HR-MS mode at the action time expires 0b10: In response to an AAI-MMRL-REQ message to allow HR-MS to transmit MS-initiated request after action time expires. 0b11: In response to an AAI-MMRL-REQ message to reject the request of HR-MS.	Always present
If (action code == 0b01 or 0b10) {			
Action time	4	LSBs of the superframe number when HR-RS start releasing the multimode or transmit AAI-MMRL-REQ message.	Always present
}			

6.2.3.65.6 AAI-MMBS-REQ

To request to transfer HR-BS role to a multimode HR-MS, the AAI-MMBS-REQ message shall be sent from superordinate HR-BS to a multimode HR-MS.

Table 763mm6 – AAI-MMBS-REQ message field description

Field	Size (bits)	Value/Description	Condition

Action code	2	Used to indicate the purpose of this message. 0b00: Request to transfer HR-BS role to the multimode HR-MS 0b01: Response for the unsolicited AAI-MMBS-RSP message by the multimode HR-MS. 0b10: Reject for the unsolicited AAI- MMBS-RSP message by the multimode HR-MS. 0b11: *Reserved*.	
BS configuration indication	2	Indicates whether the superordinate HR-BS provides the recommended PHY parameters to multimode HR-MS or not. 0b00: There are no recommended PHY parameters. 0b01: There are no recommended PHY parameters. But, must be equal to the PHY operational parameters of the superordinate HR-BS. 0b10: There are recommended PHY parameters. 0b11: *Reserved*	
If (BS configuration indication == 0b01) {			
S-SFH change count	4	Indicates the value of S-SFH change count of this HR-BS	
Global carrier configuration change count	3	Indicates the HR-MS's last received value of Global carrier configuration change count of the network. If set to 0, it implies that HR-MS never received a Global carrier configuration information.	
SCD count	4	Indicates Configuration Change Count that is associated with the system configuration of the AAI-SCD.	
Multicarrier configuration change count	4	The value is incremented by 1 upon each update	
} else if (BS configuration indication == 0b10) {			
FA index	8	FA index	
BSID	48	HR-BS ID	
MAC protocol version	8	MAC protocol version of the BS Consistent with IEEE Std 802.16-2009 definition, with new MAC protocol version defined 10 for AAI.	
CP time	2	CP time of the HR-BS	

		0b00: 1/8 0b01: 1/16 0b10: 1/4	

For(j=0; j<N-Carrier-Info; j++)
 	
{			

SA-PREAMBLE index	10		
Physical carrier index	6	Refer to the physical carrier index in AAI-Global-CFG message	
Paging carrier indication	1	Indicates whether the carrier is a paging carrier in HR-BS or not 0: no paging carrier 1: paging carrier	May be present when multiple carrier operation is applied.
PGID	16	Indicates paging group identifier where the carrier belongs	
S-SFH change count	4	Indicates the value of S-SFH change count of this HR-BS	
SFH encoding format	2	0b00: full Subpkt information 0b01: delta encoding with reference to the information of current carrier that transmits this AAI-MMBS-REQ message. 0b10: no SFH included 0b11: delta encoding with reference to the information of the preceding carrier For macrocell HR-BS, the SFH encoding format shall be either 0b00 or 0b01 or 0b11.	

If (SFH encoding format == 0b00)
 	
{			

SFH Subpkt 1	variable	See Table 839 in IEEE Std 802.16m-2011.	
SFH Subpkt 2	variable	See Table 840 in IEEE Std 802.16m-2011.	
SFH Subpkt 3	variable	See Table 841 in IEEE Std 802.16m-2011.	
} else if (SFH encoding format == 0b01‖0b11) {			

Delta information	variable	Indicates the delta encoding, between the reference carrier and the current carrier where this message is transmitted if SFH encoding format = 0b01, or between the reference carrier and the preceding carrier if SFH_encoding_format=0b11. Delta information contains SFH SP1, SP2, and SP3 attributes as defined in Table 839, Table 840, and Table 841 of IEEE Std 802.16m-2011, respectively. Each delta information attribute is optional.	
}			
}			
}			

6.2.3.65.7 AAI-MMBS-RSP

After configuring HR-BS mode or expiring predefined BS configuration deadline, the AAI-MMBS-RSP message shall be sent from multimode HR-MS to a superordinate HR-BS in response to an AAI-MMBS-REQ message. The multimode HR-MS may send the AAI-MMBS-RSP message in unsolicited manner with Response_Code = 0b00 (i.e., Request by multimode HR-MS in Unsolicited manner).

Table 763mm7 – AAI-MMBS-RSP message field description

Field	Size (bits)	Value/Description	Condition
Response code	2	This indicates response type of AAI-MMBS-RSP message. 0b00: Request by multimode HR-MS in Unsolicited manner 0b01: Approval of AAI-MMBS-REQ 0b10: Rejection of AAI-MMBS-REQ 0b11: *Reserved*	

If (Response code == 0b10)
 	
{			

Operation	2	0b00: Retransmit AAI-MMBS-REQ message (HR-BS mode of multimode HR-MS is not yet completely configured.) 0b01: Retransmit AAI-MMBS-REQ message after applying the system configuration change count (System configuration change count of multimode HR-MS is out of date.)	

Field	Size (bits)	Value/Description	Condition
		0b10: Cancel BS configuration request 0b11: *Reserved*	
}			

6.2.3.65.8 AAI-MMBS -CMD

To inform the time for starting HR-BS role, the AAI-MMBS-CMD message shall be sent from superordinate HR-BS to the multimode HR-MS. The trigger condition indicates when a HR-MS shall initiate a mode change to BS. See Table 775.

Table 763mm8 – AAI-MMBS-CMD message field description

Field	Size (bits)	Value/Description	Condition
Trigger type	1	0b0: Start HR-BS mode after expiring action time 0b1: Start HR-BS mode upon reaching trigger conditions	
If (Trigger type == 0b0)			
Action time	4	This is the wait time in units of 100 ms before the HR-MS starts to perform HR-BS mode. The multimode HR-MS shall start HR-BS mode at the action time expires.	
} else {			
Trigger condition	variable	Triggers defined in table 775.	
}			

6.2.3.65.9 HR-DCV-CMD message

Table 763dc1 – HR-DCV-CMD message field description

Field	Size (bits)	Value/Description	Condition
Frame Identifier	4	Frame which contains the ranging channel. The frame identifier is the 4 least significant bits of the frame number.	

Subframe Index	3	Indicates the subframe index of the allocated ranging opportunity.	
Dedicated ranging code index	5	Indicates the index of dedicated ranging code.	
Action	1	0b0: HR-MS to transmit the ranging signal as instructed. 0b1: HR-MS to receive the ranging signal as instructed.	
If (Action == 0b0){			
Transmit power level	5	Unsigned integer from 1 to 64 in units of 1 dBm, where 0b00000 = 0dBm and 0b11111 = 31dBm	
}			
Else{			
Report mode	2	Indicate if the report mode is exclusive (all receiving HR-MS should send HR-DCV-REP message) or triggered by threshold. 0b00: exclusive reporting 0b01: triggered-based reporting 0b10: for peer-to-peer synchronization and no reporting 0b00: reserved.	
If (Report mode == 0b01){			
SINR threshold	4	Indicates the SINR threshold for the ranging signal above which report should be made by receiving station. 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	
}			
}			
}			

6.2.3.65.10 HR-DCV-REP message

1
2
3
4

Table 763dc2 – HR-DCV-REP message field description

Field	Size (bits)	Value/Description	Condition
For (*i* = 0; *i* < Number of ranging codes to be reported; *i*++){			
Frame Identifier	4	Frame which contains the ranging channel. The frame identifier is the 4 least significant bits of the frame number.	
Subframe Index	3	Indicates the subframe index of the allocated ranging opportunity.	
Received SINR	4	Indicates the received SINR of the ranging code. 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	
Timing offset	15	Time offset, in units of F_s, of the received ranging signal, with respect to the frame timing of the HR-MS. MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB=0b0. LSB 14 bits represent timing offset correction value of [1…16384] that corresponds to 0x0000 ~ 0x3FFF, respectively.	Optional
Frequency offset	9	Frequency offset, in units of	Optional

		2% of the subcarrier spacing (f), of the received ranging signal, with respect to the frequency of the HR-MS. MSB 1bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB=0b0. LSB 8 bits represent frequency offset correction value of [1..256] that corresponds to 0x00 ~ 0xFF, respectively	
}			

6.2.3.65.11 Direct Communication Link Creation

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

Table 763dc3 – Direct Communication Link Creation Request

Syntax	Size (bit)	Notes
AAI-DC-LINK-CREATE-REQ () {		
TWDC address for transmitting	12	Address assigned to DC link
TWDC address for receiving	12	Address assigned for DC link
}		

TWDC address for transmitting

The **TWDC address** is used by the HR-MS for transmitting. The peer HR-MS of the DC-link shall receive on the resource scheduled with this **TWDC address**.

TWDC address for receiving

The HR-MS shall receive on the resource assigned to this **TWDC address** since it is assigned to the peer HR-MS on the DC-Link for transmission.

6.2.3.65.12 Direct communication link creation response

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

Table 763dc4 – Direct Communication Link Creation Response

Syntax	Size (bit)	Notes
AAI-DC-LINK-CREATE-ACK () {		
TWDC address for transmitting	12	
Confirmation Code	1	0x00: accept 0x01: reject
Reserved	7	—
}		

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

6.2.3.65.13 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 763dc5 – Direct Communication Link Deletion Request

Syntax	Size (bit)	Notes

AAI-DC-LINK-DEL () {		
TWDC address for transmitting	12	
}		

6.2.3.65.14 Direct Communication Link Deletion Response

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

Table 763dc6 – Direct Communication Link Deletion Response

Syntax	Size (bit)	Notes
AAI-DC-LINK-DEL-ACK () {		
TWDC address for transmitting	12	STID assigned to DC link
Confirmation Code	1	0x00: accept 0x01: reject
Reserved	7	—
}		

6.2.3.65.15 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 763dc7 – Direct Communication Link Report Request

Syntax	Size (bit)	Notes
AAI-DC-LINK-REPORT-REQ () {		
TWDC address for transmitting	12	

}		

6.2.3.65.16 Direct Communication Link Report Response

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

Table 763dc8 – Direct Communication Link Report

Syntax	Size (bit)	Notes
AAI-DC-LINK-REPORT-REQ () {		
TWDC address for transmitting	12	
Link state	1	0x00: active 0x01: no link found
reserved	7	—
}		

6.2.3.65.17 DM-LEST-REQ

An HR-MS transmits a DM-LEST-REQ message to establish a peer-to-peer link.

Table 763dc9 – DM-LEST-REQ message field description

Field	Size (bits)	Value/Description	Condition
Link Change Count	4	The change count of this transaction assigned by the sender. If new transaction is started, Link Change Count is incremented by one (modulo 16) by the sender.	Shall always be present
For (i=0; i<N_Flow_Est; i++) {		N_Flow_Est is the number of flows on which the sender of this message sends MAC PDUs. Range [0..1]	
FID	4	Flow identifier assigned by the sink of	

		packets on the flow	
Traffic priority	3	0 to 7: Higher numbers indicate higher priority Default: 0	
CS Specification Parameters	8	0–15: *Reserved* 16: Voice Codec G.729A 17–255: *Reserved*	
MAC Header Type	1	Indicates whether AGMH or SPMH is presented at the start of MAC PDUs of the service flow. 0 : AGMH (Advanced Generic MAC Header) 1 : SPMH (Short-Packet MAC header) default value is 0.	
}			
Reserved			

6.2.3.65.18 DM-LEST-RSP

An HR-MS transmits a DM-LEST-RSP message in response to a received DM-LEST-REQ.

Table 763dc10 – DM-LEST-RSP message field description

Field	Size (bits)	Value/Description	Condition
Link Change Count	4	Link Change Count from corresponding the DM-LEST-REQ	Shall always be present
Confirmation Code	4	Zero indicates the request was successful. Nonzero indicates failure	Shall always be present
Reserved			

6.2.3.65.19 DM-MES-REP

An HR-MS transmits a DM-MES-REP message to report the measurement results if a report trigger condition is met.

Table 763dc11 – DM-MES-REP message field description

Field	Size (bits)	Value/Description	Condition

6.2.3.65.20 DM-RCHG-REQ

An HR-MS transmits a DM-RCHG-REQ message to change radio resource for dedicated channel.

Table 763dc12 – DM-RCHG-REQ message field description

Field	Size (bits)	Value/Description	Condition
For (i=0; i<N_Resource_Change; i++) {		N_Resource_Change is the number of dedicated channels Range [0..12]	
Old DC Frame Number	4	Indicates a DC frame number with the dedicated channel is on the frame.	
Old Dedicated Channel Number	4	Indicates a number of dedicated channel with DC Frame Number.	
New DC Frame Number	4	Indicates a DC frame number with the dedicated channel is on the frame.	
New Dedicated Channel Number	4	Indicates a number of dedicated channel with DC Frame Number.	
}			

6.2.3.65.21 DM-RCHG-RSP

An HR-MS transmits a DM-RCHG-RSP message in response to a received DM-RCHG-REQ.

Table 763dc13 – DC-RCHG-REQ message field description

Field	Size (bits)	Value/Description	Condition
Confirmation Code	4	Zero indicates the request was successful. Nonzero indicates failure	Shall always be present

6.2.3.65.22 DM-TKN-REQ

An HR-MS transmits a DM-TKN-REQ message to change a token for half duplex communication.

Table 763dc14 – DM-TKN-REQ message field description

Field	Size (bits)	Value/Description	Condition
DC Frame Number	4	Indicates a DC frame number with the dedicated channel is on the frame.	
Dedicated Channel Number	4	Indicates a number of dedicated channel with DC Frame Number.	

6.2.3.65.23 DM-TKN-RSP

An HR-MS transmits a DM-TKN-RSP message in response to a received DM-TKN-REQ.

Table 763dc15 – DM-TKN-RSP message field description

Field	Size (bits)	Value/Description	Condition
Confirmation Code	4	Zero indicates the request was successful. Nonzero indicates failure	Shall always be present

6.2.3.65.24 DM-TKN-HO

An HR-MS transmits a DM-TKN-HO message to handover a token for half duplex communication

Table 763dc16 – DM-TKN-HO message field description

Field	Size (bits)	Value/Description	Condition
DCTID	24	DC Terminal Identifier. Indicate the HR-MS which takes a PTT token.	Shall always be present
DC Superframe Number	4	Indicates a DC Superframe number in which the HR-MS sends packets on the flows	

6.2.3.65.25 DM-LEST-CMD

An HR-MS transmits a DM-LEST-CMD message to establish a point-to-multipoint link.

Table 763dc17 – DM-LEST-CMD message field description

Field	Size (bits)	Value/Description	Condition
Link Change Count	4	The change count of this transaction assigned by the sender. If new transaction is started, Link Change Count is incremented by one (modulo 16) by the sender.	Shall always be present
For (i=0; i<N_Flow_Est; i++) {		N_Flow_Est is the number of flows on which the sender of this message sends MAC PDUs. Range [0..1]	
FID	4	Flow identifier assigned by the source of packets on the flow	
Traffic priority	3	0 to 7: Higher numbers indicate higher priority Default: 0	
CS Specification Parameters	8	0–15: *Reserved* 16: Voice Codec G.729A 17–255: *Reserved*	
MAC Header Type	1	Indicates whether AGMH or SPMH is presented at the start of MAC PDUs of the service flow. 0 : AGMH (Advanced Generic MAC Header) 1 : SPMH (Short-Packet MAC header) default value is 0.	
}			

6.2.3.65.26 DM-LREL-CMD

An HR-MS transmits a DM-LREL-CMD message to release one-way point-to-point and point-to-multipoint links.

Table 763dc18 – DM- LREL-CMD message field description

Field	Size (bits)	Value/Description	Condition
Link Release Command Code	8	Used to indicate the purpose of this message 0x00: Link release command. 0x01–0xff: *Reserved*	Shall always be present

6.2.3.65.27 DM-DSA-CMD

An HR-MS transmits a DM-DSA-CMD message to create a new service flow on one-way point-to-point and point-to-multipoint links.

Table 763dc19 – DM- DSA-CMD message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	The change count of this transaction assigned by the sender. If new transaction is started, FID Change Count is incremented by one (modulo 16) by the sender.	Shall always be present
For (i=0; i<N_Flow_Est; i++) {		N_Flow_Est is the number of flows on which the sender of this message sends MAC PDUs. Range [0..1]	
FID	4	Flow identifier assigned by the source of packets on the flow	
Traffic priority	3	0 to 7: Higher numbers indicate higher priority Default: 0	
CS Specification Parameters	8	0–15: *Reserved* 16: Voice Codec G.729A 17–255: *Reserved*	
MAC Header Type	1	Indicates whether AGMH or SPMH is presented at the start of MAC PDUs of the service flow. 0 : AGMH (Advanced Generic MAC Header) 1 : SPMH (Short-Packet MAC header) default value is 0.	
}			
Reserved			

6.2.3.65.28 DM-DSC-CMD

An HR-MS transmits a DM-DSC-CMD message to change the parameters of an existing service flow on one-way point-to-point and point-to-multipoint links.

Table 763dc20 – DM-DSC-CMD message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	The change count of this transaction assigned by the sender. If new transaction is started, FID Change Count is incremented by one (modulo 16) by the sender.	Shall always be present

6.2.3.65.29 DM-DSD-CMD

An HR-MS transmits a DM-DSD-CMD message to delete an existing service flow on one-way point-to-point and point-to-multipoint links.

Table 763dc21 – DM-DSD-CMD message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	The change count of this transaction assigned by the sender. If new transaction is started, FID Change Count is incremented by one (modulo 16) by the sender.	Shall always be present
For (i=0; i<N_Flow_Rel; i++) {		N_Flow_Rel is the number of flows which the sender of this message is to release. Range [0..12]	
FID	4	Flow identifier assigned by the source of packets on the flow	
}			

6.2.3.65.30 DM-MES-CMD

An HR-MS transmits a DM-MES-CMD message to request a radio measurement and reporting the measurement results on one-way point-to-point and point-to-multipoint links.

Table 763dc22 – DM-MES-CMD message field description

Field	Size (bits)	Value/Description	Condition

6.2.3.65.31 DM-RCHG-CMD

An HR-MS transmits a DM-RCHG-CMD message to change communication resource on one-way point-to-point and point-to-multipoint links.

Table 763dc23 – DM-RCHG-CMD message field description

Field	Size (bits	Value/Description	Condition

	)		
For (i=0; i<N_Resource_Change; i++) {		N_Resource_Change is the number of dedicated channels Range [0..12]	
Old DC Frame Number	4	Indicates a DC frame number with the dedicated channel is on the frame.	
Old Dedicated Channel Number	4	Indicates a number of dedicated channel with DC Frame Number.	
New DC Frame Number	4	Indicates a DC frame number with the dedicated channel is on the frame.	
New Dedicated Channel Number	4	Indicates a number of dedicated channel with DC Frame Number.	
}			

1

2

3 **6.2.3.65.32 DM-TKN-ADV**

4 An HR-MS transmits a DM-TKN-ADV message to advertise status of a token for half duplex
5 communication on a point-to-multipoint link

6

7 **Table 763dc24 – DM-TKN-REQ message field description**

Field	Size (bits)	Value/Description	Condition
DC Frame Number	4	Indicates a DC frame number with the dedicated channel is on the frame.	
Dedicated Channel Number	4	Indicates a number of dedicated channel with DC Frame Number.	
PTT Token Status	4	Zero indicates that the PTT token is available. Nonzero indicates unavailable	

8

9

10 **6.2.3.65.33 RTS**

11 An HR-MS transmits a RTS message to reserve a dedicated channel in a distributed way.

12

13 **Table 763dc25 – RTS message field description**

Field	Size (bits)	Value/Description	Condition
DCTID	24	Indicates a sending HR-MS address	
DCTID or DCGID	24	Indicates a receiving HR-MS (Group) address.	
Target address type	1	Indicates type of target address. 0: DCTID 1: DCGID	
Piggyback message indicator	1	Indicates whether a control message is piggybacked or not 0: no piggyback	

		1: MAC control message	
Reserved	6		
MAC control message	*variable*	MAC control messages in Table 1216 except RTS and CTS messages.	Present if Piggyback message indicator is set to 1

6.2.3.65.34 CTS

An HR-MS transmits a CTS message in response to RTS message.

Table 763dc26 – CTS message field description

Field	Size (bits)	Value/Description	Condition
DCTID	24	Indicates a sending HR-MS address	
DCTID	24	Indicates a receiving HR-MS address.	
Piggyback message indicator	1	Indicates whether a control message is piggybacked or not 0: no piggyback 1: MAC control message	
Reserved	7		
MAC control message	*variable*	MAC control messages in Table 1216 except RTS and CTS messages.	Present if Piggyback message indicator is set to 1

6.2.3.65.35 DM-MCHG-CMD

An HR-MS transmits a DM-MCHG-CMD (MCS Change Command) message to change MCS level of data signals on the dedicated channel.

Table 763dc27 – DM-MCHG-CMD message field description

Field	Size (bits)	Value/Description	Condition
New MCS Level	8	Indicates new MCS level	

6.2.3.65.36 HR-CEX-CMD Message

Table 763fn1 – HR-CEX-CMD message field description

Field	Size (bits)	Value/Description	Condition
Superframe Number Action (n_{start})	4	LSBs of the superframe number in which the coverage-extending cycle should be started.	Mandatory
IDCell	10	IDCell (SA-Preamble index *Idx* and subcarrier set index *n*) to be used by the scheduled HR-MS (If Two-Phase Discovery is used, the HR-BS should assign pre-access SA-Preamble to groups of HR-MS based on their service characteristics.)	Mandatory
Number of Preamble-only Superframes (m_{prep})	4	Indicates the number of superframes (starting from superframe with number n_{start}) in which the scheduled HR-MS should broadcast PA/SA-Preambles. No NCI shall be transmitted during these superframes.	Mandatory
Number of Superframes with NCI (m_{nci})	2	Indicates the number of superframes (starting from superframe with number $n_{start} + m_{prep}$) that the scheduled HR-MS transmits NCI.	Mandatory
Start RP code information of the S-RCH	4		
Number of Ranging Opportunities (m_{rng})	2	Indicates the number of ranging opportunities given to outside-of-coverage HR-MS	Mandatory

Subframe offset of Ranging Channel	2	Indicates the subframe offset (O_{SF}) of the RCH allocation. The range of values is $0 \le O_{SF} \le 3$	Mandatory
HR-MS Preamble Timing Advance (t_{adv})	[TBD]	Timing advanced that should be used by scheduled HR-MS when transmitting PA/SA-Preamble, relative to the beginning of each frame as seen by the scheduled HR-MS.	Optional
HR-MS EIRP	5	Unsigned integer from 1 to 64 in units of 1 dBm, where 0b00000 = 0dBm and 0b11111 = 31dBm	Mandatory
HR-MS to HR-MS Feedback Resource Index	11	512 FFT size: 0 in first2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.	Optional
HR-MS to HR-BS Report Resource Index	11	512 FFT size: 0 in first2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.	Optional
If(Two-Phase Discovery){			
Threshold	[TBD]		
If(Post-access parameters to be pre-assigned){			

Post *IDCell*	10	*IDCell* (SA-Preamble index *Idx* and subcarrier set index *n*) to be used by the scheduled HR-MS after detecting ranging signal above a specified threshold. (The HR-BS should assign post-access SA-Preamble such that they will be unique within physical proximity.)	
Number of Superframes with NCI (m_{nci})	2	Indicates the number of superframes (starting from superframe with number n_{start} + m_{prep}) that the scheduled HR-MS transmits NCI.	Mandatory
Start RP code information of the S-RCH	4		
Number of Ranging Opportunities (m_{rng})	2	Indicates the number of ranging opportunities given to outside-of-coverage HR-MS	Mandatory
Subframe offset of Ranging Channel	2	Indicates the subframe offset (O_{SF}) of the RCH allocation. The range of values is $0 \le O_{SF} \le 3$	Mandatory
}			
}			

6.2.3.65.37 HR-CEX-RNG-ACK Message

Table 763fn2 – HR-CEX-RNG-ACK message field description

Field	Size	Value/Description	Condition

	(bits)		
For (*j* = 0; *j* < N_Received_Codes; *j*++) {			
Ranging Preamble Code Index	2	Ranging preamble code index received in this ranging opportunity.	
Ranging Status	2	Indicate whether ranging preamble code or UL burst is received within acceptable limits by forwarding HR-MS. 0b00 = success 0b01 = continue 0b10 = abort	
If(Ranging Status == 0b00 or 0b01){			
Adjustment parameters indication (API)	3	Bit 0: Time offset adjustment indication. Bit 1: Power level adjustment indication Bit 2: Frequency offset adjustment indication	
If(API Bit 0==0b1) {			
Timing offset adjustment	15	Amount of time required to adjust AMS transmission (in units of 1/Fs). MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB=0b0. LSB 14 bits represent timing offset	

		correction value of [1..16384] that corresponds to 0x0000 ~ 0x3FFF, respectively. The AMS shall advance its transmission time if the value is negative (i.e., MSB = 0b1) and delay its transmission time if the value is positive (i.e., MSB = 0b0).	
}			
If(API Bit 1==0b1) {			
Power level adjustment	4	Power level adjustment that expresses the change in power level (in multiples of 1 dB) that the AMS shall apply to its current transmission power for initial ranging. MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB=0b0. LSB 3 bits represent power level correction value of [1..8] that corresponds to 0b000 ~ 0b111, respectively	
}			
If (API Bit 2==0b1) {			
Frequency offset adjustment	9	Frequency offset adjustment. Relative change in transmission frequency. The correction is 2% of the subcarrier	

		spacing (*f*) multiplied by the 9-bit number interpreted as a signed integer. MSB 1bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB=0b0. LSB 8 bits represent frequency offset correction value of [1..256] that corresponds to 0x00 ~ 0xFF, respectively	
}			
}			

6.2.3.65.38 AAI-DMMS-ADV

An HR-BS transmits an AAI-DMMS-ADV message to advertise an MS list for HR-MS forwarding.

6.2.3.65.39 AAI-DMLU-REQ

A forwarding HR-MS transmits an AAI-DMLU-REQ message to update a MS list for HR-MS forwarding.

6.2.3.65.40 AAI-DMLU-RSP

An HR-BS transmits a AAI-DMLU-RSP message in response to a received AAI-DMLU-REQ.

6.2.3.65.41 BBE-REQ

An HR-BS transmits a BBE-REQ message to notify HR-MSs of backbone connection availability on unicast control connection.

6.2.3.65.42 BBE-RSP

An HR-MS transmits a BBE-RSP message in response to a received BBE-REQ.

6.2.3.65.43 BBD-REQ

An HR-BS transmits a BBD-REQ message to notify HR-MSs of backbone connection unavailability on unicast control connection.

6.2.3.65.44 BBD-RSP

An HR-MS transmits a BBD-RSP message in response to a received BBD-REQ.

6.2.3.65.45 BBE-CMD

An HR-BS transmits a BBE-CMD message to broadcast backbone connection availability.

6.2.3.65.46 BBD-CMD

An HR-BS transmits a BBD-CMD message to broadcast backbone connection unavailability.

6.2.3.65.47 AP-NBR-REQ

Table 763pm1 -- 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.
}			

6.2.3.65.48 AP-NBR-REP

Table 763pm2 – 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	
}			

6.2.3.65.49 AAI-MG-IND

An HR-BS providing multicast service transmits AAI-MG-IND message in the beginning of available interval in multicast indication cycle. This message indicates whether there is DL multicast traffic for a specific multicast group. There are two formats for the AAI-MG-IND

message, indicated by the indication type field. If the indication type is set to "0," this message indicates the multicast traffic transmission offset directly. Otherwise, MGIND bitmap indicates a subgroup of multicast group and further information will be transmitted by AAI-MT-IND described in 6.2.3.65.48.

Table 763mc1 – AAI- MG-IND message field description

Field	Size (bits)	Value/Description	Condition
Indication type	1	0b0: full MGID indication 0b1: MGIND+MTIND indication	
If (Indication type == 0b0) {			
For(i=0; i<Num_MGID;i++){		Num_MGID is the number of multicast group to indicate multicast traffic is transmitting. Range : 0 ~ 32	
Multicast Group ID	12		
Offset of multicast traffic	4	frame number offset in which the ABS transmits multicast traffic	Shall be present
}			
}Else if(Indication type == 0b1) {			
MGIND bitmap	M(=64)	Indicates whether a corresponding subgroup of multicast group has multicast data to transmit, where the N-th bit of MGIND bitmap [MSB corresponds to N = 0] corresponds to MGIDs in a subgroup (2^{12}×N/M to 2^{12}× (N+1)/M-1) 0: There is no multicast traffic for any of multicast groups in the corresponding multicast subgroup 1: There is multicast traffic for at least one multicast group in the corresponding multicast subgroup	
For (*i*=0; *i*<L; *i*++) {			L equals the number of bits in MGIND bitmap whose bit is set to 1.
Offset of multicast MT-IND message	2	frame number offset in which the ABS transmits MT-IND message 0b00: first frame of this superframe 0b01: second frame of this superframe 0b10: third frame of this superframe 0b11: fourth frame of this superframe	Shall be present
}			
}			
}			

6.2.3.65.50 AAI-MT-IND

AAI-MT-IND message shall be transmitted at the offset indicated by AAI-MG-IND message described in 6.2.3.65.49. Based on the action code in AAI-MT-IND message, HR-MSs may

receive multicast traffic or perform network entry or exit sleep mode.

Table 763mc2 – AAI- MT-IND message field description

Field	Size (bits)	Value/Description	Condition
For (*i*=0; *i*<L; *i*++) {			L equals the number of bits in MGIND bitmap whose bit is set to 1 and whose offset is the current frame. The bits are ordered by the shortest MSB of MGIND bitmap.
MTIND bitmap	K(=64)	Indicates whether a corresponding multicast group has multicast data to transmit, where the Q-th bit of MTIND bitmap [MSB corresponds to Q = 0] corresponds to MGID in the subgroup (Q is the value of logK LSB of multicast group and MSB logM of multicast group is defined by MG-IND message). 0: There is no multicast traffic for the corresponding multicast group 1: There is multicast traffic for the corresponding multicast group	Shall be present
For(j=0;j<P; j++){			P equals the number of bits in MTIND bitmap whose bit is set to 1.
Action code	3	If bit0 = 1, perform network entry or exit sleep mode If bit1 = 1, perform ranging procedure with ranging purpose indication is set to HR multicast service flow update(=0b1110) If bit2 = 1, receiving multicast traffic	
If (action code bit2 == 1){			
Offset of multicast traffic	4	frame number offset in which the ABS transmits multicast traffic	Shall be present
}			
}			
}			

6.2.4 Construction and transmission of MAC PDUs

6.2.5 AAI Security

6.2.5.1 Security Architecture

6.2.5.2 Key Management protocol (PKMv3)

6.2.5.2.2 S A management

[Change Section 6.2.5.2.2 as indicated:]

A security association (SA) is the set of information required for secure communication between ABS and AMS. SA is shared between ABS and its client AMS across the AAI network. SA is identified using an SA identifier (SAID). The SA is applied to the respective ~~unicast~~ flows. ~~AAI supports unicast static SA only and~~ SAs are mapped one-by-one to cryptographic methods. (See Table 764.)

SA is used to provide keying material for unicast transport/control flows. Once an SA is mapped to an unicast transport flow, the SA is applied to all the data exchanged within the unicast transport flow. Multiple flows may be mapped to the same SA. The indication to the receiver that the MAC PDU is encrypted or not is indicated by the FID 0x1 and 0x0 in AGMH respectively for unicast control flows, and indicated by the SA that is associated to FID in AGMH and SPMH for unicast transport flows.

The Flow ID in the AGMH is used to indicate whether the PDU contains a control message encrypted based on security level. Whether each control message is encrypted or not is decided based on the security level with which the message is associated (see Table 683).

If authorization is performed successfully, SAID 0x01 is applied to flows for confidentiality and integrity, and SAID 0x02 for confidentiality only. In addition, for secure multicast service, SAID 0x03 is applied to flows for confidentiality and integrity. SAID 0x01 shall be applied to control flows as defined in Table 680. However, SAID 0x02 can be applied to transport flows only if the AMS and ABS decide to create an unprotected transport flow, the Null SAID (i.e., SAID 0x00) is used as the target SAID. SAID 0x03 can be applied to secure multicast transport flow (see Table 764.)

Table 764 – SA mapping with protection level

Name	Name of SA	Characteristics	Usage
0x00	Null SA	Neither confidentiality nor integrity protection	For non-protected transport flow.
0x01	Primary SA	Confidentiality & integrity protection(i.e., AES-CCM mode is applied)	Encryption for unicast control/ transport flow.
0x02		Confidentiality protection only(i.e., AES-CTR mode is applied)	Encryption for unicast transport flow
0x03	Multicast SA	Confidentiality & integrity protection	Encryption for multicast transport flow
~~0x03~~0		*Reserved*	

x04-0xFF			

Using PKM protocol, AMS shares the SAs' keying material with ABS. An SA contains keying material that is used to protect unicast flows (see SA context in 6.2.5.4.4).

6.2.5.2.2.1 Mapping of flows to SAs

The following rules for mapping flows to SAs apply:

a) The unicast transport flows shall be mapped to an SA.

b) The multicast or broadcast transport flows shall be mapped to Null SA.

c) The encrypted unicast control flows shall be mapped to the Primary SA.

d) The non-encrypted unicast control flows shall not be mapped to any SA.

e) The broadcast control flows shall not be mapped to any SA.

f) The secure multicast transport flows shall be mapped to any multicast SA.

The actual mapping is achieved by including the SAID of an SA in the DSA-xxx messages together with the FID.

Control messages which the Primary SA is applied to are predetermined according to the control message protection level depending on each control message type and its usage. Even if non-encrypted unicast control flows shall not be mapped to any SA, CMAC-based integrity protection can be applied per control message according the control message protection level (see 6.2.5.3.3).

6.2.6 MAC HO procedure

6.2.6.1 Network topology acquisition

6.2.6.1.1 Network topology advertisement

6.2.6.1.2 AMS scanning of neighbor ABSs

[Change the 4th paragraph of Section 6.2.6.1.2 (page 360) as indicated:]

An AMS selects the scanning candidate ABSs using the information obtained from the ABS through messages such as AAI-NBR-ADV and AAI-SCN-RSP. The ABS should prioritize the scanning candidates (e.g. based on the reliability) by presenting the candidate ABSs in descending order of priority in the AAI-SCN-RSP message. To support high reliability,

scanning candidates may be ordered based on whether the MAC context is shared or not between serving infrastructure station and neighbor station. The AMS should follow the order of scanning as suggested in the AAI-SCN-RSP message.

6.2.6.2 Trigger condition definition

[Change Table 775 as indicated:]

Table 775—Trigger description

Name	Length (Bits)	Value
Number of Triggers	6	Total number of triggers that are defined

for (*i* = 0; *i* □□Number of Triggers;
 	
i++) {		

Number of conditions	2	The number of conditions that are included in this trigger (see For-loop description below this table). When more than one conditions are included, this trigger is referred to as a complex trigger and is the logical AND combination of all the included conditions.
ABS type	4	ABS type of T-ABS for this Trigger definition: (Any, Macro ABS, Macro Hot-zone ABS, Femto ABS, etc.). A value representing "any" means this trigger applies to all T-ABSs. This value of ABS type field shall be ignored for triggers with Type= 0x3 or the Function=0x5 or 0x6 in Table 776. 0x0: Any 0x1: Macro ABS 0x2: Macro Hot-zone ABS 0x3: Femto ABS 0x4: R1 BS 0x5–0xF: *Reserved*

Name	Length (Bits)	Value
HR Multimode indication	2	Indicates whether neighbor BR/RS is HR-MS acting as BS/RS or HR-BS acting as RS 0b00: neighbor BS is neither HR-MS acting as BS/RS nor HR-BS acting as RS 0b01: neighbor BS is HR-MS acting as BS/RS 0b10: neighbor BS is HR-BS acting as RS 0b11: *reserved*
Trigger averaging parameter for intra-FA measurement	8	The averaging parameter used for averaging this trigger metric according to Equation (177) for T-ABS (which is defined in ABS type). If not present, the default trigger averaging parameter in AAI-SCD is used 0x0: 1 0x1: 1/2 0x2: 1/4 0x3: 1/8 0x4: 1/16 0x5: 1/32 0x6: 1/64 0x7: 1/128 0x8: 1/256 0x9: 1/512 0xA to 0xFF: *Reserved*
……	…	……

[Change Table 776 as indicated:]

Table 776— Description of the trigger type/function/action

Name	Size (Bits)	Value	Description
Type	3 (MSB)	Trigger metric type:	

		0x0: CINR 0x1: RSSI 0x2: RTD 0x3: Number of consecutive PSFHs missed 0x4: RD 0x5–0x7: *Reserved*	
Function	3	Computation defining trigger condition: 0x0: *Reserved* 0x1: Metric of neighbor ABS is greater than absolute value 0x2: Metric of neighbor ABS is less than absolute value 0x3: Metric of neighbor ABS is greater than S-ABS metric by relative value 0x4: Metric of neighbor ABS is less than S-ABS metric by relative value 0x5: Metric of S-ABS greater than absolute value 0x6: Metric of S-ABS less than absolute value 0x7: (For AMS in CA mode): Number of neighbor ABS's carriers (whose CINR/RSSI is greater than absolute value) is higher than threshold value. The threshold value for the "Number of neighbor ABS's carriers" can be AMS specific or ABS specific. (For AMS specific, the threshold value is defined as the number of AMS's active carriers. For ABS specific, the threshold value is configured by the S-ABS and signaled through AAI-MC-ADV.)	Function 0x1-0x4 not applicable for RTD/RD trigger metric When type 0x1 is used together with function 0x3 or 0x4, the threshold value shall range from –32 dB (0x80) to +31.75 dB (0x7F). When type 0x1 is used together with function 0x1, 0x2, 0x5, 0x6, or 0x07, the threshold value shall be interpreted as an unsigned byte with units of 0.25 dB, such that 0x00 is interpreted as –103.75 dBm and 0xFF is interpreted as –40 dBm Type 0x3 can only be used together with function 0x5 or function 0x6. Function 0x7 can only be used with Action 0x1 and applicable for AMS in CA mode. Non-CA mode AMS shall ignore this trigger.
Action	3 (LSB)	Action performed upon trigger condition is satisfied: 0x0: *Reserved* 0x1: Respond on trigger with AAI-SCN-REP 0x2: Respond on trigger with AAI-HO-REQ 0x3: Respond on trigger with AAI-SCN-REQ 0x4: Declare ABS unreachable:	Actions 0x3 and 0x6 ~~applies~~ apply only to Functions 0x5 and 0x6. Action 0x4: If this ABS is the SABS (meaning the AMS is unable to maintain communication with the ABS), AMS sends AAI-HO-IND with HO Event Code 0b10 to the S-ABS and proceeds as specified

		0x5: Cancel HO ~~0x6 and 0x7: *Reserved*~~ 0x6: Initiate mode change 0x7: *Reserved*	in 6.2.6.3.4. If this ABS is a TABS, the AMS needs not take immediate action when this trigger condition is met for a single ABS. The AMS shall act only when this condition is met for all T-ABSs included in AAI-HOCMD during HO execution. The specific actions are described in 6.2.6.3.4.

6.2.6.3 HO procedure

6.2.6.3.3 HO preparation

[Change Section 6.2.6.3.3 as indicated:]

During HO preparation phase, the S-ABS communicates with T-ABS(s) selected for HO. The T-ABS may obtain AMS information from the S-ABS via backbone network for HO optimization. If the either serving infrastructure station or target infrastructure station has no backhaul connection but they communicate each other via relay link, target infrastructure station may obtain MS information from the serving infrastructure station via their relay link in DL/UL relay zone using AAI-L2-XFER message described in 6.2.3.30 for HO optimization.

During HO preparation phase, the T-ABS may allocate a dedicated ranging code and dedicated ranging opportunity to the AMS via the S-ABS through the AAI-HO-CMD message. The dedicated code shall be used by the AMS if the ABS assigns the dedicated ranging code and the Ranging Initiation Deadline has not expired. If the AMS fails to perform CDMA HO ranging successfully until the expiration of Ranging Initiation Deadline, it shall stop using the dedicated code but randomly pick a ranging code if further ranging is necessary. The T-ABS shall select the dedicated ranging code from the group of codes that are allocated for dedicated handover ranging purpose.

Upon reception of the AAI-HO-CMD message, the AMS should pre-update STID and AK to be used in the T-ABS. Any mismatched system information between AMS and the T-ABS, if detected, may be provided to the AMS by the S-ABS during HO preparation. For AMS-initiated HO, the S-ABS may detect an S-SFH mismatch between SFH information of a candidate T-ABS as known to the AMS and the SFH information of the candidate T-ABS as known to the S-ABS by referring to the AAI-NBR-ADV change count of AMS included in AAI-HO-REQ message. In such case, the ABS should include mismatching delta SFH information in AAI-HO-CMD, or it should reject the HO.

For ABS-initiated HO, the AMS may detect an SFH mismatch by referring to the S-SFH change count included in the AAI-HO-CMD message. The AMS should not select a T-ABS

with mismatched SFH information. If the AMS does not have the latest SFH for any of the T-ABSs included in AAI-HO-CMD, the AMS should cancel the HO by sending AAI-HO-IND with HO event code 0b11 and SFH mismatch indication 0b1. When the S-ABS receives the AAI-HO-IND with HO event code 0b11 and SFH mismatch indication 0b1, it may send another AAI-HO-CMD message that includes all up-to-date delta SFH information of each recommended T-ABS. If pre-allocated at T-ABS, the S-ABS shall include an STID to be used at T-ABS in the AAI-HO-CMD message. The pre-allocated STID shall be used in the T-ABS by the AMS to communicate with the T-ABS. The FIDs that are used to distinguish different connections are not updated during the handover procedure. If the network decides that certain service flow will not exist at the T-ABS, this shall also be indicated in the AAI-HO-CMD message.

If HO_Reentry_Mode is set to 1, the S-ABS shall negotiate with the T-ABS the relevant HO parameters, hereby referred to as the "EBB HO parameters". In the single carrier handover case, the EBB HO parameters include HO_Reentry_Interleaving_Interval, HO_Reentry_Interval, and HO_Reentry_Iteration for the AMS to communicate with the S-ABS during network reentry, in which case HO_Reentry_Interleaving_Interval and HO_Reentry_Interval must be no less than the minimal values defined in AMS capability. The HO_Reentry_Interval defines the period during which an AMS performs network reentry at the T-ABS; whereas, the HO_Reentry_Interleaving_Interval defines the period during which an AMS performs normal data communication at the S-ABS after the HO_Reentry_Interval. In the multicarrier handover case, the EBB HO parameters include the carrier information in the T-ABS for the AMS performing network reentry while continuing communication with the S-ABS concurrently.

The ABS shall not set HO_Reentry_Mode to 1 unless EBB Support was declared (set to 1) by the AMS in AAI-REG-REQ. When only one T-ABS is included in the AAI-HO-CMD message, the HO preparation phase completes when S-ABS informs the AMS of its handover decision via an AAI-HO-CMD message. When multiple T-ABSs are included in the AAI-HO-CMD message, the HO preparation phase completes when the AMS informs the ABS of its T-ABS selection via an AAI-HO-IND message with HO Event code 0b00. The AAI-HO-CMD message shall include Action Time of each T-ABS for the AMS to start network reentry. The AAI-HO-CMD message shall also include a Disconnect Time Offset for each AMS to calculate disconnect time for each candidate T-ABS. Disconnect time is the time when the S-ABS expects the AMS to switch to a T-ABS. At disconnect time the S-ABS will stop sending DL data and stop providing any regular UL allocations to the AMS. When HO_Reentry_Mode is set to 0, the Disconnect Time will be (Action time - Disconnect Time Offset). For HO_Reentry_Mode = 1, Disconnect time will be (Action time + Disconnect Time Offset).

The S-ABS may reject an AMS-initiated handover by transmitting the AAI-HO-CMD message with mode set to 0b10. In this case, the S-ABS shall not include any candidate T-ABS if the T-ABS is unavailable as described in 6.2.6.3.4. If the ABS requested as a candidate T-ABS, which is available but the ABS does not have MS information, ABS list may be included in AAI-HO-CMD message with REQ-Duration. After REQ-Duration

expires, AMS is allowed to perform handover. After transmitting the AAI-HO-CMD message, S-ABS may transmit MS information to the ABS via backbone network or relay link. If the ABS chooses to accept the handover, it shall set Mode in the AAI-HO-CMD to 0b00. If the ABS sets Mode to 0b00, it may include zero, one, or more T-ABS in the AAI-HO-CMD message. The ABS may include candidate T-ABSs requested by the AMS in the AAI-HO-REQ message and/or alternate candidate ABSs not requested by the AMS. If the serving ABS and those candidate T-ABSs do not share the MS information, the serving ABS may transmit MS information to candidate T-ABSs via backbone network or relay link when either serving infrastructure station or target infrastructure station has no backhaul connection but they communicate each other via relay link. When MS information is transmitted via relay link, AAI-L2-XFER message including MS information is used in DL/UL relay zone.

The AAI-HO-CMD message indicates if the static and/or dynamic context and its components of the AMS are available at the T-ABS.

All on-going DSx transaction during HO shall be cancelled, and shall be re-started after HO completion. After an ABS receives the AAI-HO-REQ message from an AMS, the ABS shall not send any DSx message to the AMS until HO completion. After an ABS sends the AAI-HO-CMD message to an AMS, the ABS shall not send any DSx message to the AMS until HO completion.

6.2.7 Persistent scheduling in the Advanced Air Interface

6.2.8 Multicarrier operation

6.2.9 Group resource allocation

6.2.10 Connection management

[Insert the following text before the last paragraph of 6.2.10:]

Multicast connections are intended for reception by some specific MSs as a group. Messages sent over multicast connections are distinguished by the 16-bit CRC masking in the HR-Multicast DL Assignment A-MAP IE as specified in 6.12.9.2.1.

6.2.28 Support for multicast service

[Modify section 6.2.28 as indicated:]

Multicast service provides an efficient method for concurrent transport of DL data common to a group of users, using a common Multicast Group ID and an FID in an ABS. Multicast

service is associated with an ABS and is offered in the downlink only. Each multicast connection is associated with a service flow provisioned with the QoS and traffic parameters for that service flow. Service flows to carry multicast data are instantiated on individual AMSs participating in the service while in Connected State. During such instantiation, the AMS learns the parameters that identify the service and associated service flows.

The ABS shall use a combination of Multicast Group ID and FID to provide the multicast service. The Multicast Group ID is the ID of a group that receives multicast burst and is unique to an ABS. Multicast Group ID is assigned by AAI-DSA-REQ/RSP message and changed by AAI-DSC_REQ message.

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 6.12.9 shall be provided.

6.3 Physical layer

6.3.5 Downlink control structure

6.3.5.5 DL control information elements

6.3.5.5.2 A-MAP control information elements

[Change section 6.3.5.5.2.4 as indicated:]

6.3.5.5.2.4 Assignment A-MAP IE

Table 848 describes Assignment A-MAP IE Types.

Table 848 – Assignment A-MAP IE Types

A-MAP IE Type	Usage	Property
0b0000	DL Basic Assignment A-MAP IE	Unicast
0b0001	UL Basic Assignment A-MAP IE	Unicast
0b0010	DL Subband Assignment A-MAP IE	Unicast
0b0011	UL Subband Assignment A-MAP IE	Unicast
0b0100	Feedback Allocation A-MAP IE	Unicast
0b0101	UL Sounding Command A-MAP IE	Unicast
0b0110	CDMA Allocation A-MAP IE	Unicast

0b0111	DL Persistent Allocation A-MAP IE	Unicast
0b1000	UL Persistent Allocation A-MAP IE	Unicast
0b1001	Group Resource Allocation A-MAP IE	Multicast
0b1010	Feedback Polling A-MAP IE	Unicast
0b1011	BR-ACK A-MAP IE	Multicast
0b1100	Broadcast Assignment A-MAP IE	Broadcast/Multicast
0b1101	~~Reserved~~ HR-Multicast DL Assignment A-MAP IE	~~NA.~~ Multicast
0b1110	Reserved	NA.
0b1111	Extended Assignment A-MAP IE	NA.

CRC Mask

A 16-bit CRC is generated based on the randomized contents of assignment A-MAP IE and is masked by 16-bit CRC mask using the bitwise XOR operation.

The 16-bit masked CRC is constructed using a 1 bit masking prefix, a 3 bit message type indicator, and 12 bit Masking Code as described in Table 849.

Table 849 – Description of CRC Mask

Masking Prefix (1 bit MSB)	**Remaining 15 bit LSBs**	
0b0	*Type Indicator*	*Masking Code*
	0b000	12 bit STID or TSTID
	0b001	Refer to Table 850
	0b010	Refer to Table 851
	0b011	12 bit TWDC address for direct communications
0b1	15 bit RA-ID: The RA-ID is derived from the AMS' random access attributes (i.e., superframe number (LSB 5bits), frame_index (2 bits), preamble code index for ranging or BR (6 bits) and opportunity index for ranging or BR (2 bits)) as defined below: RA-ID = (LSB 5bits of superframe number | frame_index | preamble_code_index | opportunity_index)	

……

Table 851 – Description of Masking Code for type indicator 010

Decimal Value	Description
4095	Used to mask Broadcast A-MAP IE for multicast assignment
Others	~~Reserved~~ 12 bit MGID is used to make HR-Multicast DL Assignment A-MAP IE for high reliable multicast assignment

6.4 Support for Femto ABS

6.5 Multi-BS MIMO

6.6 Support for relay

6.7 Support for self-organization

6.8 Support for location-based service (LBS)

6.9 Support for Enhanced Multicast Broadcast Service

6.10 Support for Advanced Air Interface in LZone

6.11 Global values

[Insert the following new clause 6.12:]

6.12 Support for HR-Network

[Dummy Figure 900]

[Dummy Table 1200]

6.12.1 Multi-mode operation

6.12.1.1 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 in 6.12.1.1.1. The procedure applies to both STR and TTR relay modes.

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

When supporting TTR relay mode, the affected HR-BS maintains connectivity with its subordinate HR-RS by performing a dual-role BS/RS operation described in 6.12.1.1.2.2.

6.12.1.1.1 Relay link establishment

The HR-BS having no connection to backhaul transmits MM-ADV message with action type = 0b100 described in 6.2.3.70 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 6.2.15 and 6.6.2.10. 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) Obtain DL/UL parameters (from SuperFrameHeader)

c) Perform ranging

d) Basic capability negotiation, if needed

e) Authorization, authentication, and key exchange, if needed

f) Registration with the HR-BS, if needed

g) Configuration operational parameters including initiating relay link using AAI-MMRS-REQ/RSP and AAI-ARS-CONFIG-CMD messages

To establish relay link with another HR-BS (serving HR-BS), HR-BS having no connection to backhaul transmits AAI-MMRS-REQ message described in 6.2.3.71 including relay mode, i.e., either TTR or STR mode. In response to AAI-MMRS-REQ, the serving HR-BS transmits AAI-MMRS-RSP message described in 6.2.3.72 to inform whether the request is accepted or rejected. Upon receiving the AAI-MMRS-RSP message, the affected HR-BS starts establishing the relay link with serving HR-BS immediately or retransmits AAI-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 AAI-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 6.12.4.

To support handover as a part of robustness against SPOF as described in 6.12.7.2, an indication of whether MAC context information of the subordinate HR-MS is being shared by infrastructure stations shall be transmitted to HR-MS.

For the case of affected HR-BS establishing a TTR relay link with a serving HR-BS, the following actions shall be carried out:

- In the AAI-MMRS-REQ message, the affected HR-BS reports its required switching gaps *BSTTG* and *BSRTG* to the serving HR-BS. Here, *BSTTG* is the minimum transmit-to-receive turnaround gap while *BSRTG* is the minimum receive-to-transmit turnaround gap required at the affected HR-BS. Based on the values of *BSTTG* and *BSRTG*, the two HR-BSs agree on the timing advance T_a of the frame boundary of the affected HR-BS, relative to that of the serving HR-BS. The affected HR-BS can propose a value for T_a in the AAI-MMRS-REQ message, and the serving HR-BS can reply with a confirmed T_a value in the AAI-MMRS-RSP message. With the values of *BSTTG*, *BSRTG*, and T_a, the two HR-BSs calculate shared values for the switching time *R-TTI* and *R-RTI*, based on the following equations:

  $$R\text{-}TTI = 0 \text{ if } RTD/2 + T_a > BSTTG \text{ and } R\text{-}TTI = T_s \text{ if } RTD/2 + T_a < BSTTG$$

  and

  $$R\text{-}RTI = 0 \text{ if } T_a - RTD/2 > BSRTG \text{ and } R\text{-}RTI = T_s \text{ if } T_a - RTD/2 < BSRTG,$$

  where *RTD* is the round trip delay between the affected HR-BS and the serving HR-BS and T_s is the OFDMA symbol duration.
- Also included in the AAI-MMRS-REQ message sent by affected HR-BS is the proposed dual-mode switching pattern (T_{bs}, T_{rs}), as described in 6.12.1.1.2.2. This pattern shall be confirmed in the corresponding AAI-MMRS-RSP message sent by the serving HR-BS.

As an alternative to what described above, certain parts of the signaling between the two HR-BSs can be carried out through backhaul, i.e., prior to (and in preparation for) the backhaul failure at affected HR-BS.

6.12.1.1.2 Maintaining connectivity for subordinate HR-RS

6.12.1.1.2.1 Affected HR-BS supporting STR relay mode

When supporting STR relay mode, the affected HR-BS maintains its base station functionality and therefore continues to support its subordinate HR-RS.

6.12.1.1.2.2 Affected HR-BS supporting TTR relay mode

The affected HR-BS shall be able to switch between BS Operation and RS Operation in a frame-by-frame basis. The role switching pattern shall be periodic, with the dual-role HR-BS assuming BS Operation for T_{bs} consecutive frames, followed by RS Operation for T_{rs} consecutive frames. T_{bs} can be set to 0. The values of T_{bs} , T_{rs} shall be negotiated between the affected/dual-role HR-BS and its serving HR-BS. This negotiation can happen when the affected/dual-role HR-BS starts associating with the serving HR-BS, e.g., through AAI-MMRS-REQ/RSP and AAI-ARS-CONFIG-CMD messages. The configuration can be altered during operation, e.g., through AAI-MMRS-REQ/RSP, AAI-ARS-CONFIG-CMD. The dual-role operation of affected HR-BS is illustrated in Figure 901.

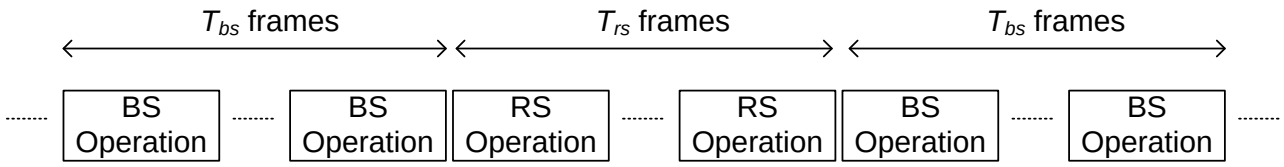


Figure 901—Affected/dual-role HR-BS performs BS/RS role-switching in a frame-by-frame basis.

The operation of affected HR-BS in each mode, i.e., BS Operation and RS Operation, depends on the value of switching interval *R-TTI* and is specified in 6.12.1.1.2.2.1 and 6.12.1.1.2.2.2.

6.12.1.1.2.2.1 When *R-TTI = 0*

When *R-TTI = 0*, the affected HR-BS shall keep its original PHY-layer configuration, including *IDCell*, frame configuration, and FFR pattern. In addition, the affected HR-BS shall set the *AAI_Relay_zone_AMS_allocation_indicator* field in AAI-SCD and AAI-ARS-CONFIG-CMD messages to 0b0. The operation of the affected/dual-role HR-BS can be described as follows.

In BS Operation Mode:

- The affected/dual-role HR-BS shall only communicate with its subordinate MS/AMS/HR-MS/HR-RS stations and shall not be available to receive from or transmit to its serving HR-BS.

- The manner in which the affected/dual-role HR-BS control and communicate with its subordinate HR-MSs/HR-RSs shall be the same as that of a normal HR-BS. The serving HR-BS is not expected to know the specific configuration of the dual-role HR-BS during BS Operation. When the affected/dual-role HR-BS transmits to or

receives from its subordinate MS/AMS/HR-MS/HR-RS during BS Operation, it does so independently to the serving HR-BS.

- The affected/dual-role HR-BS transmits control messages regarding its role-switching behaviors toward its subordinate HR-RSs. Essentially, these role-switching messages tell the subordinate HR-RSs when the HR-BS will switch to RS Operation and what are the specific behaviors of the HR-BS during RS Operation.

In RS Operation Mode:

- The affected/dual-role HR-BS shall communicate with the serving HR-BS and with the subordinate MS/AMS/HR-MS. It may or may not communicate with its subordinate HR-RS during this mode of operation. The frame structure of the affected HR-BS is divided into DL Access zone, DL Relay zone, UL Access zone, and UL Relay zone. Note that as *R-TTI = 0*, no time gap need to be inserted into the last OFDM symbol of the last subframe in the DL Access zone.

- As the affected HR-BS still transmits the same SA-Preamble, the subordinate MS/AMS/HR-MS are oblivious to the mode change of the affected HR-BS. The affected HR-BS continue to transmit to its subordinate MS/AMS/HR-MS in the DL Access zone, and receive from its subordinate MS/AMS/HR-MS in the UL Access zone.

- The affected/dual-role HR-BS receives from and transmits to its serving HR-BS during the DL Relay zone and UL Relay zone, respectively. The PHY-layer configuration for DL/UL Relay zones shall be sent by the serving HR-BS toward the affected HR-BS in the AAI-ARS-CONFIG-CMD message.

- The affected/dual-role HR-BS can communicate with its subordinate HR-RSs in the following ways:

    - The affected/dual-role HR-BS can instruct its subordinate HR-RSs to transmit UL data during the DL Relay zone, i.e., when the affected/dual-role HR-BS also receives from the serving HR-BS. While doing so, the affected/dual-role HR-BS shall instruct the transmitting HR-RSs to use the same PHY-layer configuration as used in the DL Relay zone of the serving HR-BS.

    - The affected/dual-role HR-BS can instruct its subordinate HR-RSs to receive DL messages during the UL Relay zone, i.e., when the affected/dual-role HR-BS also transmits to the serving HR-BS. While doing so, the HR-BS shall instruct the transmitting HR-RSs to use the same PHY-layer configuration as used in the UL Relay zone of the serving HR-BS. Furthermore, if an *R-RTI* = T_s is inserted in the first OFDMA symbol of the first subframe of the UL Relay zone, the dual-role HR-BS shall let its subordinate HR-RSs to be aware of this insertion.

6.12.1.1.2.2.2 When *R-TTI = T_s*

When *R-TTI = T_s*, the affected HR-BS shall change its *IDCell*, i.e., it shall pick one of the SA-Preamble sequences (and possibly new preamble carrier index) that are allocated for TTR ARS. The operation of the affected/dual-role HR-BS can be described as follows.

In BS Operation Mode:

- The affected/dual-role HR-BS shall only communicate with its subordinate AMS/HR-MS/HR-RS stations and shall not be available to receive from or transmit to its serving HR-BS.

- The affected/dual-role HR-BS shall behave like a normal HR-RS for its subordinate AMS/HR-MS. The subordinate AMS/HR-MS detect the SA-preamble transmitted by the affected/dual-role HR-BS and classify the HR-BS as a TTR HR-RS. In response, the affected HR-BS shall only transmit DL data toward its subordinate AMS/HR-MS in the DL Access zone and receive UL data from its subordinate AMS/HR-MS in the UL Access zone. Furthermore, as *R-TTI = T_s*, the affected HR-BS shall not transmit on the last OFDM symbol of the last subframe in the DL Access zone. The information regarding *R-TTI = T_s* shall be transmitted in the SFH SP2 toward subordinate AMS/HR-MS.

- The affected HR-BS shall behave like a normal HR-BS for its subordinate HR-RS. That means the affected HR-BS shall transmit to its subordinate HR-RS in the DL Relay zone, and receive from its subordinate HR-RS in the UL Relay zone.

In RS Operation Mode:

- The affected HR-BS shall communicate with its serving HR-BS. It may or may not communicate with its subordinate HR-RS in the mode of operation, and the specifications are as described in 6.12.1.1.2.2.

- The affected/dual-role HR-BS shall behave like a normal HR-RS for its subordinate AMS/HR-MS. The subordinate AMS/HR-MS detect the SA-preamble transmitted by the affected/dual-role HR-BS and classify the HR-BS as a TTR HR-RS. In response, the affected HR-BS shall only transmit DL data toward its subordinate AMS/HR-MS in the DL Access zone and receive UL data from its subordinate AMS/HR-MS in the UL Access zone. Furthermore, as *R-TTI = T_s*, the affected HR-BS shall not transmit on the last OFDM symbol of the last subframe in the DL Access zone. The information regarding *R-TTI = T_s* shall be transmitted in the SFH SP2 toward subordinate AMS/HR-MS.

6.12.1.1.3 Relay link configuration

During establishing relay link, serving HR-BS transmits AAI-ARS-CONFIG-CMD message described in 6.2.3.57 to configure PHY layer parameter set including superframe number indicating the time to establish relay link.

While HR-BS is maintaining relay link, the serving HR-BS shall send AAI-ARS-ESI

message described in 6.2.3.58 in the DL relay zone when the essential system information in SFH is changed. The HR-BS also shall send AAI-ARS-CONFIG-CMD message in the DL relay zone when PHY layer parameter needs to be reconfigured.

HR-BS acting as relay may transmit AAI-MM-ADV message with action type = 0b000 described in 6.2.3.70 to update PHY/MAC layer parameter after receiving AAI-ARS-ESI or AAI-ARS-CONFIG-CMD message.

6.12.1.1.4 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 AAI-MM-ADV message with action type = 0b101 described in 6.2.3.70 including expected time of backhaul link up. When receiving the AAI-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.

6.12.1.2 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.

6.12.1.2.1 Relay link establishment

To support relay function for HR-MS, HR-MS capable of relay function shall 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 AAI-MMRS-REQ message described in 6.2.3.71 including relay mode (i.e., either TTR or STR mode).

In response to AAI-MMRS-REQ, the HR-MS transmits AAI-MMRS-RSP message described in 6.2.3.72.

During establishing relay link, HR-BS transmits AAI-ARS-CONFIG-CMD message described in 6.2.3.57 to configure PHY layer parameter set including superframe number indicating the time to start acting as HR-RS.

To support handover as a part of robustness against SPOF as described in 6.12.7.2, an indication of whether MAC context information of the subordinate HR-MS is being shared

by infrastructure stations shall be transmitted to HR-MS.

6.12.1.2.2 Relay link configuration

While HR-MS is acting as relay mode, the superordinate HR-BS shall send AAI-ARS-ESI message described in 6.2.3.58 in the DL relay zone when the essential system information in SFH is changed. The HR-BS also shall send AAI-ARS-CONFIG-CMD message in the DL relay zone when PHY layer parameter needs to be reconfigured.

While an HR-MS operating as HR-RS, 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 AAI-MM-ADV message described in 6.2.3.70 to update PHY/MAC layer parameter after receiving AAI-ARS-ESI or AAI-ARS-CONFIG-CMD message.

6.12.1.2.3 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 sets Cell Bar bit to 1 in order to prevent HR-MS (re)entry and transmits AAI-MM-ADV message to transfer all subordinate HR-MSs to another infrastructure station. An HR-MS acting as RS may transmit an AAI-MMRL-REQ message described in 6.2.3.73 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 AAI-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 AAI-MMRL-RSP message described in 6.2.3.74 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 AAI-MMRL-RSP message in DL relay zone. Upon receiving the AAI-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 AAI-MMRL-RSP message in DL relay zone. Upon receiving the AAI-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 AAI-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 AAI-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.

6.12.1.3 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.

6.12.1.3.1 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 superordinate HR-BS may transmit AAI-MM-ADV message with trigger condition for which the subordinate HR-MSs capable of role changing to HR-BS shall report its status information. When the trigger condition is met, 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 message and/or AMS Battery Level Report header as described in 6.2.2.1.3.5.

After selecting the target HR-MS, the superordinate HR-BS requests the target HR-MS to change its mode to HR-BS by transmitting AAI-MMBS-REQ message. The AAI-MMBS-REQ message may include PHY operational parameters recommended by the superordinate HR-BS. If the target HR-MS accepts the request from the superordinate HR-BS to change the mode to HR-BS, it shall transmit AAI-MMBS-RSP message to the superordinate HR-BS when it is ready to start HR-BS role.

After receiving the AAI-MMBS-RSP message, the superordinate HR-BS shall transmit AAI-MMBS-CMD message to the target HR-MS to inform the action time or trigger conditions for starting as HR-BS mode. If the action time for mode change are included in the AAI-MMBS-CMD message, the target HR-MS starts the HR-BS mode operation upon expiring the action time. At the same time, the superordinate HR-BS may stop the HR-BS role in order to avoid potential interference from the target HR-MS. If the trigger type is 0b1, trigger conditions for mode change shall be included in the AAI-MMBS-CMD message and the mode change to HR-BS role starts after trigger event. One possible use is to prepare against an unforeseeable SPOF event, e.g., a HR-BS failure. The trigger shall be canceled if the target HR-MS performs a handover to other infrastructure stations.

If handover of subordinate MSs connected to the superordinate HR-BS is necessary, the superordinate HR-BS may transmit AAI-L2-XFER message which contains MS context information before sending AAI-MMBS-CMD message to the target HR-MS.

6.12.1.3.2 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 in 6.12.1.3.1.

6.12.2 Support for direct communication between HR-MSs

6.12.2.1 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 allocation allocated by HR-BS, that is called BS-controlled direct communication, is described in 6.12.2.2.

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

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 6.12.2.4.
- 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).

HR-MS direct communication using distributed resource allocation among nearby HR-MSs, that is called talk-around direct communication, is described in 6.12.2.3.

6.12.2.2 BS-controlled direct communication

6.12.2.2.1 Medium access control

6.12.2.2.1.1 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.

To enable neighbor discovery among directly associated HR-MSs (use case 1), the super-ordinate station shall instruct these directly associated HR-MSs to transmit and receive predefined signals.

6.12.2.2.1.1.1 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 registered 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.

6.12.2.2.1.2 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. When the link is first setup, two 12-bit Two-way Direct Communication (TWDC) addresses are assigned to each DC-link to facilitate the two way communication. Each HR-MS is assigned one TWDC address for identifying it as the transmitter over the DC-link. The Assignment A-MAP IE for direct communication link is CRC masked as specified in Table 849.

The TWDC address is referred in the link management messages such as link deletion and status report and resource assignment.

A security association may be setup between the two HR-MS linked by the direct communication.. The procedure for setup security association over a direct communication link is defined in section 6.12.10.2. The security association is shared by different flows over the direct communication link.

After a direct communication link is setup, flows can be setup over the direct communication link with the DSA transactions as specified in section 6.12.2.2.1.2.2. When a flow is assigned over a direct communication link, the sender and receiver shall monitor on direct communication related TWDC address 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 6.12.2.2.1.1. 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 TWDC addresses to the direct communication link and send TWDC addresses to the two HR-MSs using DC-LINK-CREATION-REQ messages. The HR-MSs shall sends back AAI-DC-LINK-CREATION-ACK for confirmation.

After receiving AAI-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 6.12.10.2.

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 6.12.2.2.1.2.2.

Figure 902 shows the procedure to setup a direct communication link between HR-MSs.

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

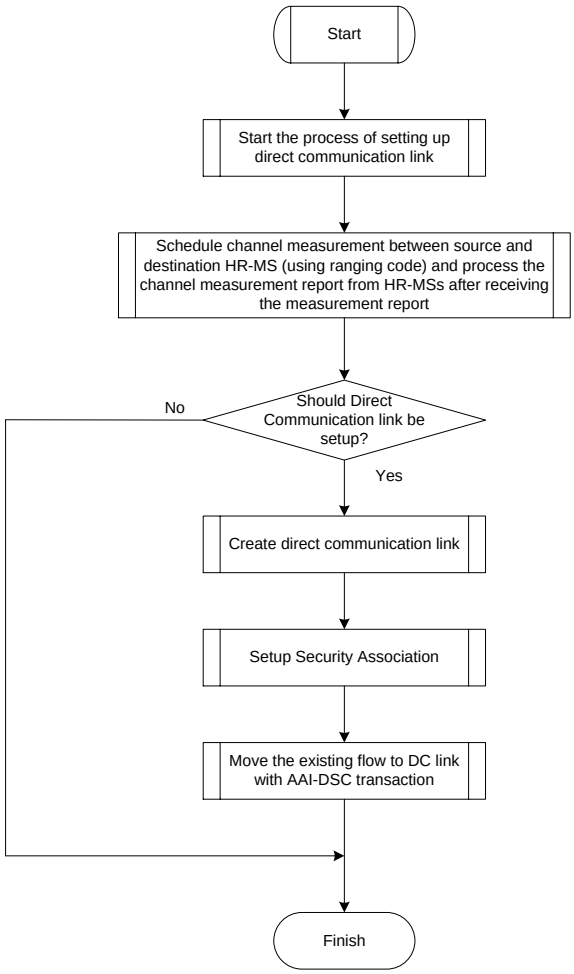


Figure 902—The overall procedure to setup direct communication

6.12.2.2.1.2.1 Direct Communication Link Management

6.12.2.2.1.2.1.1 Direct Communication Link Creation

When HR-BS creates direct communication link between two HR-MSs. It shall 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.

6.12.2.2.1.2.1.2 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.

6.12.2.2.1.2.1.3 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.

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

6.12.2.2.1.2.2 Direct communication service flow management

6.12.2.2.1.2.2.1 Direct communication service flow establishment

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 903 and described in detail in 6.12.2.2.1.2.2.1.

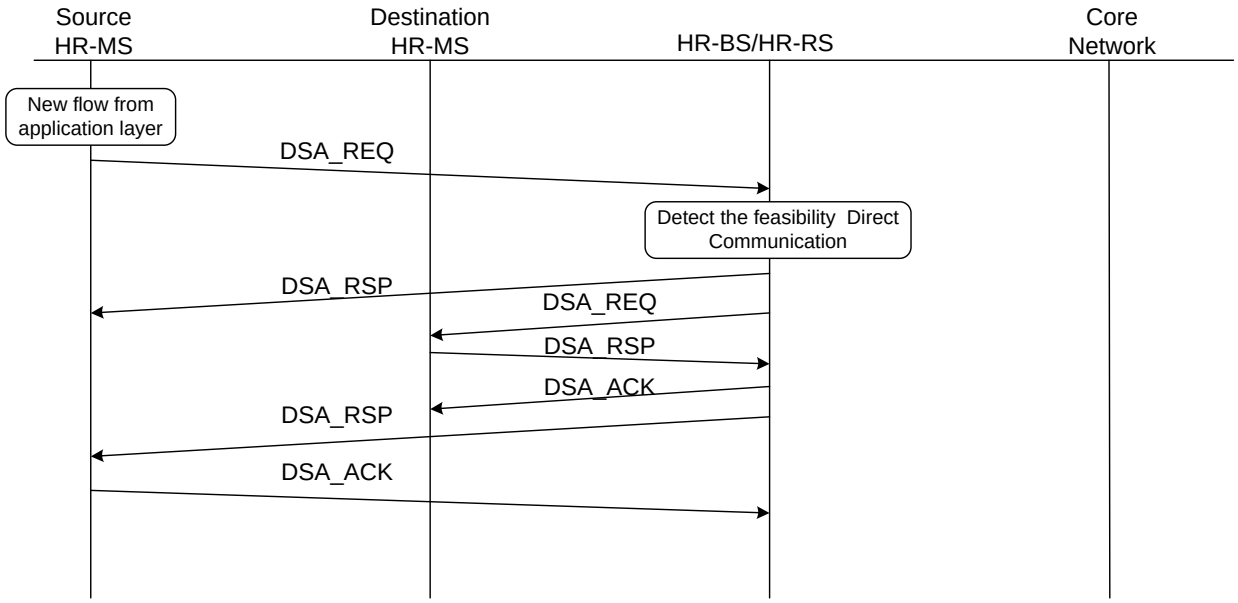


Figure 903—The establishment of direct communication between HR-MS

When receive AAI-DSA-REQ from HR-MS, if the BS already setup a direct communication link between the source and destination HR-MS and it intends to setup the flow over the direct communication link, then the HR-MS shall send an AAI-DSA_RSP to source HR-MS with CC equals to ***direct-comm-setup*** as defined in table 607 and STID of the direct communication link. At the same time, the HR-BS shall send AAI-DSA_REQ to the destination HR-MS with an indication of the direct communication flag and STID of direct communication link as specified in the table 734. The destination HR-MS shall send back a AAI-DSA-RSP with indication of accept/reject of direct communication and the HR-BS sends an AAI-DSA_ACK back to the destination HR-MS. The HR-BS shall send an AAI-DSA-RSP to the source HR-MS with indication of accept/reject of flow setup with indication of type. If direct communication setup is rejected, the flow shall be setup on the uplink in a normal way.

6.12.2.2.1.2.2.2 Dynamic Service Flow Modification and Deletion

When HR-MS initiates the service flow modification, if the modification increases the resource allocated to a flow over direct communication, then the HR-BS should hold on the transaction with source HR-MS and finish the transaction with destination and then finish the transaction with source. If the modification reduces the resource allocated to a flow, the HR-BS should finish the transaction with source and then finish the transaction with destination.

When HR-BS initiates the service flow deletion and the target flow is over a direct communication link, it should send AAI-DSD to the two HR-MS respectively. When source/destination HR-MS initiates the service flow deletion and the target flow is over a direct communication link, HR-BS should also send a AAI-DSD to the destination/source HR-MS also.

6.12.2.2.1.3 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 6.12.3.2.1.1. 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.

6.12.2.2.1.3.1 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 PA/SA-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.

6.12.2.2.1.3.2 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 PA/SA-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 inside-of-coverage HR-MS shall transmit PA/SA preambles at the first OFDMA symbols of 2^{nd} and 3^{rd} frames within each superframe. 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.

6.12.2.2.1.4 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 12-bit Two-Way Direct Multicast (TWDM) address to each HR-MS of a two-way direct communication group; each assigned TWDM address includes two non-overlapping fields, i.e., Two-way Group Identifier (TGID) and Two-way Transmitter Identifier (TTID). All HR-MSs belonging to the same two-way direct communication group share the same TGID. The TTID of the HR-MSs belonging to the same group can be the same or different.

- For each two-way direct communication group, the base station can reserve one value of TTID for itself. The base station uses the reserved TTID to transmit data/control messages to the HR-MS belonging to the two-way direct communication group;

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

- For each broadcasted Assignment A-MAP IE, the base station employs the CRC mask corresponding to Type Indicator = 0b011, as specified in Table 849. The 12 bit TWDM of the transmitting station is used in the place of TWDC.

6.12.2.2.2 Physical layer

6.12.2.2.2.1 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.

6.12.2.2.2.2 Power control for mobile to mobile communications

6.12.2.2.2.2.1 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.

6.12.2.2.2.2.2 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.

6.12.2.2.2.2.3 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

Cross link interference is handled by augmenting the PC to include SIR measured on crosslink resources

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

For power control, HR-MS shall use a modified eqn. 303:

$$SINR_{Target} = 10\log_{10}\left(\max\left(10^{SINR_{MIN}(dB)/10}, \gamma_{IoT} SIR_{DL} + \delta_{XL} SIR_{XL} - \alpha\right)\right) - \beta \times 10\log_{10}(TNS)$$

Add the following descriptors

- δ_{XL} is a fairness parameters for interference to other MS-MS transmissions , and

- SIR_{XL} is the linear ratio of the signal to interference power as received by the power controlled MS, measured on resources used for MS-MS links as determined by the BS.

6.12.2.3 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 is under HR-BS coverage.

6.12.2.3.1 Medium access control

6.12.2.3.1.1 Addressing

The HR-MS has unique addresses and logical address that identify HR-MS and connections during unicast and multicast transmission operations of talk-round direct communication.

6.12.2.3.1.1.1 DC terminal identifier (DCTID)

Each HR-MS shall have a 24-bit value that identifies a HR-MS uniquely.

6.12.2.3.1.1.2 DC group identifier (DCGID)

Each direct communication group shall have a 24-bit value that identifies a multicast group of HR-MSs uniquely for direct communication.

6.12.2.3.1.1.3 Flow identifier (FID)

Each connection is assigned a 4-bit FID that uniquely identifies the connection within the HR-MS or multicast group. FIDs are used along with a DCTID to identify a unicast control connection and unicast transport connections. FIDs are used along with a DCGID to identify a multicast control connection and multicast transport connections.

6.12.2.3.1.2 MAC PDU formats

MAC PDU formats shall be the same as described as in section 6.2.2*[with the exception of MAC PDU formats described in this section*].

6.12.2.3.1.3 MAC control messages

The peer-to-peer protocols of MAC layers in two HR-MSs communicate using the MAC control messages to perform the control plane function. MAC control messages shall be carried in a MAC PDU to be transported in a unicast control connection. In addition, the point-to-multipoint protocols of MAC layers in a multicast group of HR-MSs communicate

using MAC control messages to perform the control plane functions. Table 683 lists the MAC control messages that shall be defined in the ASN.1 format.

6.12.2.3.1.4 Security

Talk-around direct communication key is managed as described in 6.12.10.3.

6.12.2.3.1.5 Connection management

A peer-to-peer connection is a mapping between two MAC peers of HR-MSs, which is defined as a unicast connection. The unicast connection is defined in one way and identified by anDCTID and an FID.

A point-to-multipoint connection is a mapping among MAC peers of a group of HR-MSs, which is defined as a multicast connection. HR-MSs in a multicast group share the multicast connection. When an HR-MS has a right to send a packet on the multicast connection, all the other HR-MSs in the multicast group shall receive the packet from the sending HR-MS.

Two types of connections are used: control connections and transport connections. Control connections are used to carry MAC control messages. Transport connections are used to carry user data packet. These two types of connections are applicable to both unicast and multicast connections.

6.12.2.3.1.5.1 Control connections

One pair of bi-directional unicast control connections are automatically established when two HR-MSs perform two-way unicast link establishment with two-way handshake of control messages.

One multicast control connection is established when HR-MSs perform multicast link establishment multicasting one-way control message.

6.12.2.3.1.5.2 Transport connections

A unicast transport connection is unidirectional and identified by an FID between two HR-MSs. The unicast transport connection is established during the service flow creation procedure. A 4-bit FID along with sender DCTID is unique within a network.

One multicast transport connection is established and identified by an FID among a group of HR-MSs. The FID is assigned during the service flow creation procedure. A 4-bit FID along with sender DCGID is unique within a network.

6.12.2.3.1.6 Link management

HR-MS establishes a one-way unicast link of direct communication between two peer-to-peer HR-MSs.

HR-MS establishes a two-way unicast link of direct communication between two peer-to-peer HR-MSs, in which two one-way unicast links are made and work independently.

HR-MS establishes a multicast link of direct communication among a multicast group of HR-MSs.

6.12.2.3.1.6.1 Synchronization

Before link establishment, all the HR-MSs involved in direct communication shall be synchronized. The HR-MS shall acquire the PHY synchronization of direct communication on Synchronization channel. The detail synchronization procedure is described in section 6.12.2.3.2.5.

6.12.2.3.1.6.2 Link establishment

When HR-MSs need to communicate directly, the HR-MSs shall establish one of one-way unicast or two-way unicast or multicast links of direct communication. During link establishment, a transport connection shall be established so that HR-MSs communicate directly. During link establishment, multiple transport connections may be established.

Two HR-MSs establish a one-way unicast link with two-way handshake of DM-LEST-REQ/RSP messages. The DM-LEST-REQ message is piggybacked by a RTS message, which is an initial message for dedicated channel reservation. The DM-LEST-RSP message is piggybacked by a CTS message, which is in response to the RTS message.

Two HR-MSs establish a two-way unicast link which consists of two one-way unicast links. One communication of a direction uses one-way unicast signaling procedure independent to the one-way unicast signaling procedure of the opposite direction.

HR-MSs establish a multicast link with one-way DM-LEST-CMD message.

The radio resource for a dedicated channel is allocated during link establishment. A sending HR-MS shall send QoS parameters of traffic.

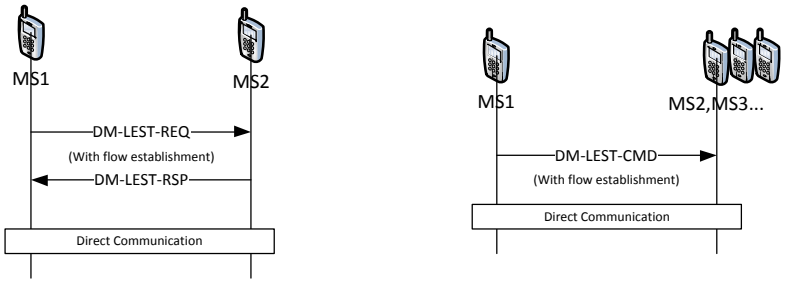


Figure 904—Message procedures of link establishment for unicast (left) and multicast (right) one-way links

6.12.2.3.1.6.3 Link release

The unicast or multicast link is terminated with link release. On link release, all the connections built on a direct communication link are terminated automatically.

Two HR-MSs release a one-way unicast link using DM-LREL-CMD messages.

Two HR-MSs release a two-way unicast link by releasing two one-way unicast links independently.

HR-MSs release a multicast link using DM-LREL-CMD message.

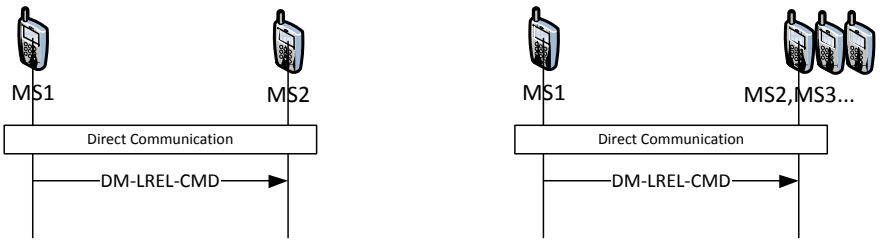


Figure 905—Message procedures of link release for unicast (left) and multicast (right) one-way links

6.12.2.3.1.7 QoS management

QoS concept of direct communication shall be the same as described as in section 6.2.12 with the exception of QoS described in this section.

6.12.2.3.1.7.1 Service Flow Management

Service flows may be created, changed, or deleted. This is accomplished through MAC management messages referred to as DM-DSA-CMD, DM-DSC-CMD, and DM-DSD-CMD messages. The DM-DSA-CMD message creates a new service flow. The DM-DSC-CMD message changes an existing service flow. The DM-DSD-CMD message deletes an existing service flow.

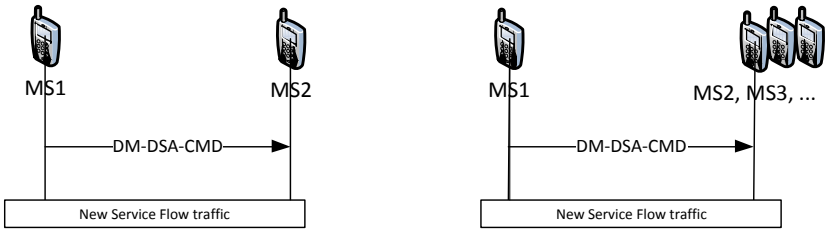


Figure 906—Message procedures of dynamic service flow addition for unicast (left) and multicast (right) one-way links

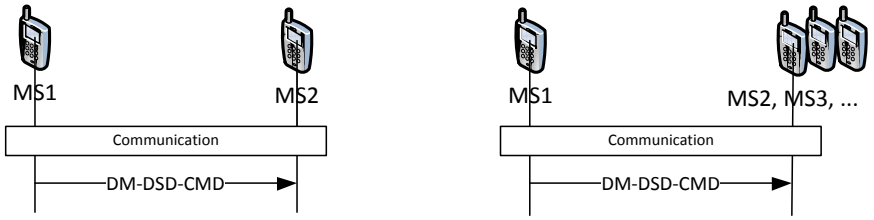


Figure 907—Message procedures of dynamic service flow deletion for unicast (left) and multicast (right) one-way links

6.12.2.3.1.8 Token management

When an HR-MS has a token, the HR-MS sends packets on a shared link for half-duplex transmission. The DM-TKN-HO message passes the token over to other HR-MS.

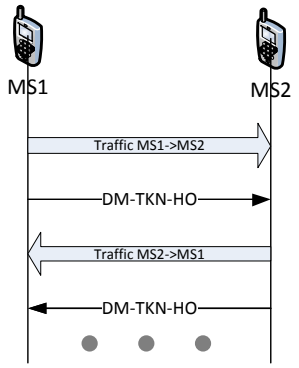


Figure 908—Message procedures of token management for unicast one-way link

If the receiving HR-MS requests the token, TKN-REQIND code on supplementary channel is sent to the sending HR-MS. If accepting it, the sending HR-MS send DM-TKN-HO message to pass the token over to the receiver HR-MS in response to TNK-REQIND code. When the receiving HR-MS gets the token, it becomes the sending HR-MS and sends packets on the dedicated channel.

For multicast one-way link, an HR-MS requests a token by sending DM-TKN-REQ message. If the sending HR-MS accepts the token request, it sends DM-TKN-RSP message in response to the DM-TKN-REQ message. DM-TKN-REQ/RSP messages are sent in a frame that the sending HR-MS does not send data packets.

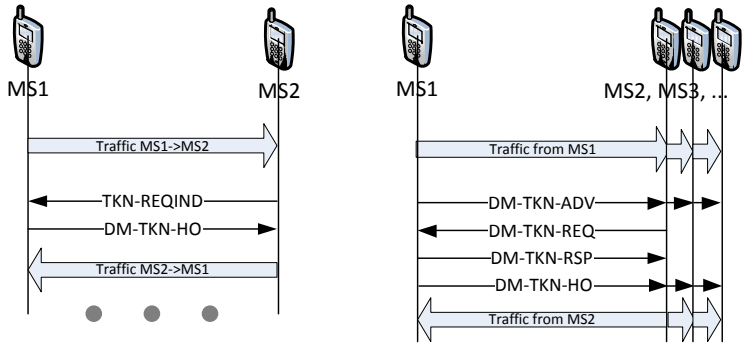


Figure 909—Message procedures of token management with token request for unicast (left) and multicast (right) one-way links

6.12.2.3.1.9 Resource management

When a receiving HR-MS needs to change resource, the HR-MS requests it to the sending HR-MS. The receiving HR-MS recommends a candidate resource at least and the sending HR-MS may use new resource to send packets toward the receiving HR-MS.

When a receiving HR-MS needs to change transmission modulation, the HR-MS requests it to the sending HR-MS.

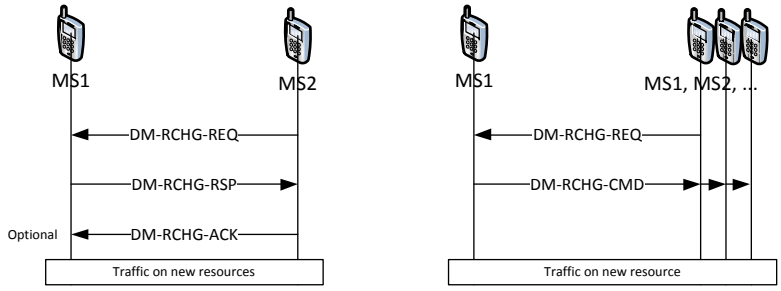


Figure 910—Message procedures of resource management for unicast and multicast links

6.12.2.3.1.10 Measurement

An HR-MS requests that the receiving HR-MS measures signals and interferences on resources and the measured values are reported periodically or at a trigger event. The sending HR-MS sends the DM-MES-CMD messages. The receiving HR-MS sends the DM-MES-REP message or CQI report on supplementary channel in response to DM-MES-CMD message.

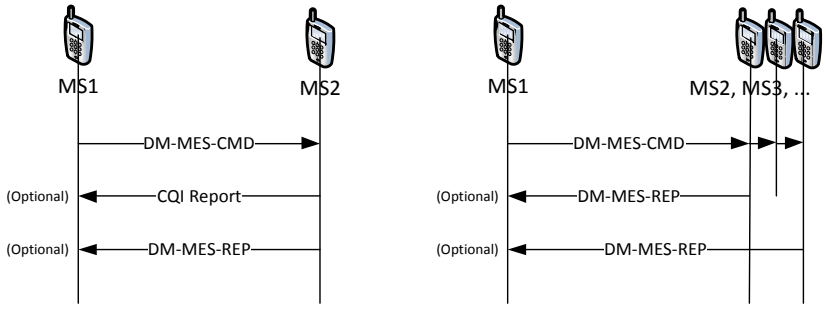


Figure 911—Message procedures of measurement for unicast (left) and multicast (right) links

6.12.2.3.1.11 Support for two hop communication

6.12.2.3.2 Physical layer

6.12.2.3.2.1 Frame structure

6.12.2.3.2.1.1 Resources for talk-around direct communication

For talk-around direct communication, two types of infra-structure communication resources are dedicatedly assigned:

- Common Direct Mode Zone (CDMZ): set of PRUs in the uplink infra-structure communication resources with fixed size and positions which are commonly assigned to all cells (must be CRU)
- Common Direct Mode Zone Extended (CDMZ-E): set of PRUs in the downlink infra-structure communication resources with fixed size and positions which are commonly assigned to all cells (must be CRU)
- Cell Specific Direct Mode Zone (CSDMZ): additionally assigned direct-mode resource blocks independently assigned by each HR-BS (CRU or DRU) and information to receive cell specific direct mode region can be obtained from common direct mode zone

Figure 912 shows an example of talk-around direct communication resource allocation. In the figure, some part of uplink infra structure resources are assigned for CDMZ, some part of downlink infra-structure resources are assigned for CDMZ-E, and some part of uplink and downlink infra structure communication resources are assigned for CDMZ. By assigning the same physical resources for CDMZ and CDMZ-E the following benefits can be obtained:

- Reduce the overhead of control channels to transmit allocation information of resources for direct-mode communication
- Reduce the computation complexity and power to obtain synchronization for direct communication, specially for the HR-MSs in the outside of HR-BS coverage

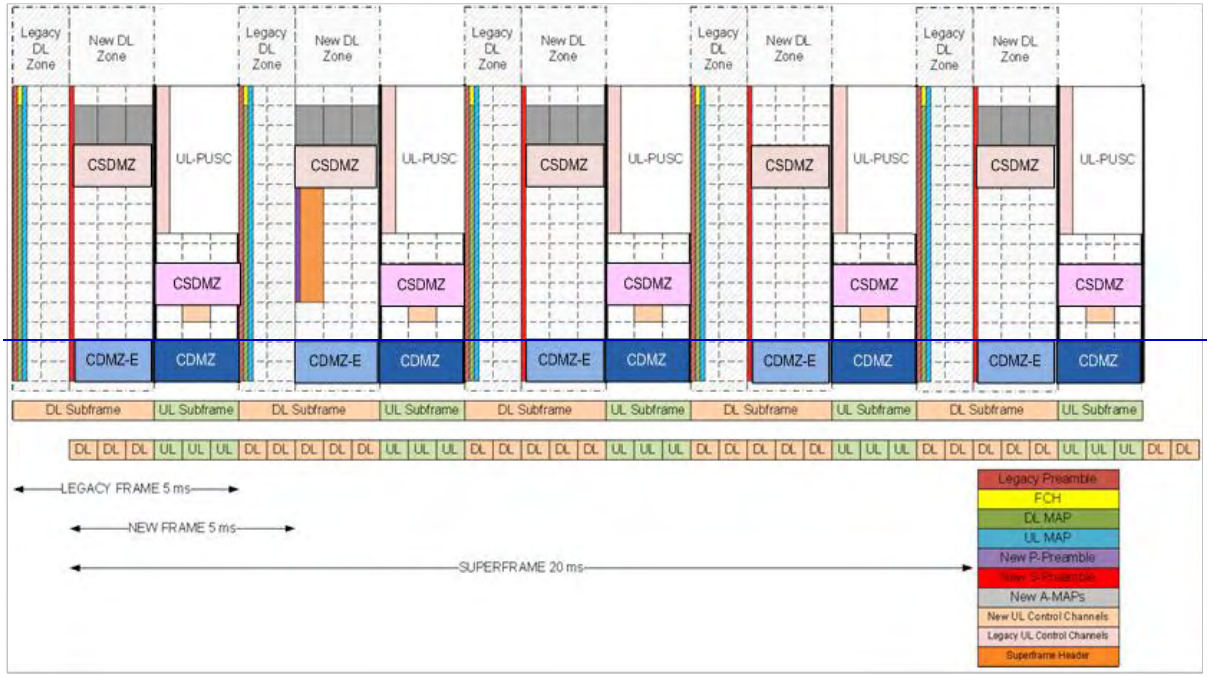


Figure 912—An example of talk-around direct communication resource allocation

The highest four PRUs of uplink resources are assigned for Common Direct Mode Zone (CDMZ). For FFT size = 512, PRU 20, 21, 22, 23 are assigned for CDMZ, for FFT size = 1024, PRU 44, 45, 46, 47 are assigned for CDMZ, and for FFT size = 2048, PRU 92, 93, 94, 95 are assigned for CDMZ. The highest four PRUs of downlink resources are assigned for Common Direct Mode Zone Extended(CDMZ-E). For FFT size = 512, PRU 20, 21, 22, 23 are assigned for CDMZ-E, for FFT size = 1024, PRU 44, 45, 46, 47 are assigned for CDMZ-E, and for FFT size = 2048, PRU 92, 93, 94, 95 are assigned for CDMZ-E. The resources for Cell Specific Direct Mode Zone (CSDMZ) are multiple of four PRUs, and determined by each HR-BS independently and the assignment information is transmitted in the CDMZ.

6.12.2.3.2.1.2 Frame structure for CDMZ

Logical frame of CDMZ is composed by collecting all resources of CDMZ in a superframe as shown in. In the example, there are three uplink subframes for each 5msec frame.

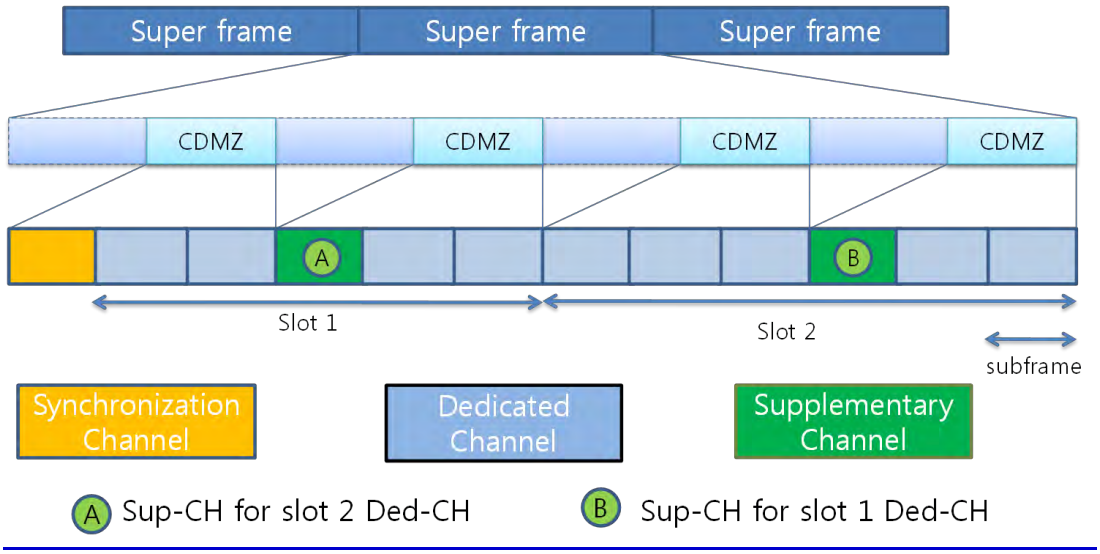


Figure 913—An example of common direct mode logical frame construction

There are three physical channels for CDMZ:

- Synchronization Channel (Sync-CH)
- Dedicated Channel(Ded-CH)
- Supplementary Channel(Sup-CH)

The first subframe of the CDMZ logical frame is occupied by synchronization channel. All the HR-MSs receives the synchronization signal on the Sync-CH except HR-MSs transmitting the Sync-CH. The HR-MSs are synchronized to the received synchronization signal if the signal timing has priority to HR-MS's synchronization timing itself. The details of timing priority is FFS. Some HR-MSs sends the synchronization signal on the Sync-CH at selected subframes. HR-MS selects its slots for sending synchronization timing in distributed way. The details of how to select is FFS. The synchronization channel is composed of two parts: synchronization channel preamble part (P-SCH1) and synchronization message part (P-SCH2). The synchronization channel preamble part is used for acquiring time and frequency synchronization, and synchronization sequence part is used for transmitting SYNC-CH IE which includes frame structure information, hop count, transmitter ID et. al. The detailed design of synchronization channel is described in 6.12.2.3.2.2.

Resources excluding the first subframe assigned for Sync-CH are assigned for Ded-CH and Sup-CH. If there are $N_{subframe\_per\_fame}$ subframes in a 5ms frame, ($N_{subframe\_per\_fame}$ +1)-th subframe and ($3N_{subframe\_per\_fame}$ +1)-th subframe are assigned for Sup-CH and the other resources are assigned for Ded-CH.

A dedicated channel is a physical channel to send direct communication packets for two HR-MSs or a group of HR-MSs. An HR-MS sends a packet on one or more than one dedicated subchannels and the other HR-MSs receives the packet on it. If two HR-MSs and a group of HR-MSs are involved, the transmissions are unicast and multicast, respectively. The

resources for dedicated channel is divided into small size sub-blocks (mRB: mini-Resource Block), as shown in Figure 914. One mRB is composed of 6 subcarriers-by-6 OFDM symbols, and there are 12 mRBs for each subframe (4PRU/ 1/3 PRU = 12). In the figure 914, mRB *i*-*j* denotes *j*-th mRB in the *i*-th subframe. A dedicated subchannel is composed of a collection of 12 mRBs distributed across the entire frequency region in the slot.

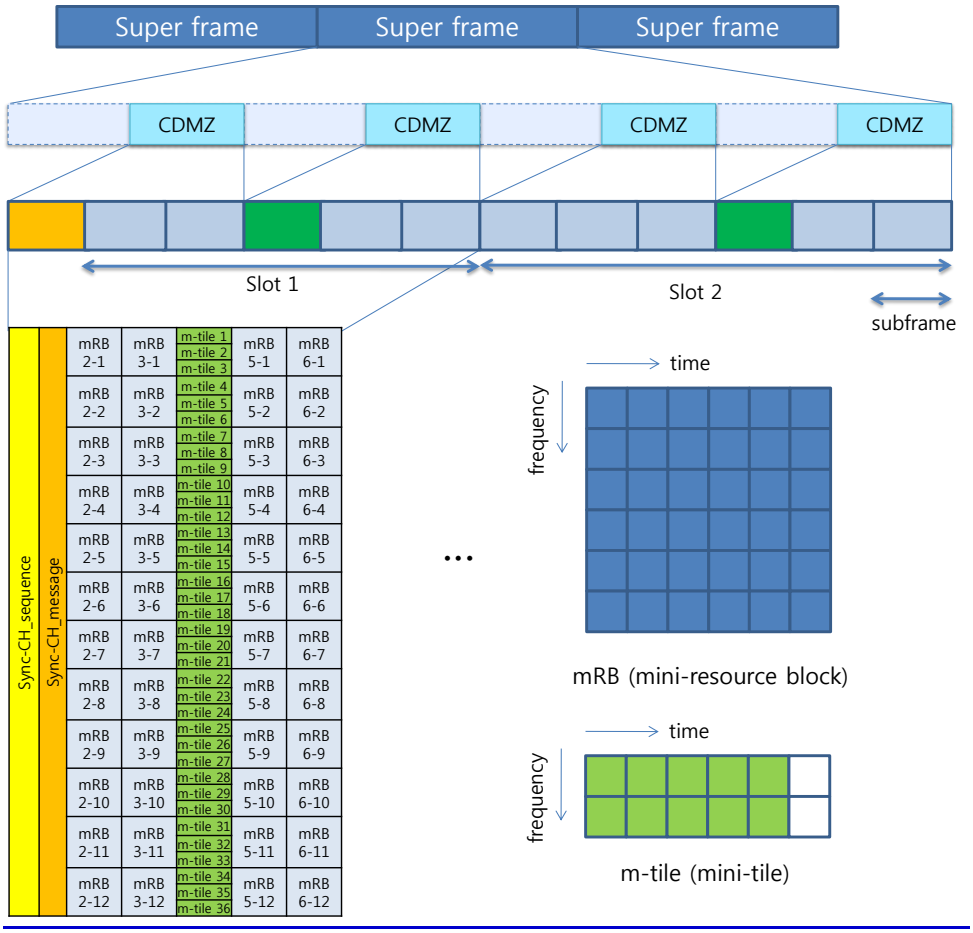


Figure 914—An example of CDMZ resource segmentation and construction of mRBs and m-tiles (3 UL subframes/ 5msec frame)

A supplementary sub-channel is one-to-one mapped with a dedicated sub-channel. As shown in Figure 913, Sup-CH for Ded-CH in slot 1 is located in slot 2, and Sup-CH for Ded-CH in slot 2 is located in slot 1. By using the supplementary sub-channel, the following indication of MAC messages transmission, PHY signalings and short feedback messages related with the corresponding dedicated subchannel are transmitted.

- MAC messages: indication of MAC messages e.g. RTS, CTS for corresponding dedicated subchannel
- PHY signalings: periodic ranging sequence et. al.
- Short feedback messages: ACK, NAK, CQI et. al.

A subframe for supplementary sub-channel is divided into 36 mini-tiles as shown in Figure 914, and a mini-tile is composed of 2 subcarriers-by- 5 OFDM symbols. Since all HR-MSs should listen the supplementary channels, to obtain Tx. And Rx. Switching time, no signal is transmitted in the last OFDM symbol of supplementary channel (6th OFDM symbol). The details of Sub-CH design are discussed in described in *6.12.2.3.2.4*

6.12.2.3.2.1.3 Frame structure for CDMZ-E and CSDMZ

The frame structure for CDMZ-E and CSDMZ is an extension of the frame structure of CDMZ. The only difference is that there is no Sync-CH in the CDMZ-E and CSDMZ. As shown in Figure 915, The first subframe is assigned for Ded-CH. If 4 more than four PRUs are assigned for CSDMZ (multiples of 4), a CSDMZ frame is composed by four PRUs in the UL or DL resources, and there are multiple CSDMZ frames. For example, if eight DL PRUs and four UL PRUs are assigned for CSDMZ, there are two CSDMZ frames in the DL resources, and one CSDMZ frame in the UL resource.

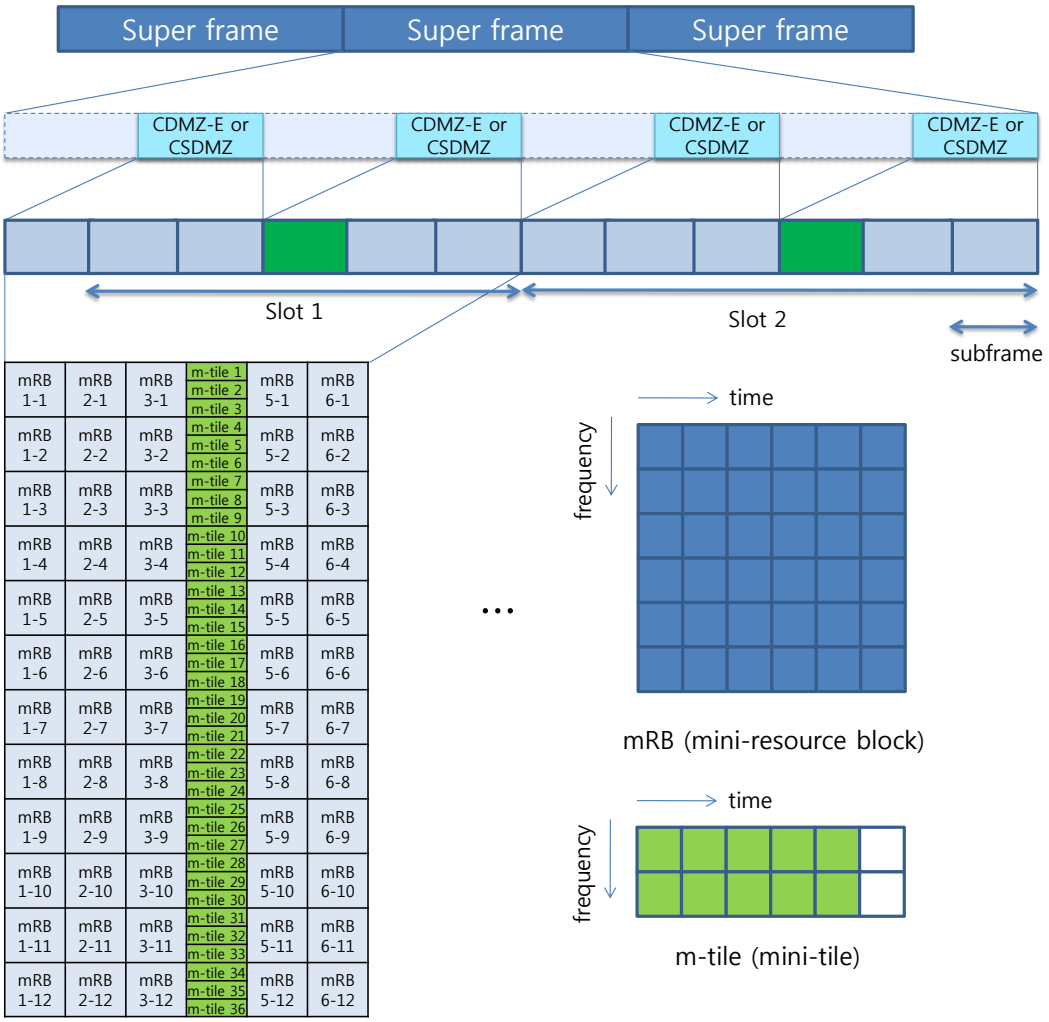


Figure 915 – An example of CDMZ-E or CSDMZ resource segmentation and construction of mRBs and m-tiles (3 UL subframes/ 5msec frame)

6.12.2.3.2.1.4 Construction of dedicated subchannels for each TDC frame

For a TDC frame, if there are $N_{subframe\_per\_fame}$ subframes in a 5ms frame, a logical TDC frame is composed of $4N_{subframe\_per\_fame}$ subframes, and resources for Ded-CH are divided into dedicated subchannels. The number of dedicated subchannels in slot 1 and 2 are summarized in the Table 1201, and Table 1202. A dedicated subchannel is composed of 12 mRBs distributed across the entire four PRUs in the slot.

Table 1201 – The number of dedicated sub-channels according to $N_{subframe\_per\_fame}$ (CDMZ)

$N_{subframe\_per\_fame}$	The number of dedicated sub-channels in the slot 1 ($N_{ded\text{-}subchannel,1}$)	The number of dedicated sub-channels in the slot 2 ($N_{ded\text{-}subchannel,2}$)	Total number of dedicated sub-channels ($N_{ded\text{-}subframe}$)
2	2	3	5
3	4	5	9
4	6	7	13
5	8	9	17

Table 1202 – The number of dedicated sub-channels according to $N_{subframe\_per\_fame}$ (CDMZ-E and CSDMZ)

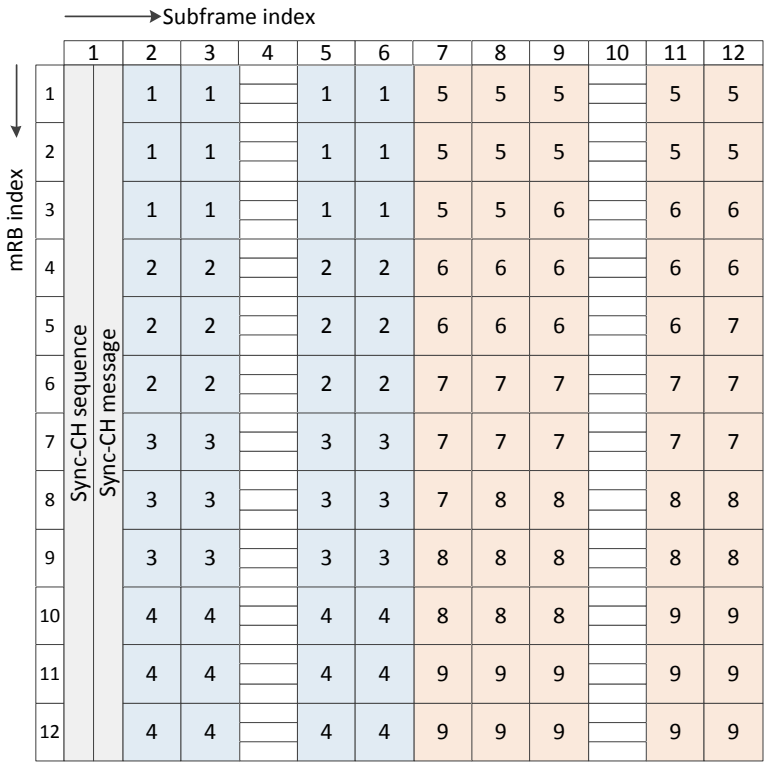
$N_{subframe\_per\_fame}$	The number of dedicated sub-channels in the slot 1 ($N_{ded\text{-}subchannel,1}$)	The number of dedicated sub-channels in the slot 2 ($N_{ded\text{-}subchannel,2}$)	Total number of dedicated sub-channels ($N_{ded\text{-}subframe}$)
2	3	3	6
3	5	5	10
4	7	7	14
5	9	9	18

mRBs for each dedicated subframe are assigned by the following assignment method:

-Step 1: For each slot 12 successive mRBs are temporally assigned from subframe 1 to subframe $N_{ded\text{-}subframe,1}$ in slot 1, and from subframe $N_{ded\text{-}subchannel,1}+1$ to subframe $N_{ded\text{-}subchannel,1} + N_{ded\text{-}subchannel,2}$ in slot 2, in time first manner.

-Step 2: For each subframe mRBs are permuted by using the permutation sequence generated by using the method in 6.3.4.3.3 with parameters of M=12, and SEED = 343*subframe index.

Figure 916 shows an example of mRB assignment for dedicated subchannels, when $N_{subframe\_per\_fame} = 3$, $N_{ded\text{-}subchannel,1} = 4$, and $N_{ded\text{-}subframe,2}=5$.



mRB index \ Subframe index	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1		1	1	5	5	5		5	5	
2	1	1		1	1	5	5	5		5	5	
3	1	1		1	1	5	5	6		6	6	
4	2	2		2	2	6	6	6		6	6	
5	2	2		2	2	6	6	6		6	7	
6	2	2		2	2	7	7	7		7	7	
7	3	3		3	3	7	7	7		7	7	
8	3	3		3	3	7	8	8		8	8	
9	3	3		3	3	8	8	8		8	8	
10	4	4		4	4	8	8	8		9	9	
11	4	4		4	4	9	9	9		9	9	
12	4	4		4	4	9	9	9		9	9	

Step 1: temporal assignment

Sync-CH sequence \ Sync-CH message	1	2	3	4	5	6	7	8	9	10	11	12
1	3	2		1	4	5	8	8		7	7	
2	4	3		4	1	6	7	9		9	6	
3	2	4		2	1	9	6	6		8	5	
4	4	3		2	1	5	8	7		9	7	
5	2	1		3	2	6	9	7		5	5	
6	4	1		1	3	5	6	8		5	7	
7	3	4		3	2	7	9	6		6	9	
8	1	4		3	4	7	7	5		9	8	
9	2	1		2	4	8	5	6		7	8	
10	3	3		4	3	8	5	5		6	6	
11	1	2		4	2	7	8	9		8	9	
12	1	2		1	3	9	5	8		6	9	

Step 2: permutation in the subframe

Figure 916 – An example of mRB assignment for supplementary subchannels when $N_{subframe\_per\_fame}$ = 3, $N_{ded\text{-}subchannel,1}$ = 4, and $N_{ded\text{-}subchannel,2}$=5.

6.12.2.3.2.1.5 Construction of supplementary subchannels for each TDC frame

There are 36 mini-tiles for supplementary subchannels. For the *n*-th supplementary subchannel corresponding to the *n*-th dedicated subchannel, four mini-tiles with indices of mod(mini-tile index-1, 9)+1 = mod(*n*-1, 9)+1 in the different slot are assigned. For example, the 5-th supplementary subchannel is composed of mini-tile 5, 14, 23, and 32, and the 12-th supplementary subchannel is composed of mini-tile 3, 12, 21, and 30.

6.12.2.3.2.2 Synchronization channel

The Synchronization channel is used for frequency and time synchronization among HR-MSs involved in direct communications. The location of the synchronization is located at fixed position within dedicated resource reserved by HR-BS.

When an HR-MS transmits any channels for direct communication between HR-MSs, the transmitting HR-MS shall pre-compensate the frequency offset according to the frequency difference between the HR-MS and HR-BS. An HR-MS within the coverage of the HR-BS estimates frequency offset with the frequency of the serving HR-BS. Some HR-MSs can transmit some reference signals to spread the reference frequency of the HR-BS. The HR-MSs outside of HR-BS coverage can estimate frequency reference by using the propagated reference signals. If no propagated reference signal can be received, the HR-MS outside of coverage pre-compensate frequency offset according to the previously estimated offset value which was used when that HR-MS is inside of HR-BS coverage.

In addition to the frequency synchronization, the synchronization channel is used for acquiring time synchronization. Synchronization channel shall be used to estimate the transmission timing of the direct communication channels to prevent timing offset between the desired signals and interference signals at the receiver.

6.12.2.3.2.2.1 Synchronization channel structure

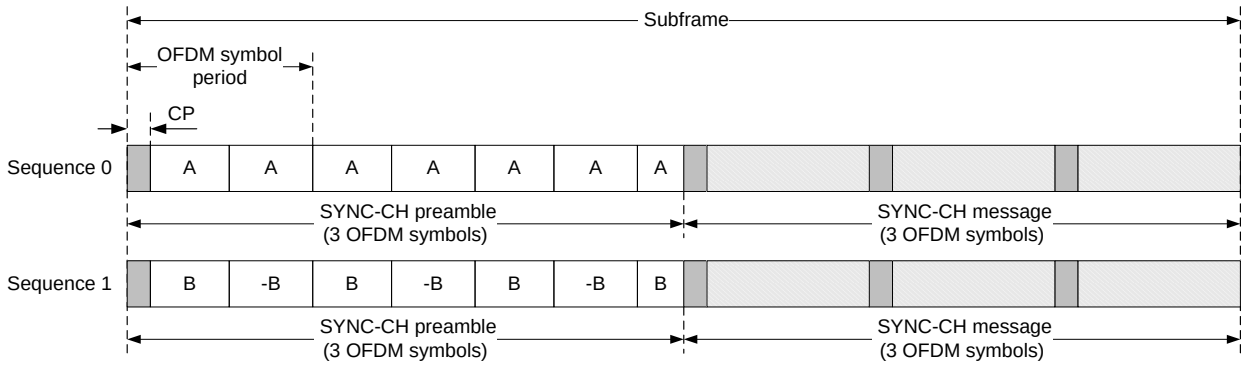


Figure 917—Synchronization channel for direct communication

Figure 917 describes the synchronization channel structure for direct communication in the time domain. One synchronization channel occupies one subframe composed of six OFDM symbols. The first three OFDM symbols are used for Sync-CH preamble transmission and the last three OFDM symbols include the Sync-CH message. In the frequency domain, 72 contiguous subcarriers are assigned to transmit the synchronization channel for direct communication. The Sync-CH preamble is used for preamble detection, timing offset estimation, frequency offset estimation, and channel estimation. In the frequency domain, a preamble sequence with 36 binary codes is mapped to 36 subcarriers and remaining 36 subcarriers are not used. The time domain preamble sequence is obtained by taking IFFT of the frequency domain preamble sequence. In the time domain, sequence 0 is denoted as repetition of a basic pattern with $N_{FFT}/2$ samples, where N_{FFT} is the FFT size, and sequence 1 is composed of a basic pattern with $N_{FFT}/2$ samples and the sign reversed version of the basic pattern. The first Sync-CH symbol is defined by the CP and the time domain preamble sequence. Second and third Sync-CH symbols are defined by the repetition of the time domain preamble sequence without the CP. To limit the preamble length to three OFDM symbols, the time domain preamble sequence is repeated by (2+α) times, where α is given by

$$\alpha = 2N_{CP} / N_{FFT}$$

where N_{CP} is the CP length.

6.12.2.3.2.2.2 Preamble sequences for synchronization channel

The preamble sequences are defined by the pseudonoise binary codes produced by the PRBS used for ranging code generation. The generator polynomial of the PRBS is $1+X^1+X^4+X^7+X^{15}$. The PRBS generator is initialized by the seed b14 … b0 = 1,1,0,1,0,1,0,0,0,0,0,0,0,0,0, where b0 is the LSB of the PRBS seed. The preamble sequences are subsequences of the pseudonoise binary sequence C_k generated by the PRBS. The number of preamble sequences is two. Each sequence is composed of 36 binary codes and 36 zeros. Suppose that the first bit of the PRBS output is C_0. Then, the preamble sequences are defined as follows.

$$S_k^0 = \begin{cases} 0, & k = 0, 2, \cdots, 70 \\ 1 - 2 \times C_k, & k = 1, 3, \cdots, 71 \end{cases}$$

$$S_k^1 = \begin{cases} 1 - 2 \times C_k, & k = 0, 2, \cdots, 70 \\ 0, & k = 1, 3, \cdots, 71 \end{cases}$$

where S_k^j is the *k*-th bit of the *j*-th preamble sequence. The transmit HR-MS selects one of the preamble sequences to generate the SYNC-CH preamble. The receive HR-MS shall be able to detect all the preamble sequences considering the preamble patterns.

6.12.2.3.2.2.3 Synchronization channel IE

Synchronization channel message is transmitted after channel encoding. The synchronization channel IE is composed of the fields in Table 1203.

Table 1203—Synchronization channel IE

Field name	Field size
Transmitter HR-MS ID	TBD
Reference time	2
Hop count	2
Reference signal strength	TBD
Frame structure information	4
CRC	16

6.12.2.3.2.2.3.1 Pilot structure for OFDM symbols transmitting SYNC-CH IE

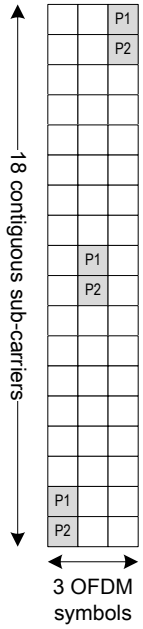


Figure 918 – Pilot structure for OFDM symbols transmitting SYNC-CH IE

Figure 918 shows the pilot structure for resources utilized for SYNC-CH IE transmission. To support SFBC, pilots for two antenna ports are assigned.

6.12.2.3.2.2.3.2 Resource mapping of SYNC-CH IE

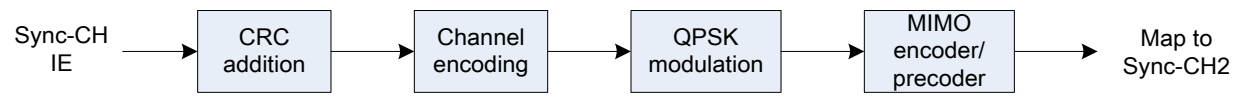


Figure 919 – Physical processing block diagram for the SYNC-CH IE

Figure 919 shows the physical processing block diagram for the SYNC-CH IE. The Sync-CH IE shall be appended with a 16-bit CRC, per the CRC16-CCITT specification in Rec. ITU-T X25. The number of bits including the 16-bit CRC is 64 bits. The resulting sequence of bits shall be encoded by the TBCC described in 6.3.10.2 with parameter $M=2K_{bufsize}$ and $K_{bursize}=3L$, where L is the number of information bits. Then the effective code rate is 1/6. The encoded bit sequence shall be modulated using QPSK. The modulated symbols shall be mapped to two transmission streams using SFBC as described in 6.3.6.1.1. The two streams using SFBC shall be processed and mapped to the transmit antenna as described in 6.3.6.1.2. Antenna specific symbols at the output of the MIMO precoder shall be mapped to the resource elements in the last three OFDM symbols described in 6.12.2.3.2.1.

6.12.2.3.2.3 Dedicated Channel (Ded-CH) structure

As described in 6.12.2.3.2.1, resources for Ded-CH is divided into $N_{ded\text{-}subchannel}$ dedicated subchannels for each TDC frame according to the number of subframes assigned for the logical frame. By using the dedicated subchannel, two types of signals can be transmitted: one is Ded-CH packet and the other is Ded-CH preamble. For each dedicated subchannel, four LRUs are assigned.

6.12.2.3.2.3.1 Pilot structure for mRBs transmitting Ded-CH packet

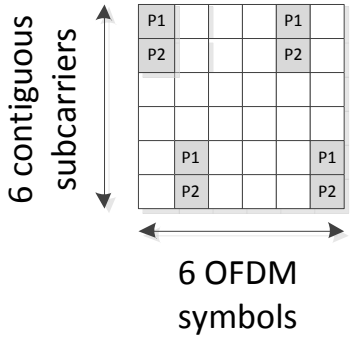


Figure 920 – Pilot structure for OFDM symbols transmitting SYNC-CH IE

Figure 920 shows the pilot structure for mRBs utilized for Ded-CH packet transmission. To support SFBC, pilots for two antenna ports are assigned.

6.12.2.3.2.3.2 Ded-CH preamble transmission

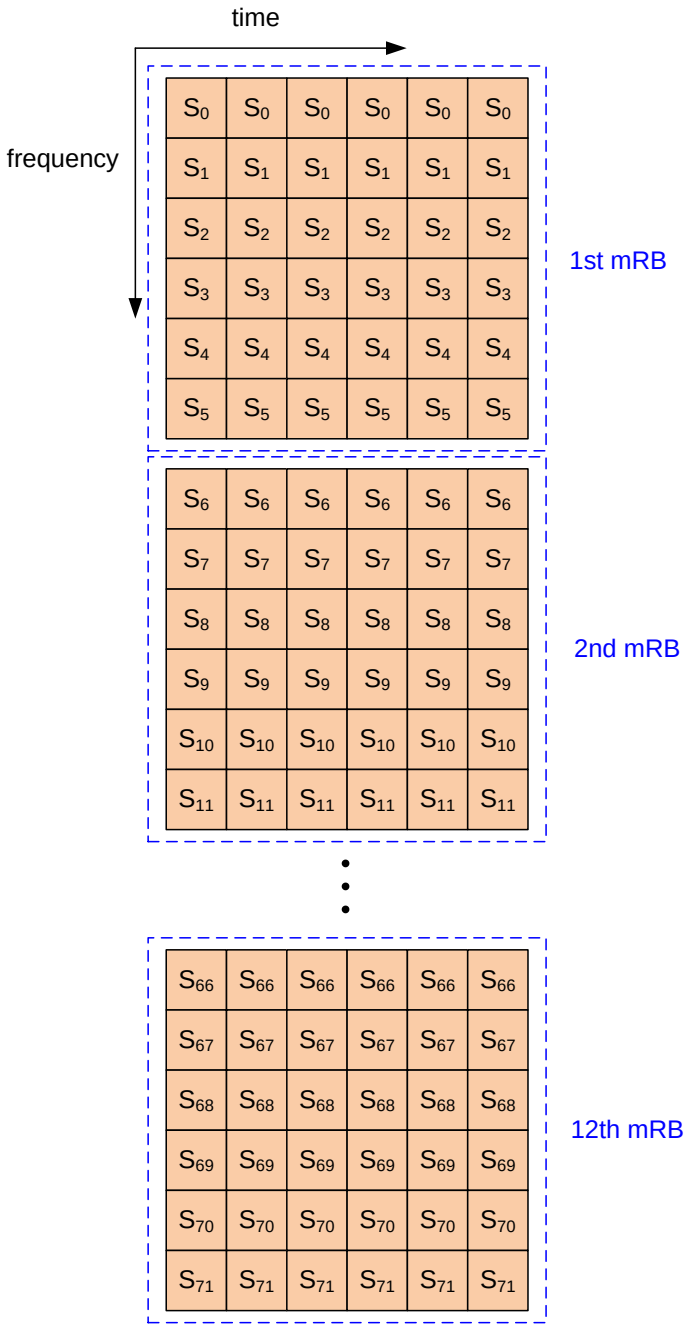


Figure 921 – Logical channel structure for Ded-CH preamble

Figure 921 describes the logical channel structure for Ded-CH preamble. The Ded-CH preamble occupies one Ded-CH composed of 12 mRBs, which are physically distributed in the time and frequency domain (the mRB in the lower subframe index and mRB index has lower mRB index in the mRBs of a dedicated subchannel. The preamble sequence for Ded-CH is mapped to Ded-CH resources as shown in Figure yy2. The preamble sequence includes 72 binary codes which are divided into 12 subsequences with 6 binary codes corresponding to 12 mRBs. In the time domain, the same preamble sequence is repeatedly transmitted for 6 OFDM symbols.

To generate the pseudonoise binary codes, we use the PRBS whose generator polynomial is $1+X^1+X^4+X^7+X^{15}$. This PRBS is the same as that for UL (uplink) ranging code generation of 802.16e and 802.16m, described by Figure 257 of IEEE 802.16-2009. The PRBS generator is initialized by the seed b14 … b0 = [1,1,0,1,0,1,0,0,0,0,0,0,0,0,0], where b0 is the LSB of the PRBS seed. The binary sequence for the Ded-CH preamble is defined by the subsequence of the pseudonoise sequence C_k generated by the PRBS output. Suppose that the first bit of the PRBS output is C_0. Then, the sequence for the Ded-CH preamble is defined by

$$S_k = 1 - 2 \times C_{k+72}, \quad k = 0,1,\cdots,71 \tag{1}$$

Using the Ded-CH preamble, the receiver can estimate time offset, frequency offset, link SINR (signal to interference plus noise ratio), radio channel, etc.

6.12.2.3.2.3.3 Ded-CH packet transmission

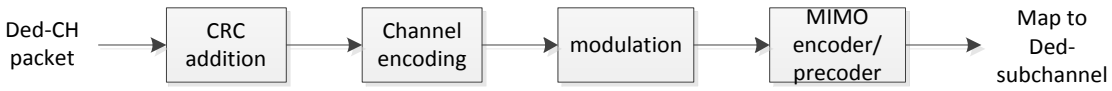


Figure 922 – Physical processing block diagram for the Ded-CH packet transmission

Figure 922 shows the physical processing block diagram for the Ded-CH packet. The Ded-CH packet IE shall be appended with a 16-bit CRC, per the CRC16-CCITT specification in Rec. ITU-T X25. The procedures for channel encoding for the Ded-CH packet are identical with the IEEE 802,16m data packet transmission, which are described in 6.3.10.1. Effective code rate and modulation size are determined by the procedures in 6.3.10.1. The modulated symbols shall be mapped to two transmission streams using SFBC as described in 6.3.6.1.1. The two streams using SFBC shall be processed and mapped to the transmit antenna as described in 6.3.6.1.2. Antenna specific symbols at the output of the MIMO precoder shall be mapped to the resource elements in the dedicated subchannel described in 6.12.2.3.2.1.

6.12.2.3.2.4 Supplementary Channel

There are two subframes to transmit supplementary channel in a super frame. One subframe for supplementary channel is located in the first uplink subframe of the second frame, and the other subframe for supplementary channel is located in the first uplink subframe of the fourth frame. A supplementary sub-channel is one-to-one mapped with each dedicated sub-channel. By using the supplementary sub-channel, the following MAC messages, PHY signalings and short feedback messages related with the corresponding dedicated sub-channel are transmitted.

- MAC messages: RTS, CTS, MCS information, ranging response et. al.
- PHY signalings: periodic ranging sequence, sounding signal et. al.
- Short feedback messages: ACK, NACK, CQI, CSI, RI (rank information) et. al.

As shown in Figure 2 ~ Figure 5, C_i is the *i*-th supplementary sub-channel corresponding to the *i*-th dedicated sub-channel. A supplementary sub-channel is composed of two sub-blocks distributed in the frequency domain. Since all HR-MSs should listen the supplementary channels, to obtain Tx. And Rx. Switching time, no signal is transmitted in the last OFDM symbol of supplementary channel (6-th OFDM symbol). The sub-block of supplementary sub-channel is composed of 3 subcarriers-by- 5 OFDM symbols. The supplementary sub-channels corresponding to the dedicated sub-channels in slot 1 are located in slot 2, and the supplementary sub-channels corresponding to the dedicated sub-channels in slot 2 are located in slot 1. By assigning a dedicated sub-channel and the corresponding supplementary sub-channel in a cross way, the setup time of communication link and the retransmission latency can be minimized. For example, if an HR-MS transmits a packet by using the dedicated sub-channel 1 in slot 1, because the corresponding supplementary sub-channel is located in slot 2, the receiving HR-MS can transmit ACK/NACK signal by using the supplementary sub-channel in the same superframe, and the retransmission packet can be transmitted in the next superframe.

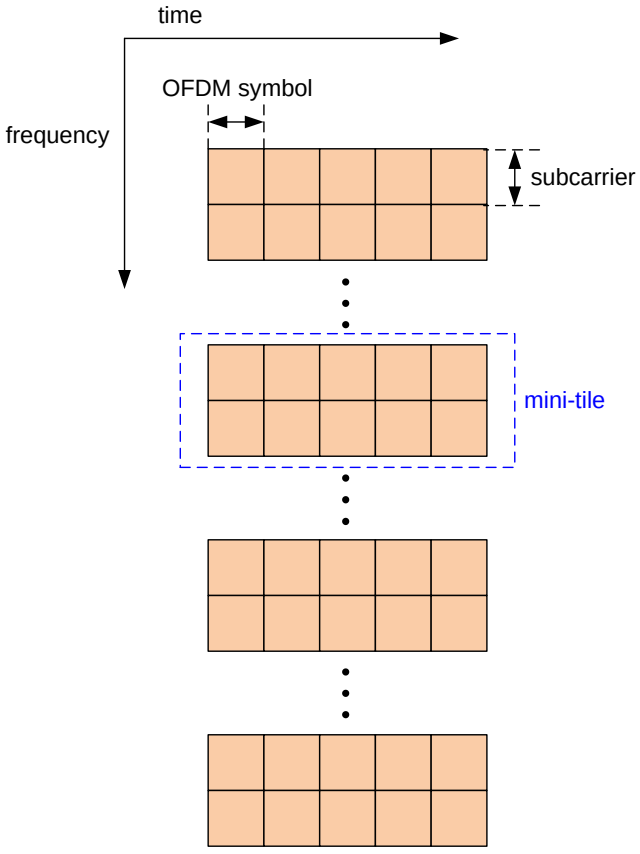


Figure 923 – Supplementary channel structure

Figure 923 describes the proposed Sup-CH structure for TDC. Details of the Sub-CH structure are defined in 6.12.2.3.2.1. One Sup-CH is composed of four distributed mini-tiles, where a mini-tile has (2 subcarriers)×(5 symbols) rectangular-shaped resource elements. A Sup-CH includes ranging channel, CQI channel, and feedback channel, which are transmitted

in TDM (time division multiplexing) manner.

6.12.2.3.2.4.1 Ranging channel

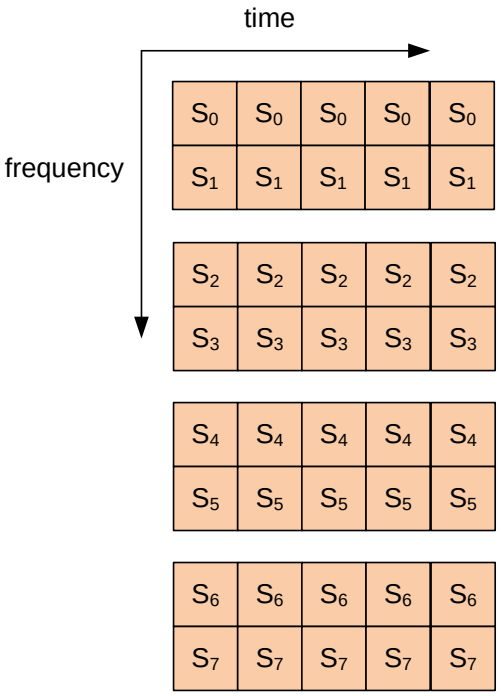


Figure 924 – Ranging channel structure

The ranging sequence is mapped to the Sup-CH resource elements as shown in Figure 924. $\{S_k; 0 \le k \le 7\}$ denotes a binary sequence with length 8, defined by

$$[S_0\ S_1\ S_2\ S_3\ S_4\ S_5\ S_6\ S_7] = [1,-1,\ -1,1,\ -1,1,\ 1,-1]$$

The same binary sequence is repeatedly transmitted for 5 OFDM symbols. The ranging channel is periodically transmitted, where the starting slot number and the transmission period are determined during the link initialization.

6.12.2.3.2.4.2 CQI channel

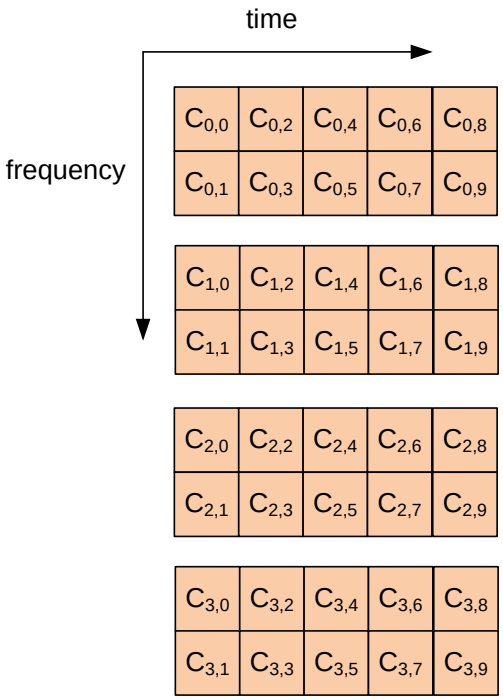


Figure 925 – CQI channel structure

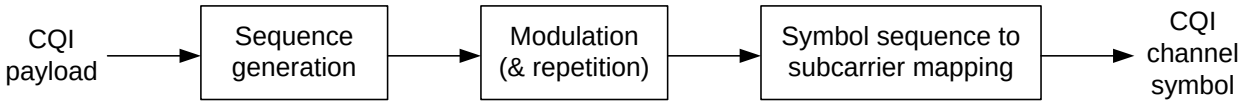


Figure 926 – Mapping of information in the CQI channel

The process of composing the CQI channel is illustrated in Figure 926. The CQI channel payload bits are used to generate the CQI sequence according to Table yy1. The resulting bit sequence is modulated, repeated and mapped to the CQI channel symbols $s[k]$ (0 mapped to +1 and 1 mapped to -1). The mapping of $s[k]$ to the Sup-CH resource elements is defined as follows.

$$C_{i,j} = s[K_i[j]], \text{ for } i = 0,1,2,3, \ 0 \le j \le 9$$

where $K_i[j]$ denotes the j-th element of K_i, defined by

$$K_0 = \{0,1,2,3,4,5,6,7,8,9\}$$

$$K_1 = \{2,3,4,6,7,8,9,0,1,5\}$$

$$K_2 = \{8,9,2,3,4,5,6,7,0,1\}$$

$$K_3 = \{5,6,7,8,9,0,1,2,3,4\}$$

Table 1204 – Sequences for CQI channel

Index	Sequence	Usage
0	1111111111	level 0
1	0010110001	level 1
2	0100100110	level 2
3	1001101000	level 3
4	1011000100	level 4
5	0110001010	level 5
6	0000011101	level 6
7	1101010011	level 7
8	1100011000	Reserved
9	0001010110	Reserved
10	0111000001	Reserved
11	1010001111	Reserved
12	1000100011	Reserved
13	0101101101	Reserved
14	0011111010	Reserved
15	1110110100	Reserved

The codeword set defined in Table 1204 can carry up to 4 information bits. The codeword set is mapped to the SINR level, measured by the AMS transmitting the CQI channel using the Ded-CH preamble and the pilot symbols included in the Ded-CH. The CQI channel is periodically transmitted, where the starting slot number and the transmission period are determined during the link initialization. The ranging channel and the CQI channel shall be assigned to separate time slots, by properly adjusting the starting slot number and the transmission period.

6.12.2.3.2.4.3 Feedback channel

The Sup-CH can be used to transmit the feedback channel, that includes ACK channel, NAK channel, MCS Change Confirm, RCHG Indication, etc. The feedback channel is transmitted using the slots which are not used by the ranging channel and the CQI channel. The feedback channel uses the same codeword set and symbol sequence to subcarrier mapping as the CQI

channel. The codeword sequences and mapping of feedback channel are defined in Table 1205.

Table 1205 – Sequences and mapping of feedback channel

Index	Sequence	Usage
0	1111111111	ACK
1	0010110001	NAK for frame 0
2	0100100110	NAK for frame 1
3	1001101000	NAK for frame 2
4	1011000100	NAK for frame 3
5	0110001010	MCS Change Confirm
6	0000011101	RCHG Indication
7	1101010011	Reserved
8	1100011000	Reserved
9	0001010110	Reserved
10	0111000001	Reserved
11	1010001111	Reserved
12	1000100011	Reserved
13	0101101101	Reserved
14	0011111010	Reserved
15	1110110100	Reserved

6.12.2.3.2.5 Distributed synchronization

An HR-MS listens to a synchronization channel and receives synchronization preambles in the synchronization channel. The HR-MS selects a reference time among candidate values including synchronization preambles, GPS, and HR-BS preambles. When deciding to send a synchronization preamble on synchronization channel, the HR-MS sends it periodically with a period T_{sync}.

An HR-MS follows a priority rule to select a reference time in descending order of priority as

the followings:

1) HR-BS preamble

2) GPS

3) Synchronization preamble that has smaller value of the ‘hop counter’ field and smaller value of the ‘reference signal strength’ field than received signal strengths in Synchronization channel message IE. The reference source is either HR-BS or GPS.

4) Synchronization preamble that has smaller value of the ‘hop counter’ field and smaller value of the ‘reference signal strength’ field than received signal strengths in Synchronization channel message IE. The reference source is HR-MS local clock.

5) HR-MS local clock.

The HR-MS calculates a sending reference time from the selected reference time, in which hop counter increases by one. If signal strength of received synchronization preamble of the selected reference time, is smaller than value of the ‘reference signal strength’ field in received synchronization preamble with the hop counter value of the sending reference time, the HR-MS sends a synchronization preamble periodically.

6.12.2.3.2.6 Distributed resource reservation

An HR-MS listens to all the supplementary channels and all the dedicated channels. If signal strength on a dedicated channel and corresponding supplementary channel is greater than a threshold, the HR-MS shall avoid using the dedicated channel and the corresponding channel.

An HR-MS selects a dedicated channel and reserves it using ‘request to send’ (RTS) and ‘clear to send’ (CTS) messages. The HR-MS sends RTS message on the dedicated channel and the RTS message includes a sending DCTID and a receiving address – DCTID or DCGID. If the receiving address is DCTID, the receiving HR-MS sends CTS message on the dedicated channel in response to RTS message. If the receiving address is DCGID, the receiving HR-MSs sends ACK on corresponding supplementary channel in response to RTS message and the sending HR-MS detects ACK signal. After exchange of RTS message and its response, the HR-MS sends packets on the dedicated channel continuously.

In addition, CTS and RTS messages can piggyback MAC control messages including DM-LEST-REQ, DM-LEST-RSP, etc. The ‘piggyback message indicator’ field is in CTS and RTS messages and if the field is set to 1 a MAC control message is piggybacked by CTS and RTS messages.

6.12.2.3.2.7 CQI report and link adaptation

The receiving HR-MS of a dedicated channel reports channel quality information (CQI) on corresponding supplementary channel periodically. When receiving CQI reports, the sending HR-MS decides a MCS level of data signal on the dedicated channel and informs the receiving HR-MS of the MCS level using an MCS Change Command message. The receiving HR-MS sends MCS Change Confirm code on feedback channel in response to the MCS Change Command message. After receiving the MCS Change Confirm code, the sending HR-

MS changes MCS level of a data signal on dedicated channel. The receiving HR-MS shall try to decode the data signal with new MCS level. If fails, the receiving HR-MS shall decode the data signal with old MCS level.

6.12.2.3.2.8 HARQ

The sending HR-MS sends a data packet on dedicated channel in a DC frame. If the receiving HR-MS fails to decode the data packet successfully, it sends NAK feedback within four DC frames. There are four types of NAK feedbacks and each type of NAK feedbacks indicates a frame number that data packet corrupts. The sending HR-MS retransmits the data packet with NAK indicated frame number next frame.

If the receiving HR-MS has no feedback, ACK feedback are sent on the supplementary channel. It indicates that the receiving HR-MS receives all the packets on the dedicated channel.

6.12.2.4 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.

6.12.2.4.1 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 the duration of six OFDMA symbols. If no preamble 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 CW_{max} 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.

6.12.2.4.2 Format of discovery message

The network discovery message shall take following format: frame preambles, PA-Preamble and SA-Preamble shall be transmitted first, and then followed by the discovery information as specified in 6.12.2.4.3.

Based on the preamble pattern, HR-MS knows the signals are from a BS or from HR-MSs. The discovery message shall be transmitted after the SA-Preamble and use radio resource specified by SA-Preamble. The radio resource is TBD.

6.12.2.4.3 Direct communication discovery messages format

The discovery message AAI_DC_DISCOV_Message shall take the following encoding format:

Table 1206—DC discovery message encodings

Syntax	Size (bit)	Notes
AAI_DC_DISCOV_Message() {	—	—
MAC Address	48	MAC address of the device
Length	16	The length of the message
NBR Count	8	Number of neighboring HR-MSs
for(i=0;i<n;i++){		
AAI_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.

AAI_DC_DISCOV_IE

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

6.12.2.4.3.1 Encoding of AAI_DC_DISCOV_IEs

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

Table 1207—DC discovery IE encodings

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

A few types of IEs have been defined in Table 1208.

Table 1208—DC discovery IE types

Type	**Name**
0x01	AAI_DC_DISCOV_NODE_NAME
0x02	AAI_DC_DISCOV_NBR_ADDR
0x03	AAI_DC_DISCOV_INVITE
0x04	AAI_DC_DISCOV_INVITE_ACCEPT
0x05	AAI_DC_DISCOV_INVITE_REJECT
0x06 – 0xfe	Reserved
0xff	AAI_DC_DISCOV_DATA

6.12.2.4.3.1.1 AAI_DC_DISCOV_NODE_NAME

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

Table 1209—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

6.12.2.4.3.1.2 AAI_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 1210—DC Neighbor Address IE

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

6.12.2.4.3.1.3 AAI_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 1211—DC Invitation IE

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

6.12.2.4.3.1.4 AAI_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 an HR-BS.

Table 1212—DC Accept IE

Type (1 byte)	Length (1 byte)	Value (variable length)
0x04	6	MAC address of the inviting HR-MS

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

6.12.2.4.3.1.5 AAI_DC_DISCOV_INVITE_REJECT

The IE contains the MAC address of the HR-MS who sends out a DC_DISCOV_INVITE_ACCEPT message and the current HR-MS reject the invitation. It intends to not join the HR-MS network when the HR-MS become an HR-BS.

Table 1213—DC Reject IE

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

6.12.2.4.3.1.6 AAI_DC_DISCOV_DATA

A short data packet is allowed to be attached as an IE. The interpretation of the data packet is up to application.

Table 1214—DC Data IE

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

6.12.3 Support for HR-MS forwarding to network

6.12.3.1 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 in 6.12.2.2, HR-MS forwarding to network is described in 6.12.3.2.

Using talk-around direct communication described in 6.12.2.3, HR-MS forwarding to network is described in 6.12.3.3.

6.12.3.2 BS-controlled HR-MF forwarding to network (FTN)

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. This is described in 6.12.3.2.1.1.
- 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. MAC-layer support for this process is described in 6.12.3.2.1 while PHY-layer support for this is described in 6.12.3.2.2.

6.12.3.2.1 Medium access control

6.12.3.2.1.1 Network entry involving forwarding HR-MS

For an HR-MS that is inside-of-coverage of an HR-BS/RS, the network entry process is as described in 6.2.15 and 6.6.2.10.

For an HR-MS that is out-of-coverage of any HR-BS/RS but within reach of a forwarding HR-MS, the process of network entry can be described as follows.

To enable coverage extension, a serving HR-BS/HR-RS shall schedule some of its directly-associated HR-MSs to transmit PA/SA-Preamble signals so that an outside-of-coverage HR-MS can detect and start network entry.

Any new HR-MS 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. For that, the last [TBD] SA-Preamble sequences in each segment are reserved for transmission by coverage-extending HR-MS.

The HR-BS may instruct HR-MS that are associated with it to transmit network configuration information (NCI) at pre-defined resources relative to the preambles transmitted by the HR-MS. The NCI, when transmitted, defines resources for access by the HR-MS that is not under HR-BS coverage. This corresponds to the coverage extension procedure defined in 6.12.3.2.1.1.1. If NCI is omitted then access resources are defined by the index and the sub-carrier set index of the SA-Preamble. This corresponds to the coverage extension procedure defined in 6.12.3.2.1.1.2.

6.12.3.2.1.1.1 Coverage Extension with NCI Preceding Initial Ranging

The procedure starts when serving HR-BS/RS transmits an HR-CEX-CMD message to instruct one or a group of its directly-associated HR-MS to carry out a coverage-extending process. The format of HR-CEX-CMD message is defined in Table 780 and includes the following information:

- *Idx* and *n*: the index of the SA-Preamble and index of SA-Preamble carrier set, respectively, to be transmitted by the scheduled HR-MS (or group of HR-MS). The scheduled HR-MS shall also transmit PA-Preamble, however this preamble is the same as that transmitted by serving HR-BS and therefore need not be specified.
- t_{adv}: the timing advance that should be used by the scheduled HR-MS (or group of HR-MS) when transmitting PA/SA-Preambles. This offset is with respect to the DL frame timing as seen by the scheduled HR-MS.
- n_{start} : the superframe number in which the new coverage-extending process should be started.
- m_{prep}: the number of superframes, counting from the superframe with number n_{start}, that the scheduled HR-MS (or group of HR-MS) shall transmit PA/SA-Preambles without transmitting NCI. The value of m_{prep} shall not be greater than a system parameter N_{prep_max}.
- m_{nci}: the number of superframes in which NCI is to be transmitted, i.e., the NCI shall be transmitted in superframes $(n_{start} + m_{prep})$ to $(n_{start} + m_{prep} + m_{nci} - 1)$.
- m_{rng}: the number of ranging opportunities, together with their particular configurations.
- The location of the channel used to feedback to the new HR-MS (if pre-allocated).
- The power setting to be used by scheduled HR-MS (or group of HR-MS) when transmitting preambles and NCI.
- Other information to be transmitted in NCI (see Table 1215 and Table 1216).

Upon receiving the HR-CEX-CMD message, the scheduled HR-MS (or group of HR-MS), from now on simply referred to as forwarding HR-MS, shall start transmitting PA/SA-Preambles in superframe $n_{start.}$ The forwarding HR-MS transmits PA-Preamble in the first symbol of the 2nd frame and SA-Preamble in the first symbol of the 3rd frame of every superframe with superframe number from $n_{start.}$ to $(n_{start} + m_{prep.} - 1)$.

Next, the forwarding HR-MS transmits NCI in superframes with number from $(n_{start} + m_{prep})$ to $(n_{start} + m_{prep} + m_{nci} - 1)$. During these m_{nci} superframes, the forwarding HR-MS continue to transmit PA/SA-Preambles as specified above. The transmission of NCI can be described as follows:

- NCI partitioning: The NCI is divided into two subpackets, i.e., Initial Network Configuration Information (I-NCI) and Supplementing Network Configuration Information (S-NCI). I-NCI is transmitted first, with its location determinable from the SA-Preamble index, *Idx*, and subcarrier set index, *n*, of the SA-Preamble transmitted by the forwarding HR-MS. The content of I-NCI is described in Table 1215. The content of S-NCI is described in Table 1216. The location of S-NCI is specified in the I-NCI. The physical structure of I-NCI and S-NCI are described in 6.12.3.2.2.2.

- Transmission of I-NCI: The I-NCI shall be transmitted in the $N_{I\text{-}NCI}$ Distirubted LRUs (DLRUs) in the first subframe of a superframe, with the particular resource index being determinable from the SA-Preamble transmitted by the forwarding HR-MS. Within the selected subframe, the I-NCI shall occupy the last 5 OFDM symbols, i.e., effectively forming a Type-3 subframe.

- Transmission of S-NCI: the resource allocated for S-NCI shall be defined in I-NCI (see Table 1215). In general, this allocation depends on the *IDCell* and the frame configuration of the serving HR-BS/RS.

When a new HR-MS detects PA/SA-Preambles and I/S-NCI transmitted by the forwarding HR-MS and decides to start initial ranging through the forwarding HR-MS, the following process shall be carried out:

- The new HR-MS, after acquiring downlink synchronization and uplink transmission parameters shall pick one of the ranging codes specified in S-NCI using a uniform random process. The HR-MS shall send the selected ranging code on the first allocated ranging channel specified in S-NCI.

- Upon receiving the ranging code from the new HR-MS, the forwarding HR-MS is supposed to respond with an HR-CEX-RNG-ACK message. As specified in S-NCI, m_{rng} ranging opportunities shall be allocated. If the new HR-MS has previously transmitted a ranging code in a ranging opportunity which is not the last opportunity, the HR-MS shall expect to receive an HR-CEX-RNG-ACK message from the forwarding HR-MS before the next ranging opportunity. If the new HR-MS does not receive such an HR-CEX-RNG-ACK message, it shall pick another ranging code using a uniform random process and transmit on the coming ranging opportunity. The new HR-MS may ramp-up its transmit power as specified in S-NCI. If the new HR-MS transmits a ranging code in the last ranging opportunity specified in S-NCI, it shall expect to receive an HR-CEX-RNG-ACK message within Tx1 Timer.

- The HR-CEX-RNG-ACK message provides responses to all the successfully received and detected ranging preamble codes in the ranging opportunity preceding its transmission. There are four possible ranging status responses from the forwarding HR-MS to the new HR-MS in the HR-CEX-RNG-ACK message, i.e.,
    - Continue: The forwarding HR-MS informs the new HR-MS of needed adjustments (e.g., time, power, and possibly frequency corrections) and a status notification of "continue".
    - Success: The forwarding HR-MS informs the new HR-MS of status "success", but may have adjustment suggestions to the new HR-MS if necessary. With status success, the forwarding HR-MS shall inform the new HR-MS of a BW allocation in the uplink for the new HR-MS to send HR-CEX-RNG-REQ message.
    - Abort: The forwarding HR-MS informs the new HR-MS to abort the current initial ranging process.
    - Continue with 2nd Phase: This status notification is only applicable if the current coverage extension process follows the Two-Phase approach, as specified in HR-CEX-CMD message. The forwarding HR-MS informs the new HR-MS to prepare to receive post-access preambles and post-access S-NCI. This status shall only be sent once, i.e., it shall not be given when the new HR-MS has already been carrying out ranging using post-access preambles and post-access S-NCI from forwarding HR-MS.

- Based on the received response of ranging status, the new HR-MS performs the following:
  - Upon receiving a Continue status notification and parameter adjustments in HR-CEX-RNG-ACK message, the new HR-MS shall adjust its parameters accordingly and continue the ranging process by randomly selecting one ranging code and transmitting in the next available ranging opportunity, or as instructed in the HR-CEX-RNG-ACK message.
  - Upon receiving a Success status notification, the new HR-MS shall wait for the forwarding HR-MS to inform it of a BW allocation in the UL to send HR-CEX-RNG-REQ message. The BW shall be allocated to fit the size of HR-CEX-RNG-REQ. The forwarding HR-MS forwards the corresponding request to the serving HR-BS, and subsequently acts on behalf of the HR-BS in sending an HR-CEX-RNG-RSP message to the new HR-MS. If the new HR-MS does not receive BW allocation for HR-CEX-RNG-REQ within Tx or the HR-CEX-RNG-REQ/RSP is not completed in [TBD] frames, it stops the process and try to associate with another HR-MS or a HR-BS/RS.
  - Upon receiving an Abort status notification, the new HR-MS shall stop the ranging process. It shall not attempt to restart initial ranging with a forwarding HR-MS transmitting the same SA-Preamble in the next n_{closed} coverage extending process.
  - Upon receiving Continue with 2nd Phase status notification, the new HR-MS waits for post-access PA/SA-Preambles and post-access S-NCI to be transmitted by forwarding HR-MS. Upon receiving post-access PA/SA-Preambles and S-NCI, the new HR-MS start a new round of initial ranging as follows steps as described above. and carries out ranging process as described above. The initial transmission power for the ranging is determined based on the last ranging prior to detection of post-access SA-Preamble and S-NCI.

- HR-BS assigns and transfers a TSTID by AAI-RNG-RSP message when ranging status is Success. Initial ranging process is over after receiving the HR-CEX-RNG-RSP message. The TSTID is used until STID is newly assigned and received at successful registration.

In the above procedure, the transmission of initial ranging code by the new HR-MS shall follow:

- For frame configuration without FDM-based UL PUSC zone support:

  - In the time domain, the S-RCH allocation is specified by the subframe offset O_{SF} transmitted in S-NCI, i.e., ranging opportunity is located at $mod(O_{SF} + 1, NUL)^{th}$ uplink AAI subframe of a particular frame. The information for ranging frequency resource allocation, i.e., the subband index for ranging resource allocation is determined by the *IDcell* of the superordinate HR-BS (transmitted in I-NCI) and the allocated number of subbands R_{SB} according to the following equation, where *IDcell* is defined in 6.3.5.1.2 and R_{SB} is $L_{SB\text{-}CRU,FPi}/4$, where $L_{SBCRU,\,FPi}$ is the number of allocated subband CRUs as defined

in 6.3.7.3 for FP_i corresponding to reuse 1 partition or power-boosted reuse 3 partition only if there is no reuse 1 partition.

$$I_{SB,s} = mod(IDcell + 1, R_{SB}),$$

where $I_{SB,s}$ denotes the subband index $(0, \ldots, R_{SB} - 1)$ for ranging resource allocation among R_{SB} subbands.

- For frame configuration with FDM-based UL PUSC zone support:
    - The un-associated HR-MS shall transmit ranging preamble in a similar way to what specified in 6.3.8.2.4.3.

After a successful initial ranging, the forwarding HR-MS shall assist HR-BS and the new HR-MS to exchange control messages to complete basic capability negotiation, HR-MS authorization and key exchange, and registration.

The behavior of the forwarding HR-MS and serving HR-BS/RS during initial ranging of the new HR-MS shall be as follows.

- After transmitting NCI (i.e., in I/S-NCI messages), the forwarding HR-MS shall monitor the specified ranging opportunities for any initial-ranging attempt by new HR-MS. If no such ranging attempt is detected, the coverage extension process terminates.

- When the forwarding HR-MS detects one or more ranging codes transmitted on the allocated ranging opportunities, it shall calculate signal strength and necessary adjustments (time, power, frequency corrections). An HR-CEX-RNG-ACK message shall be transmitted to the new HR-MS.

- If resource in the uplink area has been pre-allocated by HR-BS for the forwarding HR-MS to transmit HR-CEX-RNG-ACK message, the forwarding HR-MS shall transmit an HR-CEX-RNG-ACK message to the new HR-MS, with corresponding status and adjustments (if necessary). The HR-BS shall also monitor the pre-allocated resource for the HR-CEX-RNG-ACK in order to carry out any further proactive resource allocation for the coverage extending process.

- If resource has not been pre-allocated for the forwarding HR-MS to transmit HR-CEX-RNG-ACK message, the forwarding HR-MS shall transmit an HR-CEX-RNG-REP report to the HR-BS. The HR-CEX-RNG-REP message contains signal strength and possibly necessary adjustments for the new HR-MS. The HR-BS may receive HR-CEX-RNG-REP messages from multiple scheduled forwarding HR-MS. The HR-BS is supposed to follow up with an HR-CEX-FLU message before the next allocated

ranging opportunity of the coverage extending process if there is any. Otherwise, if this is the last ranging opportunity as specified in S-NCI, the HR-CEX-FLU message is supposed to be transmitted within *Tx2* Timer, where *Tx2* < *Tx1*. The HR-CEX-FLU message specifies the forwarding HR-MS that shall transmit an HR-CEX-RNG-ACK message to the new HR-MS (if such a message need to be transmitted). The resource to transmit such an HR-CEX-RNG-ACK message has been pre-specified in the original HR-CEX-CMD message, and has been made known to the new HR-MS through the S-NCI.

- After the ranging status has become Success, HR-BS shall allocate bandwidth in the uplink to allow the new HR-MS to transmit HR-CEX-RNG-REQ message. The forwarding HR-MS shall recognize this allocation IE in the A-MAP and inform the new HR-MS accordingly (using a CDMA Allocation IE). The resource allocation for HR-CEX-RNG-REQ message shall be preceded by HR-UL-RCV-IE which allocates uplink resource for the forwarding HR-MS to relay ranging, registration, capability negotiation, security exchanges from the new HR-MS to serving HR-BS.

- The HR-BS may request the forwarding HR-MS to report any ranging attempt, whether they have crossed the response threshold or not, for management purposes.

6.12.3.2.1.1.2 Coverage Extension with Initial Ranging Preceding NCI

The procedure starts when serving HR-BS (or serving HR-RS) transmits an HR-CEX-CMD message to instruct one or a group of its directly-associated HR-MS to carry out a coverage-extending process.

Upon receiving the HR-CEX-CMD message, the scheduled HR-MS (or group of HR-MS), from now on simply referred to as forwarding HR-MS, shall start transmitting pre-access PA/SA-Preambles.

Both pre-access and post-access SA-Preamble are assigned by the serving HR-BS. The HR-BS may assign same SA-Preamble to multiple forwarding HR-MS. The HR-BS should assign pre-access SA-Preamble to groups of HR-MS based on their service characteristics. The HR-BS should assign post-access SA-Preamble such that they will be unique within physical proximity.

When a new HR-MS detects PA/SA-Preamble sequences transmitted by the forwarding HR-MS and decides to start initial ranging through the forwarding HR-MS, the process can be described as follows:

- The new HR-MS, after acquiring downlink synchronization and uplink transmission parameters shall pick one of the ranging codes derived from the SA-Preamble ID using a uniform random process. The HR-MS shall send the selected ranging code on the first allocated ranging channel.

- Upon receiving the ranging code from the new HR-MS, the forwarding HR-MS is supposed to respond with post-access SA-Preamble and NCI. If the new HR-MS does not receive, a post access SA-Preamble and NCI it may ramp-up the transmit power for the next ranging attempt, if necessary.

- The forwarding HR-MS responds to ranging that has exceeded a threshold determined by the HR-BS.

If the new HR-MS detects a post-access SA-Preamble and NCI it shall pick one of the ranging codes (specified in NCI) using a uniform random process. The HR-MS shall send the selected ranging code on the first allocated ranging channel. The initial transmission power for the ranging is determined based on the last ranging prior to detection of post-access SA-Preamble and NCI.

- There are three possible ranging status responses from the forwarding HR-MS to the new HR-MS in the HR-CEX-RNG-ACK message, i.e.,
    - Continue: The forwarding HR-MS informs the new HR-MS of needed adjustments (e.g., time, power, and possibly frequency corrections) and a status notification of "continue".
    - Success: The forwarding HR-MS informs the new HR-MS of status "success", but may have adjustment suggestions to the new HR-MS if necessary. With status success, the forwarding HR-MS shall inform the new HR-MS of a BW allocation in the uplink for the new HR-MS to send HR-CEX-RNG-REQ message.
    - Abort: The forwarding HR-MS informs the new HR-MS to abort the current initial ranging process.

- Based on the received response of ranging status, the new HR-MS perform the following:
    - Upon receiving a Continue status notification and parameter adjustments in HR-CEX-RNG-ACK message, the new HR-MS shall adjust its parameters accordingly and continue the ranging process by randomly select one ranging code and transmit in the next available ranging opportunity, or as instructed in the HR-CEX-RNG-ACK message.
    - Upon receiving a Success status notification, the new HR-MS shall wait for the forwarding HR-MS to inform it of a BW allocation in the UL to send HR-RNG-REQ message.
    - Upon receiving an Abort status notification, the new HR-MS shall stop the ranging process.

- HR-BS assigns and transfers a TSTID by AAI-RNG-RSP message when ranging status is success. Initial ranging process is over after receiving the HR-RNG-RSP message. The TSTID is used until STID is newly assigned and received at successful registration.

After a successful initial ranging, the forwarding HR-MS shall assist HR-BS and the new HR-MS to exchange control messages to complete basic capability negotiation, HR-MS authorization and key exchange, and registration.

The behavior of the forwarding HR-MS and serving HR-BS/RS during initial ranging of the new HR-MS shall be as follows.

- After transmitting NCI, the forwarding HR-MS shall monitor the specified ranging opportunities for any initial-ranging attempt by new HR-MS until told to stop by the HR-BS.

- When the forwarding HR-MS detects one or more ranging codes transmitted on the allocated ranging opportunities, it shall calculate signal strength and necessary adjustments (time, power, frequency corrections). An HR-CEX-RNG-ACK message shall be transmitted to the new HR-MS.

- After the ranging status has become Success, HR-BS shall allocate bandwidth in the uplink to allow the new HR-MS to transmit HR-CEX-RNG-REQ message. The forwarding HR-MS shall recognize this allocation IE in the A-MAP and inform the new HR-MS accordingly.

- The HR-BS may request the forwarding HR-MS to report any ranging attempt (whether they have crossed the response threshold or not).

6.12.3.2.1.2 Connection management involving HR-MS

[TBD]

6.12.3.2.1.3 Construction and transmission of MAC PDUs by forwarding HR-MS

Forwarding and forwarded HR-MS shall construct and transmit MAC PDUs in the same way as described in 6.2.4.

6.12.3.2.1.4 Bandwidth request involving forwarding HR-MS

A forwarding HR-MS carries out bandwidth request to the serving HR-BS/RS as a normal HR-MS, i.e., as specified in 6.2.11.1. The way a forwarded HR-MS carries out bandwidth request depends on whether it is inside or outside of the coverage of the HR-BS/RS.

6.12.3.2.1.4.1 BR by an inside-of-coverage forwarded HR-MS

When a forwarded HR-MS is inside the coverage of the serving HR-BS/RS, it carries out bandwidth request to the serving HR-BS/RS as a normal HR-MS, i.e., as specified in 6.2.11.1. The corresponding forwarding HR-MS does not need to be aware of the bandwidth request from the forwarded HR-MS.

6.12.3.2.1.4.2 BR by an out-of-coverage forwarded HR-MS

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.

6.12.3.2.1.5 Synchronization between forwarding and forwarded HR-MS

When the forwarded HR-MS is inside the coverage of the serving HR-BS/RS, synchronization between itself and the corresponding forwarding HR-MS is achieved as described in 6.12.2.2.1.2.1.

When the forwarded HR-MS is out-of-coverage of the serving HR-BS/RS, synchronization between itself and the corresponding forwarding HR-MS is achieved as described in 6.12.2.2.1.2.2.

6.12.3.2.1.6 HO procedures involving forwarding HR-MS

6.12.3.2.1.6.1 General description

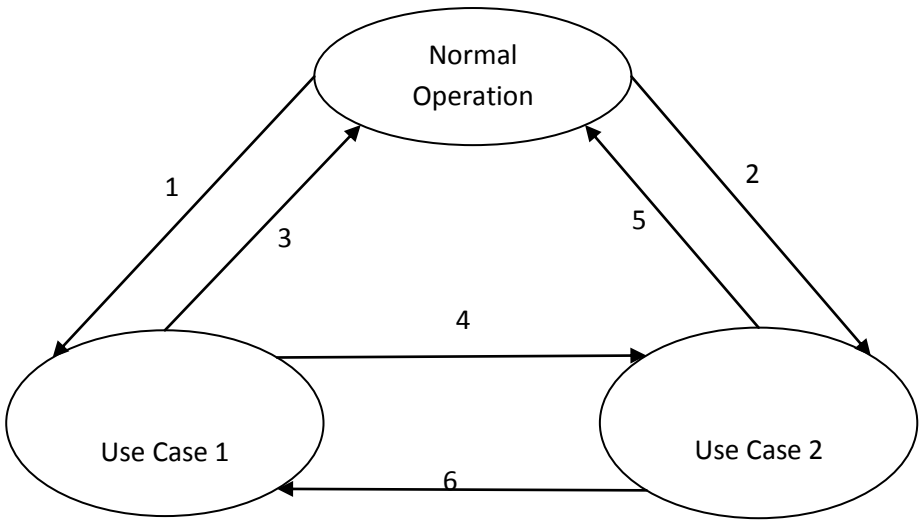


Figure 927 – Transitions between different operating modes.

Figure 927 highlights changes in HR-MS operation, from normal operation in which HR-MS communicate directly with serving HR-BS/RS to the two possible use cases of HR-MS FTN.

6.12.3.2.1.6.2 Transitions from normal operation to FTN operation:

Transitions from normal operation to Use case 1 or 2 can be triggered by the outcomes from the neighbor discovery process. It can also be due to changes in link, interference, and other operating conditions within the network.

6.12.3.2.1.6.3 Transitions from FTN use case 1 to normal & FTN use case 2:

Transitions from Use case 1 of HR-MS FTN to either Normal operation or Use case 2 can be triggered by changes in the link conditions between HR-BS, Forwarding HR-MS, and Forwarded HR-MS. To detect these changes, idle periods can be scheduled by HR-BS for the forwarding and forwarded HR-MS to measure link qualities.

6.12.3.2.1.6.4 Transitions from FTN use case 2 to normal & FTN use case 1:

Transitions from Use case 1 of HR-MS FTN to either Normal operation or Use case 2 can be triggered by changes in the link conditions between HR-BS, and forwarding/forwarded HR-MSs. To detect these changes, idle periods can be scheduled by HR-BS for Forwarding HR-MS, Forwarded HR-MS to measure link qualities.

6.12.3.2.1.7 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 6.12.3.2.1.1.

6.12.3.2.2 Physical layer

6.12.3.2.2.1 Frame structure for HR-MS FTN

A forwarding HR-MS and an inside-of-coverage forwarded HR-MS fully follow the superframe and frame configurations set by the serving HR-BS/RS, as described in 6.3.3, 6.6.6, and 6.6.4. A forwarded HR-MS that is out-of-coverage of the serving HR-BS/RS obtains essential superframe and frame configurations through A-Preambles and control channels from its corresponding forwarding HR-MS. These forwarding control channels

include I-NCI, S-NCI, Forwarding MAP (F-MAP).

From the point of view of forwarding and forwarded HR-MS, the frames within each superframe are classified into forwarding and reversed frames. The forwarding HR-MS transmits to its forwarded HR-MS in uplink subframes of forwarding frames. The forwarding HR-MS receives from its forwarded HR-MS in uplink subframes of reversed frames. The 1st and 3rd frames of each superframe are classified as forwarding frames while the 2nd and 4th frames of each superframe are classified as reversed frames. The restriction in transmitting/receiving modes of the forwarding and forwarded HR-MS does not apply to the transmission and reception of PA/SA-Preambles, which is described in 6.12.3.2.2.2.1.

Resources for HR-MS Direct Communications and HR-MS Forwarding to Network shall be scheduled by the serving HR-BS/RS. 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.

6.12.3.2.2.2 Control structure for HR-MS FTN

Physical control signaling for BS-controlled HR-MS FTN includes PA/SA-Preambles, I-NCI/S-NCI, F-MAP that are transmitted by forwarding HR-MS, HR-MS-to-HR-MS feedback channels and ranging channels that are used by both forwarding and forwarded HR-MS, and Forwarded-link BR channel that is used by forwarded HR-MS.

6.12.3.2.2.2.1 Transmission of A-Preambles

As described in 6.12.3.2.1.1, under the instruction of the serving HR-BS/RS, an HR-MS transmits PA/SA-Preambles, together with I/S-NCI, to help an out-of-coverage HR-MS to carry out network entry and get associated with the serving HR-BS/RS. After the out-of-coverage HR-MS has successfully completed network entry, it becomes a forwarded HR-MS that is attached to the helping/forwarding HR-MS.

A forwarding HR-MS shall periodically transmit PA/SA-Preambles as long as there is at least one out-of-coverage forwarded HR-MS attached to it. PA-Preamble shall be transmitted in the first OFDMA symbol of the 2nd frame of a superframe, while SA-Preamble shall be transmitted in the first OFDMA symbol of the 3rd frame of a superframe. The periodicity of PA/SA-Preamble transmission can be different from that applied during the network entry of an out-of-coverage HR-MS. The periodicity of PA/SA-Preamble transmission is informed to the forwarded HR-MS at the end of the network entry process and is updated through the field “Preamble Periodicity” in the S-NCI.

6.12.3.2.2.2.2 I-NCI

The I-NCI shall be transmitted in the last $N_{I\text{-}NCI}$ Distirubted LRUs (DLRUs) in the first subframe of a superframe.-Within the selected subframe, the I-NCI shall occupy the last 5 OFDM symbols, i.e., effectively forming a Type-3 subframe. From the point of view of an out-of-coverage HR-MS or a forwarded HR-MS attempting to decode I-NCI, the DL subframe in which I-NCI is located has only one frequency partition FP_0. All N_{PRU} in this subframe are distributed LRUs. The permutation and frequency partition of this subframe can be described by *DSAC* = 0 (all minibands without subband), *DFPC* = 0 (reuse 1 only), $DCAS_{SB,0}$ = 0 (no subband CRU allocated), and $DCAS_{MB,0}$ = 0 (no miniband CRU allocated). Definitions of these parameters are given in 6.3.4. Furthermore, the subcarrier permutation of this subframe is carried out as defined in 6.3.7.3.2, with the *IDcell* being calculated in the following modified way:

$$IDcell = 256\ mod(n+1,3) + mod(Idx + 1, 256),$$

where *Idx* is the preamble index and *n* is the preamble subcarrier set index of the SA-Preamble transmitted by the registered HR-MS.

I-NCI is transmitted by an HR-MS under the following cases:

- When the HR-MS is instructed by its serving HR-BS/RS to help in a network entry process for some out-of-coverage HR-MS, as described in 6.12.3.2.1.1.
- When there are changes in system configurations that affect the communication between a forwarding HR-MS and its attached forwarded HR-MS. In this case, the transmission of I-NCI shall be made known in advance to the attached forwarded HR-MS through the field "I-NCI Transmission Indicator" in the S-NCI.

When I-NCI is transmitted for network entry of out-of-coverage HR-MS, if the transmitting HR-MS already has some attached forwarded HR-MS, it may set the field "I-NCI Transmission Indicator" to inform its attached forwarded HR-MS accordingly. This allows the transmitted I-NCI to be used by both unassociated HR-MS for network entry and by attached HR-MS for system configuration updates.

The content of I-NCI is described in **Table 1215**.

Table 1215 – I-NCI IE format

Syntax	Size (bits)	Notes
BS *IDcell*	10	
Frame Configuration Index	6	The mapping between value of this index and frame configuration is listed in Table 806, Table 807, and Table 808
If (WirelessMAN-OFDMA		True if Frame configuration index is equal to

with FDM-based UL PUSC Zone Support){		– 5, 7, 9, 11, 13, 15, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 or 30 for 5/10 MHz channel bandwidth according to Table 806; – 4, 6, 8 or 10 for 8.75 MHz channel bandwidth according to Table 807; – 3 or 5 (with CP=1/8) for 7 MHz channel bandwidth according to Table 808. False if Frame configuration index is something else
UL_Permbase	7	Indicates UL_Permbase used in WirelessMAN-OFDMA system with FDM-based UL PUSC Zone.
Reserved	[TBD]	
}else{		
USAC	5/4/3	Indicates the number of subbands K_{SB} as defined in Table 903 to Table 905 in 6.3.7.2.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
UFPC	4/3/3	Indicate the frequency partition configuration as defined in Table 906 to Table 908 in 6.3.7.2.3 For 2048 FFT size, 4 bits For 1024 FFT size, 3 bits For 512 FFT size, 3 bits
UFPSC	3/2/1	Indicate the number of subbands allocated to

		FPi (*i* > 0) in 6.3.7.2.3 For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bits
$UCAS_{SB0}$	5/4/3	Indicates the number of subband-based CRUs in FP0 in 6.3.7.3.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$UCAS_{MB0}$	5/4/3	Indicates the number of miniband-based CRUs in FP0 in 6.3.7.3.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
Subframe index for S-NCI	3	The 2 LSB bits indicate the index of the UL subframe in which S-NCI is transmitted. The MSB bit indicates the frame in which S-NCI is transmitted. MSB bit == 0 indicate the 1st frame while MSB bit = 1 indicate the 3rd frame.
LRU starting index for S-NCI	6	Indicates the starting index of the LRUs allocated for S-NCI
Reserved	[TBD]	
}		

6.12.3.2.2.2.3 S-NCI

The S-NCI shall be transmitted in $N_{S\text{-}NCI}$ contiguous DLRUs of an uplink subframe. The ways in which S-NCI is transmitted can be described as follows:

- When an HR-MS is instructed by its serving HR-BS/RS to help in a network entry process for some out-of-coverage HR-MS (as described in 6.12.3.2.1.1), the HR-MS transmits S-NCI in an uplink subframe within either the 1st frame or the 3rd frame of the superframe in which I-NCI is transmitted.

- A forwarding HR-MS shall periodically transmit S-NCI as long as there is at least one out-of-coverage forwarded HR-MS attached to it. During this operation, S-NCI can be transmitted in either 1st or 3rd frame of a superframe. The frame-location and periodicity of S-NCI transmission shall be made known to the forwarded HR-MS through a control message [TBD].

In both cases described above, the index of the uplink subframe and the index of the starting LRU in which S-NCI is transmitted are signaled in the I-NCI fields "Subframe index for S-NCI" and "LRU starting index for S-NCI", respectively. When transmitted, S-NCI spans the last 5 OFDMA symbols of the selected subframe.

The content of S-NCI is described in **Table 1216**.

Table 1216 – S-NCI IE format

Syntax	**Size (bits)**	**Notes**
If (Support of WirelessMANOFDMA with FDM-based UL PUSC Zone){		
Subframe offset of the RCH	2	Indicates the subframe offset (O_{SF}) of the RCH allocation. The range of values is $0 \leq O_{SF} \leq 3$
Start RP code information of the RCH	4	Indicates the k_{ns}, which is the parameter for start of the RP code group (r_{ns0}). $r_{ns0}(k_{ns}) = 16 \times k_{ns} + 1, k_{ns} = 0,1, ...,15$
Number of RP codes allocated for coverage extension ranging	2	Indicates the number of RP codes and the particular codes that can be used for ranging with the forwarding HR-MS.
}else{		
Subframe offset of the S-RCH	2	Indicates the subframe offset (O_{SF}) of the S-RCH allocation
Start RP code information of the S-RCH		Indicates the *ks* that is the parameter controlling the start root index of the RP codes (r_{s0}). $r_{s0} = 6 \times k_s + 1$ The range of values is $0 \leq k_s \leq 15$

Transmission timing offset of SRCH	3	Indicates N_{RTO}, which is the parameter used for the calculation of the sample number, T_{RTO}, which is applied to advance the ranging signal transmission timing relative to the defined uplink transmission timing point based on the frame structure from AMS perspective when AMS conducts initial or handover ranging in a femtocell. T_{RTO} = floor(N_{RTO} × (T_g – 2) × F_S)(samples) where N_{RTO} = *min*($RTD / (T_g – 2)$, 7), and *RTD* is the round trip delay from the femto-ABS to the overlay macro-ABS. The range of values is $0 \leq N_{RTO} \leq 7$.
}		
UCASi	3/2/1	Indicates the number of total allocated CRUs, in a unit of a subband, for FP*i* ($i \geq 0$) in 6.3.7.3.1 For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bits
Forwarding EIRP	5	Unsigned integer from 1 to 31 in units of 1 dBm, where 0b00000=1 dBm and 0b11111=31 dBm.
HR-MS Transmit Power Limitation Level	5	Unsigned 5-bit integer. Specifies the maximum allowed HR-MS transmit power. Values indicate power levels in 1 dB steps starting from 0 dBm.
EIRxPIR,min	5	Unsigned integer from –133 to –102 in units of 1 dBm, where 0b00000 = –133 dBm and 0b11111 = –102 dBm.
Pre-access S-NCI Indicator	1	Indicates whether this is a pre-access S-NCI that is

		used for Group Discovery mode 0b0: not a pre-access S-NCI 0b1: pre-access S-NCI
Preamble Periodicity	2	Indicates the pattern by which the forwarding HR-MS transmits PA/SA-Preambles during HR-MS FTN 0b00: PA-Preamble is transmitted in the 1st symbol of the 2nd frame of every superframe while SA-Preamble is transmitted in the 1st symbol of the 3rd frame of every superframe 0b01: PA/SA-Preambles are transmitted once every two superframes 0b10: PA/SA-Preambles are transmitted alternatively, with PA-Preamble being transmitted in odd-number superframes and SA-Preamble being transmitted in even-number superframes 0b11: Reserved
I-NCI Transmission Indicator	2	Indicate the next transmission of I-NCI 0b00: No plan for I-NCI transmission 0b01: I-NCI is going to be transmitted in the next superframe 0b10: I-NCI is going to be transmitted in two superframes from the current superframe 0b11: Reserved

6.12.3.2.2.2.4 Forwarding MAP

The Forwarding MAP (F-MAP) carries service control information. Service control information consists of assignment information and power control information. For each forwarding HR-MS, its F-MAP region occupies a number of contiguous DLRUs within an uplink subframe in a forwarding frame. Each F-MAP region is further divided into F-MAP blocks, each occupies a [TBD] number of contiguous DLRUs. F-MAP blocks can be received and decoded independently from each other. The index of the first LRU allocated to the F-MAP region for each forwarding HR-MS is specified by the field "LRU starting index for S-NCI" in I-NCI. When transmitted, F-MAP spans the last 5 OFDMA symbols of the subframe.

The timing interpretation of the F-MAP assignments shall be as follows:

- For forwarding transmissions from forwarding HR-MS toward forwarded HR-MS, if the allocation signaling is transmitted in an F-MAP block within a particular subframe, then the corresponding forwarding transmission shall also be located within the same subframe.
- For reversed transmissions from forwarded HR-MS toward forwarding HR-MS, if the allocation signaling message is transmitted in an F-MAP block within a particular subframe with index *"n"* within a forwarding frame, then the corresponding reversed transmission shall be located in the subframe with the same subframe index *"n"* but within the next reversed frame.

6.12.3.2.2.2.5 HR-MS-to-HR-MS feedback channels

Direct-link feedback channel (DL-FBCH) carry channel quality feedback, MIMO feedback, and event-driven indicators between forwarding and forwarded HR-MS. DL-FBCH follows the same physical structure as that of the Primary Fast Feedback channel, i.e., PFBCH. However, the encoding mechanism for DL-FBCH is not the same as that for PFBCH. The OFDMA resource allocated to PFBCH shall be time-shared by DL-FBCH.

6.12.3.2.2.2.6 Ranging channel

Ranging channel is used by both forwarding and forwarded HR-MS to achieved transmission synchronization between them. The forwarding and forwarded HR-MS make use of the same synchronized ranging channel S-RCH defined in 6.3.8.1.4.2 and 6.3.8.1.4.3.

6.12.3.2.2.2.7 Forwarded BR channel

Forwarded BR channel is used for forwarded HR-MS to carry out contention-based random access bandwidth request, as described in 6.12.3.2.1.4. Forwarded BR channel follows the same physical structure as that of the UL BR channel described in 6.3.8.1.5, 6.3.8.2.5, and 6.3.8.3.2.

6.12.3.2.2.2.8 Timing implications to uplink transmission by forwarding HR-MS

As all uplink control channels described in 6.3.8, including feedback channels, BR channel, Ranging channel span 6 OFDMA symbols of the allocated subframe, so do the corresponding physical control channels between forwarding and forwarded HR-MS. When forwarded HR-MS transmits control/data messages toward forwarding HR-MS, the transmissions span the last 5 OFDMA symbols of the corresponding subframe.

When HR-BS allocates uplink resource for the forwarding HR-MS for its own uplink transmission, if the allocated subframe that is calculated based on the A-MAP relevance and HARQ timing (6.2.14.2.2) is the same as a subframe that is allocated to one of the attached forwarded HR-MSs, the subframe allocated to the forwarding HR-MS shall be delayed until the earliest subframe that is not allocated to any of the forwarding HR-MS's forwarded HR-MSs.

The forwarding HR-MS may also need to switch between transmitting and receiving states during uplink subframes to allow forwarded HR-MS to transmit to the forwarding HR-MS in an uplink subframe. When doing so:

- If a forwarded HR-MS is going to transmit in a particular uplink subframe and the transmission does not span the first OFDMA symbol of that subframe, and if prior to that subframe, the forwarding HR-MS is in the transmitting state, then the forwarding HR-MS shall switch from the transmitting to the receiving state during the

unoccupied first OFDMA symbol of the subframe allocated to the forwarded HR-MS to transmit.

- If a forwarded HR-MS is going to transmit in a particular uplink subframe and the transmission spans the entire subframe, and if in the subframe that precedes the first subframe, the forwarding HR-MS also needs to transmit to the HR-BS, then the transmission by the forwarding HR-MS shall not occupy the last OFDMA symbol of the subframe that is used by the forwarding HR-MS to transmit to the HR-BS. The forwarding HR-MS shall use this unoccupied last OFDMA symbol for switching from the transmitting state to the receiving state.

- If a forwarded HR-MS is going to transmit in a particular uplink subframe and if the forwarding HR-MS needs to transmit to the HR-BS in the next uplink subframe, then the transmission by the forwarding HR-MS in this next subframe shall not occupy the first OFDMA symbol of the subframe. The forwarding HR-MS shall use this unoccupied first OFDMA symbol for switching from the receiving state to the transmitting state.

6.12.3.3 Talk-around HR-MS forwarding to network

6.12.3.3.1 Medium access control

6.12.3.3.1.1 HR-MS discoveries

A forwarding HR-MS shall maintain a list of HR-MSs that are in communication range using talk-around direct communication.

An HR-BS shall maintain a list of HR-MSs that are collected from forwarding HR-MSs for HR-MS forwarding. An HR-BS broadcast the HR-MS list for HR-MS forwarding to forwarding HR-MSs using AAI-DMMS-ADV message. When new HR-MS is added or HR-MSs are deleted, the forwarding HR-MS shall update the HR-MS list by an exchange of MAC Management messages with HR-BS such as AAI-DMLU-REQ/RSP.

6.12.3.3.1.2 Forwarding connection management

A unicast forwarding connection between HR-BS and forwarding HR-MS is a unicast transport connection established to forward data traffic in one-way from HR-BS to forwarding HR-MS or vice versa.

A multicast forwarding connection between HR-BS and forwarding HR-MS is a multicast transport connection established to forward data traffic in one-way from HR-BS to forwarding HR-MSs.

Each unicast or multicast forwarding connection, which is established for supporting HR-MS forwarding, carries forwarding data packets. When HR-BS sends data packets on a unicast or multicast forwarding connection, forwarding HR-MS discriminates the data packets with type of transport connection and forwards the data packets on a direct communication link. When a forwarding HR-MS receives data packets on a direct communication link, the forwarding HR-MS discriminates the data packets and forwards the data packets on a unicast forwarding connection toward HR-BS.

6.12.3.3.1.2.1 Forwarding connection establishment

When a forwarding HR-MS is requested to establish a forwarding connection from HR-MSs out of BS's coverage, the forwarding HR-BS establishes a unicast or multicast forwarding connection. The unicast or multicast forwarding connection between HR-BS and forwarding HR-MS is established by exchanges of MAC Management messages such as AAI-DSA-REQ/RSP/ACK.

6.12.3.3.1.2.2 Forwarding connection release

The forwarding connection is terminated with forwarding connection release. On forwarding connection release, the context of forwarding connection are removed at both HR-BS and forwarding HR-MSs.

An HR-BS and a forwarding HR-MS release a unicast or multicast forwarding connection by exchanges of MAC Management messages such as AAI-DSD-REQ/RSP/ACK.

6.12.3.3.1.3 QoS management

QoS concept of forwarding connections shall be the same as described as in section 6.2.12 with the exception of QoS described in this section.

6.12.3.3.2 Physical layer

6.12.4 Support for standalone network

For WirelessMAN HR Advanced air interface, when HR-BS lost the connectivity to the backbone network and the neighboring HR-BSs, the network nodes under the coverage of this HR-BS shall form a standalone network. The local connectivity shall be provided for the mobile stations within the coverage of Base station. When the Base Station loses the backbone connection, the established service flow between mobile stations within the coverage of the base station shall be maintained.

When backbone connectivity is lost, the MAC connectivity is provided among HR-MSs within BS's coverage

6.12.4.1 Backbone status management

6.12.4.1.1 Backbone enable notification

When backbone connectivity is available, the HR-BS shall notify HR-MSs of its availability. The transport connections may be recovered from their unavailable status.

An HR-BS exchanges the BBE-REQ/RSP message with HR-MSs on unicast control connections.

An HR-BS broadcasts the BBE-CMD message to all the HR-MSs under BS's coverage.

6.12.4.1.2 Backbone disable notification

When backbone connectivity is not available, the HR-BS shall notify HR-MSs of its unavailability. After backbone disables, all the transport connections on which packets transfer to network are not available.

An HR-BS exchanges the BBD-REQ/RSP message with HR-MSs on unicast control connections.

An HR-BS broadcasts the BBD-CMD message to all the HR-MSs under BS coverage.

6.12.4.2 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 a STN-REQ message from HR-BS and receiving acknowledgement message STN-ACK from HR-MS or HR-RS within its coverage area.

6.12.4.3 Entry process for standalone network

The HR standalone network with WirelessMAN HR Advanced 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.

6.12.5 Support for high reliability 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 6.12.6.

6.12.5.1 Relaying connection notifications over an alternative interface

An alternative interface is an interface between two stationary HR-MSs that is not an IEEE 802.16 air interface. It may be an air interface on an unlicensed spectrum such as WLAN, or a wired interface on a power line.

When an HR-BS has downlink data for a HR-MS that has powered down or in an extended sleep mode (Such as a DCR mode) from the 802.16 network, the HR-BS may send a multicast Connection Notification message to the multicast group to which the target HR-MS belongs. In the multicast message, the identity of the target HR-MS is included. When HR-MS in the multicast group that is currently connected to the network receives the notification, the HR-MS is assumed to relay the notification to the target HR-MS identified in the Connection Notification message over the alternative interface. Upon receipt of this notification, the target HR-MS shall enter the network and receive any pending messages from the HR-BS.

6.12.6 Support for local forwarding

HR-RS/BS should detect the local forwarding opportunity and be able to bind together the uplink flow ID from the source and the downlink flow ID to the destination for two communicating HR-MSs within its control during connection establishment or connection re-establishment for handover, if it is allowed by HR-BS. After the binding HR-RS is able to forward the data from the source to the destination without going through HR-BS and may optionally forward to HR-BS one copy of the data that is being locally forwarded, if required.

6.12.7 Support for path management against degraded network

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

- alternative path management described in 6.12.7.1
- reliable HO optimization described in 6.12.7.2
- forwarding between HR-infrastructure stations (using subordinate HR-station) described in 6.12.7.3

6.12.7.1 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

6.12.7.1.1 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 6.12.2.2.1.1.

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

a) neighbor discovery as described in 6.12.2.2.1.1
b) collecting HR-MS' neighbor information as described in 6.12.2.2.1.1
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 6.12.2.2.1.1
c) The HR-BS collects the neighbor information of requesting HR-MS as described in 6.12.2.2.1.1
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.

6.12.7.1.2 Alternative path switching

When the trigger condition specified in the TLV of the last AAI-HO-CMD described in 6.2.3.12 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 AAI-HO-CMD message with mode = 0b11, HO Reentry Mode = 0b0 and CDMA_RNG_FLAG = 1 to the HR-MS.

The alternative path information may be updated with a new AAI-HO-CMD 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.

6.12.7.1.3 Alternative path maintaining

Alternative path may be selected during the role change or release the mode as described in 6.12.1.

6.12.7.2 Reliable HO procedure

MS' MAC context information may be shared between HR-infrastructure stations periodically.

When an HR-BS prioritizes the scanning candidates in AAI-SCN-RSP message described in 6.2.3.15, those scanning candidates may be ordered based on whether the MS' MAC context is shared or not between serving infrastructure station and neighbor station as described in 6.2.6.1.2.

To indicated whether neighbor BS/RS is HR-MS acting as BS/RS or HR-BS acting as RS, HR Multimode indication is transmitted in the trigger condition as described in Table 775.

The HR Multimode indication is included in AAI-SCD and NBR-ADV described in 6.2.3.13 and 6.2.3.31 to indicate current BS/RS or neighbor BS/RS is multicast station, respectively.

If the either serving infrastructure station or target infrastructure station has no backhaul connection but they communicate each other via relay link, target infrastructure station may obtain MS information from the serving infrastructure station via their relay link in DL/UL relay zone using AAI-L2-XFER message described in 6.2.3.30 for HO optimization.

The S-HR-BS may reject an HR-MS-initiated handover by transmitting the AAI-HO-CMD message described in 6.2.3.12 with mode set to 0b10. In this case, the S-HR-BS shall not include any candidate T-HR-infrastructure station if the T-HR-infrastructure station is unavailable via neither backbone nor relay link. Those candidate T-HR-infrastructure stations include normal HR-BS/RS, HR-MS acting as HR-BS/RS, HR-BS acting as HR-RS. If the HR-infrastructure station requested as a candidate T-HR-infrastructure station, which is available but the HR-BS does not have HR-MS information, HR-BS list may be included in AAI-HO-CMD message with REQ-Duration. After REQ-Duration expires, HR-MS is allowed to perform handover. After transmitting the AAI-HO-CMD message, S-HR-BS may transmit MS information to the HR-infrastructure station via backbone network or relay link.

If the serving HR-infrastructure station and those candidate T-HR-infrastructure stations do not share the HR-MS information, the serving HR-infrastructure station may transmit MS information to candidate T-HR-infrastructure stations via backbone network or relay link when either serving infrastructure station or target infrastructure station has no backhaul connection but they communicate each other via relay link. When MS information is transmitted via relay link, AAI-L2-XFER message including MS information is used in DL/UL relay zone.

6.12.7.3 Forwarding between HR-infrastructure stations

In HR-Networks, the HR-MS may transmit/receive data to/from any one infrastructure station at any given time. And the HR-MS may forward previously received data to other infrastructure stations at other times. To provide higher reliability and have robustness against SPOF, HR-Network shall support Forwarding Between Infrastructure Stations.

6.12.7.3.1 Discovery of Designated HR-MS

The Degraded HR-BS which lost the wired backbone connection to the core network and does not have direct relay link to any of adjacent HR-BSs shall discover one or more HR-MSs which are able to establish Forwarding connections to an adjacent HR-BS. To initiate the scanning procedure, Degraded HR-BS shall transmit the unsolicited SCN-RSP message to sub-ordinate HR-MSs which have Forwarding Between Infrastructure Stations capability. The SCN-RSP message may contain ABS ID of recommending HR-BSs if Degraded HR-BS has information of neighboring HR-BSs.

The HR-MSs which have received the SCN-RSP message shall perform measurement of the neighboring HR-BSs for Designated HR-MS decision of the Degraded HR-BS. After

completion of HR-MS scanning, HR-MSs shall report the results to Degraded HR-BS by using SCN-REP message.

6.12.7.3.2 HO for Alternative Connection

By using the received measurement results from sub-ordinate HR-MSs, Degraded HR-BS shall select a Designated HR-MS and a Target HR-BS which is the Designated HR-MS having connectivity to. Degraded HR-BS shall command HO for Alternative Connection by AAI-HO-CMD message to Designated HR-MS. The AAI-HO-CMD message may contain ABS ID of the Target HR-BS. Upon the reception of AAI-HO-CMD message, Designated HR-MS shall perform the reentry procedure with the Target HR-BS. The reentry procedure to Target HR-BS follows the procedure in HO for Alternative Connection. The optimized HO is may not be applied due to the failure of backbone connectivity at the Degraded HR-BS.

After completion of HO for Alternative Connection, Designated HR-MS shall maintain the context of Degraded HR-BS and Degraded HR-BS shall also maintain the context of Designated HR-MS for data forwarding.

6.12.7.3.3 Switched access between two HR-BSs

The Designated HR-MS shall start switched access between two HR-BSs after completion of reentry to Target HR-BS. The Designated HR-MS shall communicate with each active HR-BS in Forwarding Access Period. To start Forwarding Access Period, Designated HR-MS shall send the Access Request to an active HR-BS via Switched Access Control signaling header. The Access Request may contain required Forwarding Access Time to access and bandwidth request indication. Upon reception of the Access Request, an active HR-BS shall respond by the Access Response via Switched Access Control signaling header. The Access Response shall contain granted Forwarding Access Time. An active HR-BS may also allocate for UL resources to Designated HR-MS if the bandwidth request is indicated in the Access Request.

Designated HR-MS shall switch to another HR-BS when the Forwarding Access Time is expired. When the Designated HR-MS or the active HR-BS attempts to change remaining Forwarding Access Time (e.g. to extend or to shrink), it shall send the Access Request to active HR-BS or Designated HR-MS to reassign Forwarding Access Time.

6.12.7.3.4 Forwarding connection establishment

Degrade HR-BS shall initiate establishment of Forwarding connections (incoming and outgoing traffic) to Target HR-BS. The establishment of Forwarding connections shall be done by the DSA procedures. Degraded HR-BS shall initiate the DSA procedure with Designated HR-MS. After completion of DSA procedure which initiated by Degraded HR-BS, Designated HR-MS shall initiate the DSA procedure with Target HR-BS. The Service Classification Rules of Degraded HR-BS for incoming traffic shall be delivered to Target HR-BS in consecutive DSA procedures.

In Designated HR-MS, connections with two HR-BSs are locally coupled, i.e. a DL connection with Degraded HR-BS is coupled to a UL connection with Target HR-BS for outgoing traffic and a DL connection with Target HR-BS is coupled to a UL connection with Degraded HR-BS for incoming traffic. Designated HR-MS shall forward traffic on a DL

connection of a HR-BS to another HR-BS without interaction to the higher-layer of Designated HR-MS.

6.12.8 Support for priority access operation

6.12.9 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 Multicast Group ID and FID 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 Multicast Group ID and FID for 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 Multicast Group IDs and FIDs 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 appears in AAI-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.

6.12.9.1 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 state or idle state. 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 FID is used for the multicast service (i.e., there are no dedicated FIDs for multicast transport connections). To ensure proper multicast operation, the Multicast

Group ID and FID 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 Multicast Group IDs and FIDs shall be known and be the same for all HR-BSs belonging to the same HR Multicast Group Zone.

6.12.9.1.1 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 928. The procedure includes

- Capacity exchange using AAI-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 AAI-REG-REQ message and the HR-BS will indicate if it supports multicast for that HR-MS through AAI-REG-RSP message. The basic multicast capability exchange in AAI_REG-REQ/RSP message is described in 6.2.3.8 and 6.2.3.9.

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's discovery and registration of multicast services with the HR-BS through upper layer signaling are outside the scope of this standard.

The AAI-DSA, AAI-DSC and AAI-DSD messages are used to establish, change, and delete multicast service flows respectively. The HR-BS shall send the AAI-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).

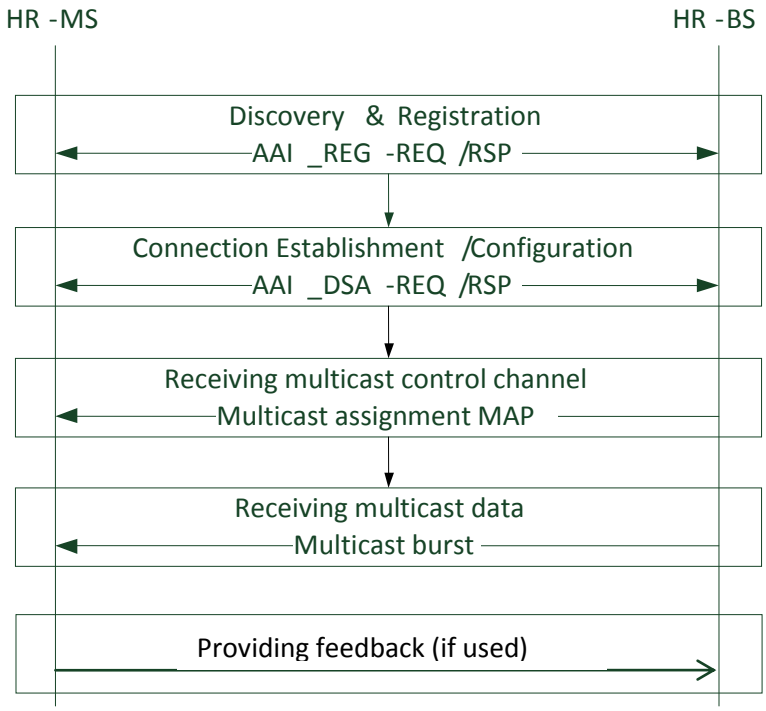


Figure 928—Procedure of multicast communication establishment

6.12.9.1.2 Multicast communication operation in connected state

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 6.2.6.3.

When the HR-MS transits to a new Multicast Zone while in Active Mode or Sleep Mode, the HR-MS shall send AAI-RNG-REQ message described in 6.2.3.1 with Ranging Purpose Indication = 0b1110 at the target HR-BS. In response to the request for multicast service flow update, the HR-BS shall transmit AAI-RNG-RSP message described in 6.2.3.2, which may include Multicast Group Zone Identifier, Multicast Group ID, FID Update, and feedback parameters if used, to provide updated service flow management encodings for any affected multicast flow(s) as part of the handover procedure.

6.12.9.1.3 Multicast communication operation in idle state

When an HR-MS in Idle state 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 broadcast messages in the Multicast Zone of the service HR-BS. If the idle 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 AAI-RNG-REQ message with Ranging Purpose Indication = 0b1110. In response to the request for multicast location update, the HR-BS shall transmit AAI-RNG-RSP message which may include the Multicast Group Zone identifier, Multicast Group ID, and FID and feedback parameters if used to provide update service flow management encodings for any affected multicast flow(s).

HR-BS providing multicast service transmits multicast indication cycle using AAI-SCD and AAI-DSA/AAI-DSC messages. The multicast indication cycle is unique to HR multicast group zone and it consists of multicast available interval and multicast unavailable interval. Multicast available interval is the first superframe of each multicast indication cycle. In the multicast available interval, the HR-BS providing multicast service transmits MG-IND message described in 6.2.3.65.49 and MT-IND message described in 6.2.3.65.50 during multicast available interval of HR multicast group zone. MG-IND and MT-IND message are used to indicate

- multicast service establishment/change/release
- whether the multicast traffic is transmitted after those messages are transmitted
- to perform network entry or exit sleep mode to transmit multicast related message to change/release multicast service and update multicast security key.
- to perform multicast service flow update using ranging procedure

Multicast indication cycle included in AAI-SCD message is used for multicast service establishment.

During multicast service establishment/change using DSA/DSC message, new multicast indication cycle may be transmitted.

During multicast available interval, HR-BS transmits MG-IND message in the beginning of available interval to indicate multicast traffic of one or more specific multicast groups will transmit. MG-IND includes an indication whether MT-IND message will be transmitted. If the MT-IND message is transmitted after transmitting MG-IND using frame offset, MGIND bitmap indicates a multicast subgroup which is included in the MT-IND message. Multicast group is divided into some subgroups (i.e., length of MGIND bitmap) and each subgroup has following number of multicast groups:

$$\text{Number of multicast group in a subgroup} = 2^{12}/M,$$

where M is the length of MGIND bitmap and N-th bit in MGIND bitmap indicates a subgroup of multicast groups from $2^{12}\times N/M$ to $2^{12}\times (N+1)/M-1$.

MT-IND message is transmitted in the offset included in MG-IND message after transmitting MG-IND message and it indicates whether multicast traffic of specific multicast group will transmit. The multicast group is indicated based on the MGIND bitmap in MG-IND message and MTIND bitmap in MT-IND message.

N-th bit in MGIND bitmap indicates the value of logM MSB of Multicast Group ID and Q-th bit in MTIND bitmap indicates the value of logK LSB of Multicast Group ID. For the indicated Multicast Group ID, according to the action code, HR-MSs, member of the Multicast Group, perform network entry or receive multicast traffic.

6.12.9.2 Multicast protocol features and functions

6.12.9.2.1 Downlink control channel for multicast communication

HR-multicast control channel (i.e., HR-Multicast DL Assignment A-MAP IE) carries configuration information (including allocation/change/release) for multicast communication for one multicast zone in an HR-BS. In HR-Multicast DL Assignment A-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-Assignment A-MAP IE. Unless the Lifetime expires, this HR-Multicast DL Assignment A-MAP does not change during the allocation duration. At the time the Lifetime expires, the HR-Multicast DL Assignment A-MAP shall change or release the allocation.

Table 1217—HR-Multicast DL Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
HR-Multicast_DL_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	HR-Multicast DL Assignment A-MAP IE
Allocation period	2	Period of persistent allocation of multicast resource. If (Allocation Period==0b00), it indicates the deallocation of persistent resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 6 frames
If (Allocation Period == 0b00) {		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number for AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default TTI) 0b1: 4 DL AAI subframe for FDD or all DL AAI subframes for TDD (long TTI)

Reserved	22	
} else if(Allocation Period != 0b00) {		
Isizeoffset	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Multi-layer encoding 0b11: CDR
If (MEF ==0b01) {		Parameter for vertical encoding
M_t	3	Number of streams in transmission M_t<=N_t N_t: Number of transmit antennas at the HR-BS 0b000: 1 stream 0b001: 2streams 0b010: 3streams 0b011: 4streams 0b100: 5streams 0b101: 6streams 0b110: 7streams 0b111: 8streams
Reserved	1	
} else if (MEF == 0b10) {		Parameters for multi-layer encoding
Si	4	Index to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO, and the modulation constellation of paired user in the case of 2 stream transmission 0b0000: 2 streams with PSI=stream1 and other modulation = QPSK 0b0001: 2 streams with PSI=stream1 and other modulation = 16QAM 0b0010: 2 streams with PSI=stream1 and other modulation = 64QAM 0b0011: 2 streams with PSI=stream1 and other modulation information not available 0b0100: 2 streams with PSI=stream2 and other modulation =QPSK 0b0101: 2 streams with PSI=stream2 and other modulation =16QAM 0b0110: 2 streams with PSI=stream2 and other modulation =64QAM 0b0111: 2 streams with PSI=stream2

		and other modulation information not available 0b1000: 3 streams with PSI=stream1 0b1001: 3 streams with PSI=stream2 0b1010: 3 streams with PSI=stream3 0b1011: 4 streams with PSI=stream1 0b1100: 4 streams with PSI=stream2 0b1101: 4 streams with PSI=stream3 0b1110: 4 streams with PSI=stream4 0b1111: n/a
}		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number for AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default TTI) 0b1: 4 DL AAI subframe for FDD or all DL AAI subframes for TDD (long TTI)
Lifetime(L)	4	Indicates the time to transmit next HR-Multicast DL Assignment A-MAP and the information of this HR-Multicast DL Assignment A-MAP does not change during the allocation duration. The next HR-Multicast DL Assignment A-MAP is at the superframe whose superframe number, Nsuperframe, satisfies the following condition. Nsuperframe modulo L+1 = 0
Reserved	7	
}		
}		

*A 16bit CRC is generated based on the randomized contents of the HR-Multicast DL Assignment A-MAP IE. The CRC is masked by the 16-bit CRC mask (with masking prefix = 0b0 and message type indicator = 0b010) generated according to Table 849 as describe in 6.3.5.5.2.4.

6.12.9.2.2 Feedback operation for multicast

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**.**

6.12.9.3 Multicast key management

Multicast key is managed as described in 6.12.10.4.

6.12.10 Support for security

6.12.10.1 Security procedure for direct communication data security

6.12.10.1.1 Security procedure for BS-controlled secure direct communication

6.12.10.1.1.1 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 6.12.10.1.1.2.1.

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 929.

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 $N_{HR\text{-}BS}$ and encrypts $E_{HR\text{-}MS1\_KEK}$(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr) and computes $CMAC_{HR\text{-}BS} = MAC_{CMAC1}$("DC_REPLY_OK_BS"|$T_{HR\text{-}BS}$|$N_{HR\text{-}BS}$|$E_{HR\text{-}MS1\_KEK}$(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"|$T_{HR\text{-}BS}$|$N_{HR\text{-}BS}$|$E_{HR\text{-}MS1\_KEK}$(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr)|HR-MS1Addr|HR-MS2Addr|$CMAC_{HR\text{-}BS}$. HR-BS/Authenticator also encrypts $E_{HR\text{-}MS2\_KEK}$(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr) and computes $CMAC_{HR\text{-}BS} = MAC_{CMAC2}$("DC_REPLY_OK_BS"|$T_{HR\text{-}BS}$|$N_{HR\text{-}BS}$|$E_{HR\text{-}MS2\_KEK}$(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"|$T_{HR\text{-}BS}$|$N_{HR\text{-}}$

$_{BS}$|$E_{HR\text{-}MS2\_KEK}$(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr)|HR-MS2Addr|HR-MS1Addr|$CMAC_{HR\text{-}BS}$.

Step 2a: If HR-MS1 received Key-Transfer-MSG#1 message from HR-BS/Authenticator, HR-MS1 first checks $T_{HR\text{-}BS}$, $N_{HR\text{-}BS}$ for freshness and $CMAC_{HR\text{-}BS}$ 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 $E_{HR\text{-}MS1\_KEK}$(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 $T_{HR\text{-}BS}$, $N_{HR\text{-}BS}$ for freshness and $CMAC_{HR\text{-}BS}$ 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 $E_{HR\text{-}MS2\_KEK}$(DMK, key_lifetime, HR-MS2Addr, HR-MS1Addr) and obtains the security key DMK and its lifetime key_lifetime.

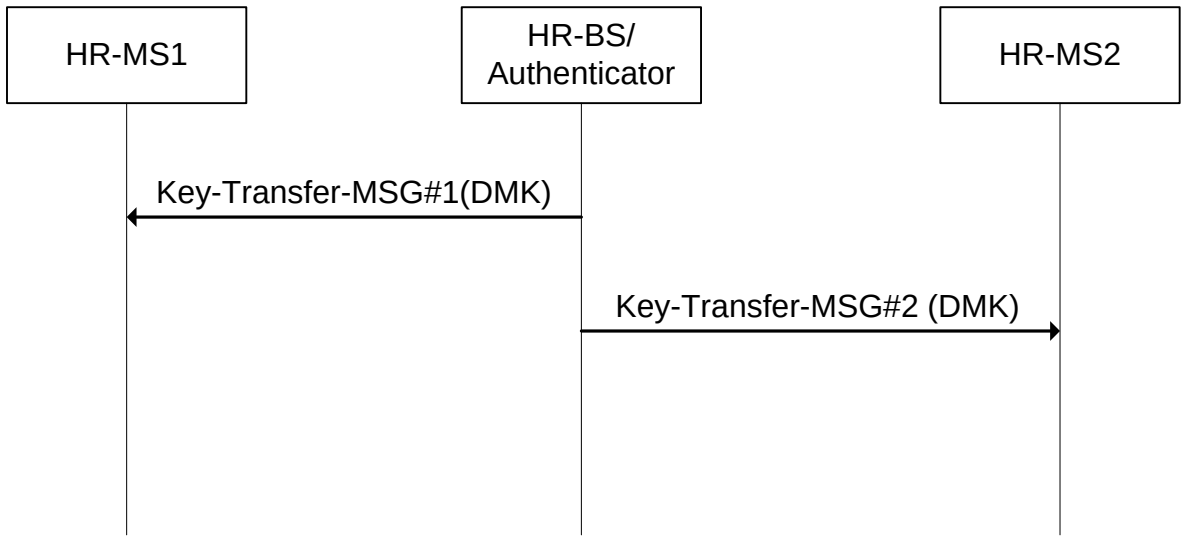


Figure 929—Flow Diagram of Authentication and Key Establishment of Network Aided Direct Communication scenario.

6.12.10.1.1.1.1 Message type

Table 1218 —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

6.12.10.1.1.1.2 Message attributes

Table 1219—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 1220—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

6.12.10.1.1.2 Autonomous mutual authentication of HR-MS and data security for direct communications

6.12.10.1.1.2.1 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 6.12.10.1.1.1.

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 930 shows the flow diagram while Figure 931 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 $N_{HR\text{-}MS1}$ and uses the pre-established shared key DMK to compute DAK, DCMAC key and $CMAC_{HR\text{-}MS1} = MAC_{DCMAC}(N_{HR\text{-}MS1}|DMK\_Sequence\_No|DAKID|Key\_lifetime)$. Finally, HR-MS1 sends the DirectComms_KeyAgreement_MSG_#1 message to HR-MS2, where DirectComms_KeyAgreement_MSG_#1 = $N_{HR\text{-}MS1}|DMK\_Sequence\_No|DAKID|Key\_lifetime|CMAC_{HR\text{-}MS1}$.

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 $CMAC_{HR\text{-}MS1}$. If the verification fails, HR-MS2 shall ignore the DirectComms_KeyAgreement_MSG_#1 message. If the verification is correct, HR-MS2 selects $N_{HR\text{-}MS2}$ and computes $CMAC_{HR\text{-}MS2} = MAC_{DCMAC}(N_{HR\text{-}MS1}|N_{HR\text{-}MS2}|DAKID|DMK\_Sequence\_No|DC\_Security\_Parameters)$. Finally, HR-MS2 sends DirectComms_KeyAgreement_MSG_#2 message to HR-MS1, where DirectComms_KeyAgreement_MSG_#2 = $N_{HR\text{-}MS1}|N_{HR\text{-}MS2}|DAKID|DMK\_Sequence\_No|DC\_Security\_Parameters|CMAC_{HR\text{-}MS2}$.

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 $CMAC_{HR\text{-}MS2}$. If the verifications fail, HR-MS1 shall ignore the DirectComms_KeyAgreement_MSG_#2 message. If the verifications are correct, HR-MS1 computes $CMAC_{HR\text{-}MS1}' = MAC_{DCMAC}(N_{HR\text{-}MS1}|N_{HR\text{-}MS2}|DMK\_Sequence\_No|DC\_SAID|DC\_Security\_Parameters)$. Finally, HR-MS1 sends DirectComms_KeyAgreement_MSG_#3 message to HR-MS2, where DirectComms_KeyAgreement_MSG_#3 = $N_{HR\text{-}MS1}|N_{HR\text{-}MS2}|DMK\_Sequence\_No|DC\_SAID|DC\_Security\_Parameters|CMAC_{HR\text{-}MS1}'$. 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: Upon receiving the DirectComms_KeyAgreement_MSG_#3 message, HR-MS2 checks the received nonces for freshness and $CMAC_{HR\text{-}MS1}'$. 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 $CMAC_{HR\text{-}MS1}$' 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.

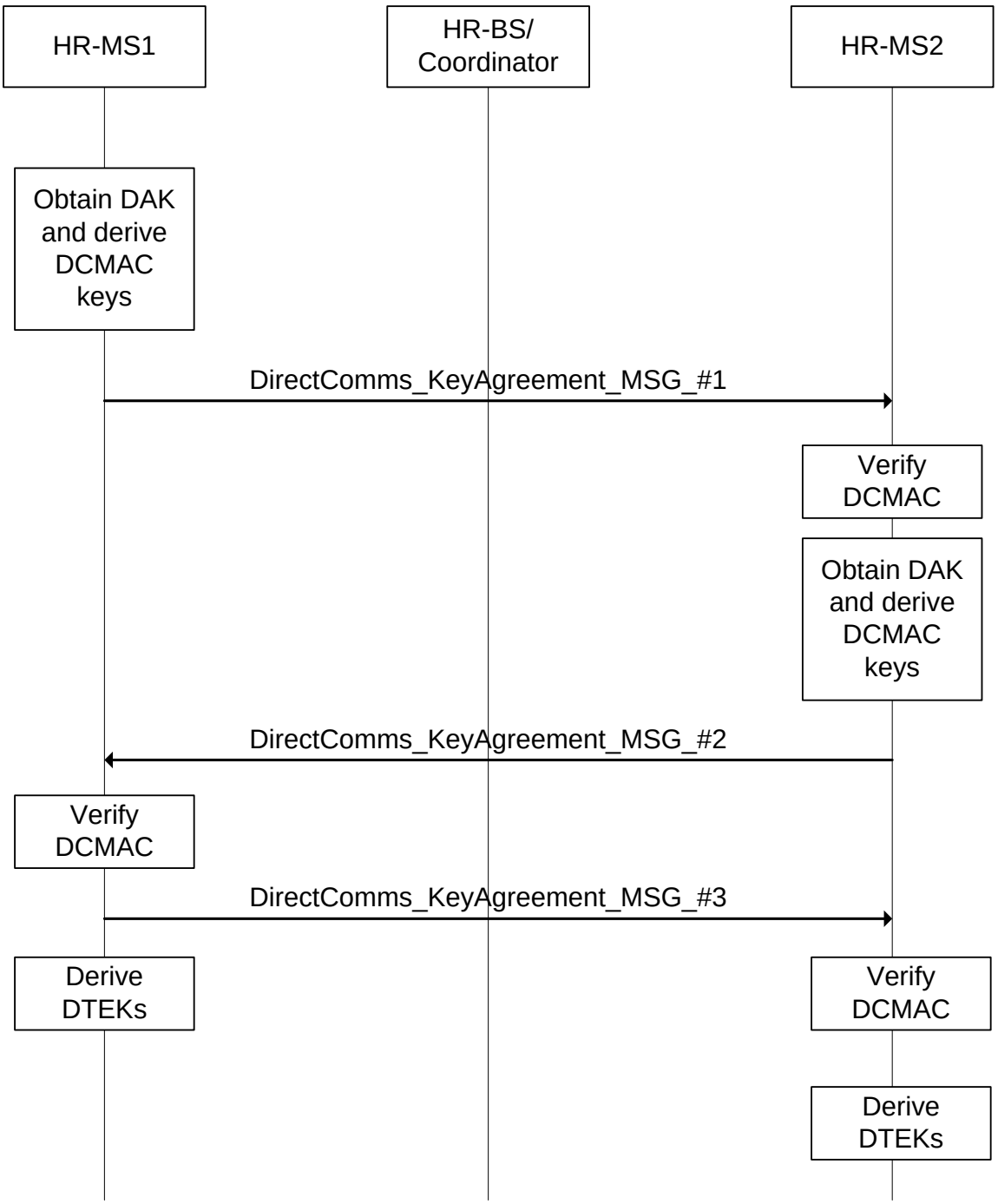


Figure 930—Flow Diagram of Authentication and Key Establishment of Direct Communication without Infrastructure (Pre-shared key case).

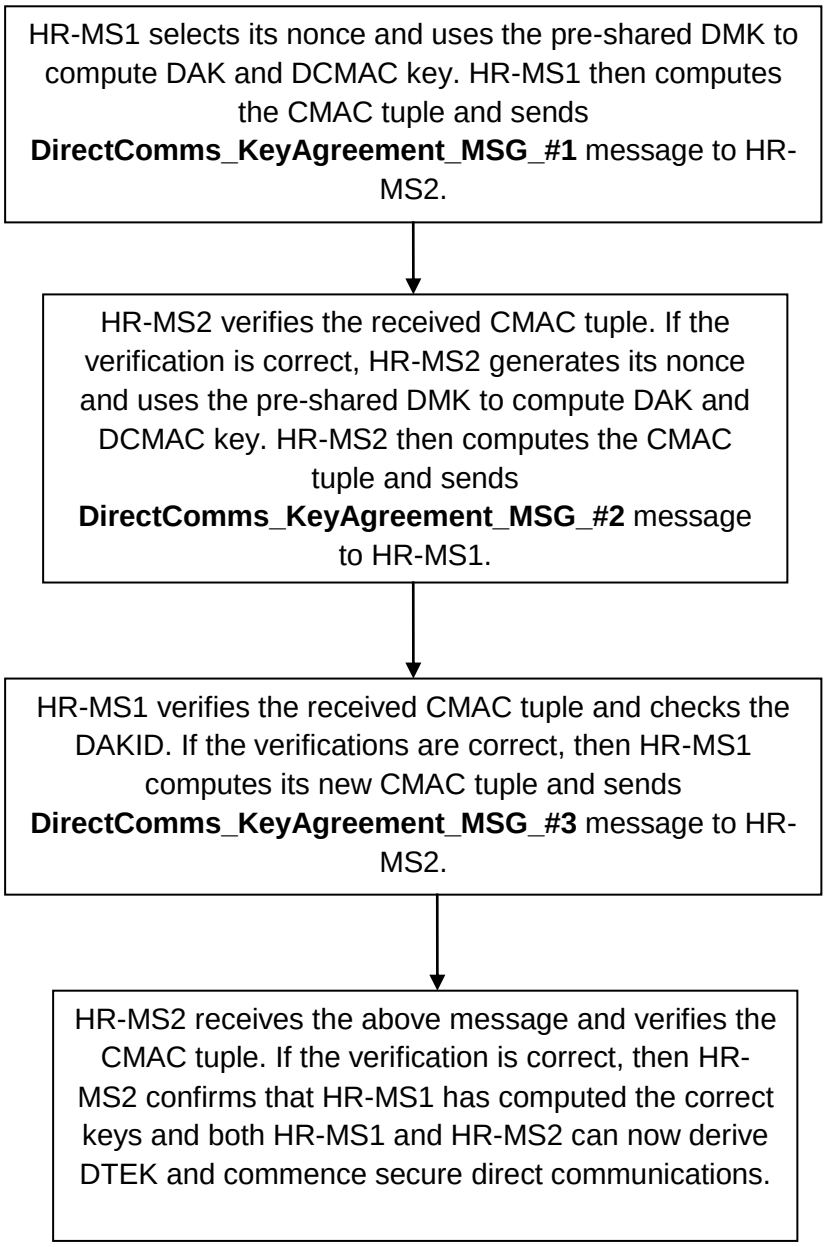


Figure 931—Flow Chart of Pre-shared key-based Autonomous Direct Communication Authentication and Key Establishment Security Procedure.

6.12.10.1.1.2.1.1 Message type

Table 1221—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

6.12.10.1.1.2.1.2 Message attributes

Table 1222—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 1223—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 1224 —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
$CMAC_{HR-MS1}'$	Message digest calculated using DCMAC key

6.12.10.1.1.2.2 Secure direct communication using public key infrastructure

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

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

The key agreement handshake procedure described below shall be used for HR-MSs to mutually authenticate themselves (without access to a security server) using Public Key Infrastructure and to derive data security keys for secure direct communications. The flow diagram for this scenario is depicted in Figure 932 and the Flow Chart for this scenario is shown in Figure 933.

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

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

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

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.

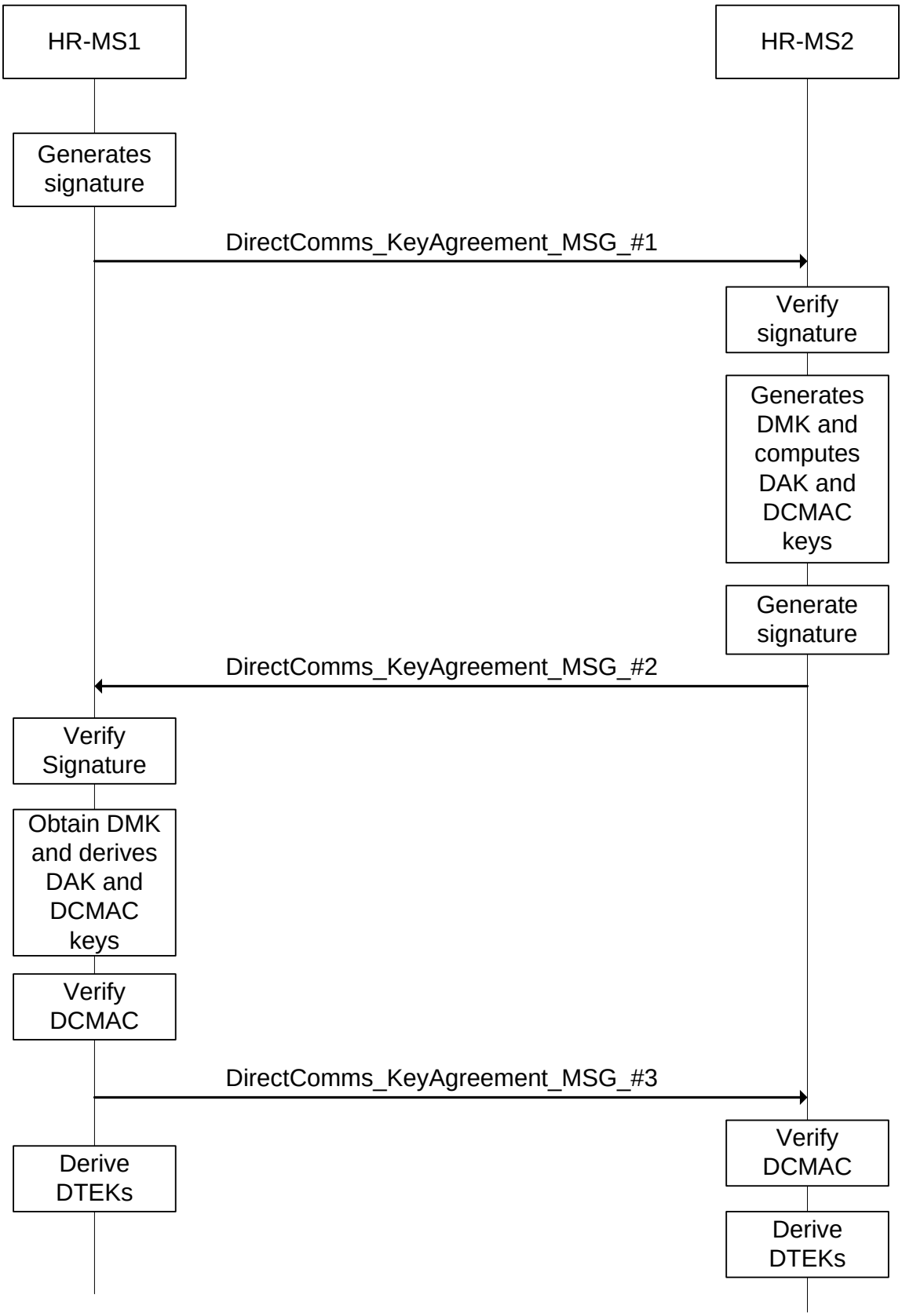


Figure 932—Flow Diagram of Authentication and Key Establishment of Direct Communication without Infrastructure (HR-MS becomes HR-BS*case).

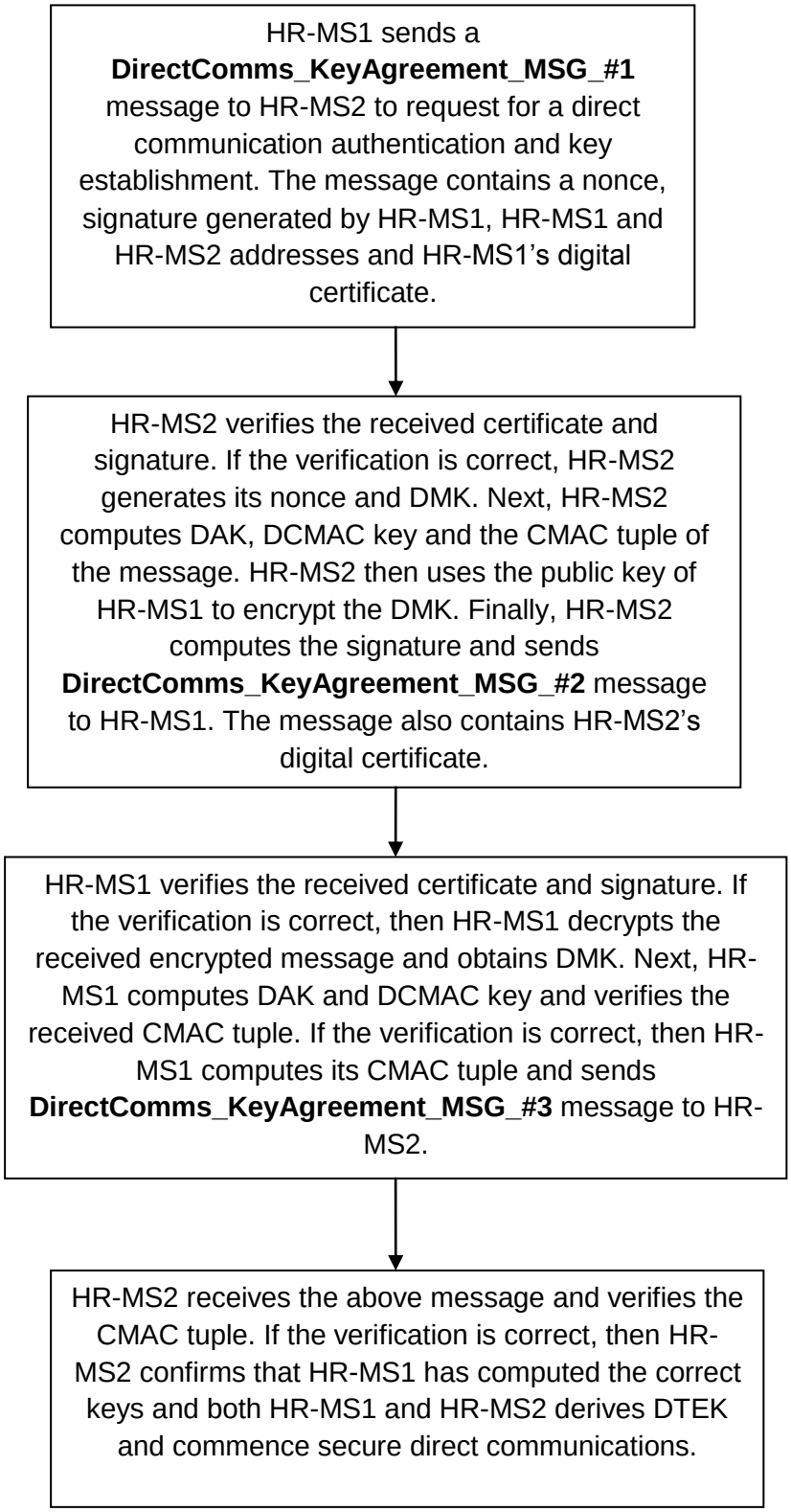


Figure 933—Flow Chart of PKI-based Autonomous Direct Communication Authentication and Key Establishment Security Procedure.

6.12.10.1.1.2.2.1 Message type

Table 1225—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

6.12.10.1.1.2.2.2 Message attribute

Table 1226—DirectComms_KeyAgreement_MSG_#1 message attribute

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

Table 1227—DirectComms_KeyAgreement_MSG_#2 message attribute

Attribute	Contents
T_{HR-MS2}	Timestamp generated by HR-MS2
N_{HR-MS2}	Freshly generated random number of 64bits by HR-MS2
HR-MS1Addr	Address of HR-MS1
HR-MS2Addr	Address of HR-MS2
N_{HR-MS1}	Nonce generated by HR-MS1 in DirectComms_KeyAgreement_MSG_#1 message
E_{HR-MS1_PK}(DMK, key_lifetime, HR-MS1Addr, HR-MS2Addr)	Public key encryption using HR-MS1's Public 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 1228—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

6.12.10.1.1.3 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.

6.12.10.1.1.3.1 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 1229.

Table 1229—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.

6.12.10.1.1.3.2 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 1230.

Table 1230—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.

6.12.10.1.1.3.3 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.

6.12.10.1.1.3.4 DTEK context

The DTEK context includes all parameters of the DTEK and is described in Table 1231.

Table 1231—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)

6.12.10.1.1.3.5 DSA context

The DSA context is described in Table 1232.

Table 1232—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

6.12.10.1.1.4 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.

6.12.10.1.1.4.1 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).

6.12.10.1.1.4.2 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)

6.12.10.1.1.4.3 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)

6.12.10.1.1.4.4 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.

6.12.10.1.2 Security procedure for Talk-around secure 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.

6.12.10.2 Security procedure for secure multicast operation

PKMv3 as described in 6.2.5.2 provides HR-stations with strong protection from theft of service by encrypting connections between HR-MSs and HR-BSs.

PKMv3 also shall provide HR-stations with strong protection from theft of service by encrypting multicast connections between HR-MSs and HR-BSs, as defined in this subsection.

If a DL multicast connection is to be encrypted, each HR-MS participating in the connection shall have an additional security association (SA) (i.e., multicast SA), allowing that

connection to be encrypted using keys that are independent of those used for other encrypted transmissions between HR-MSs and the HR-BS.

Similar to unicast key management, multicast traffic can be encrypted using multicast specific key management based on PMKv3 as described in Figure 934. Multicast CMAC (MCMAC) key and Multicast TEK (MTEK) are derived from Multicast AK (MAK). MAK is a pre-established shared key among an HR-BS and a group of HR-MSs in an HR multicast group.

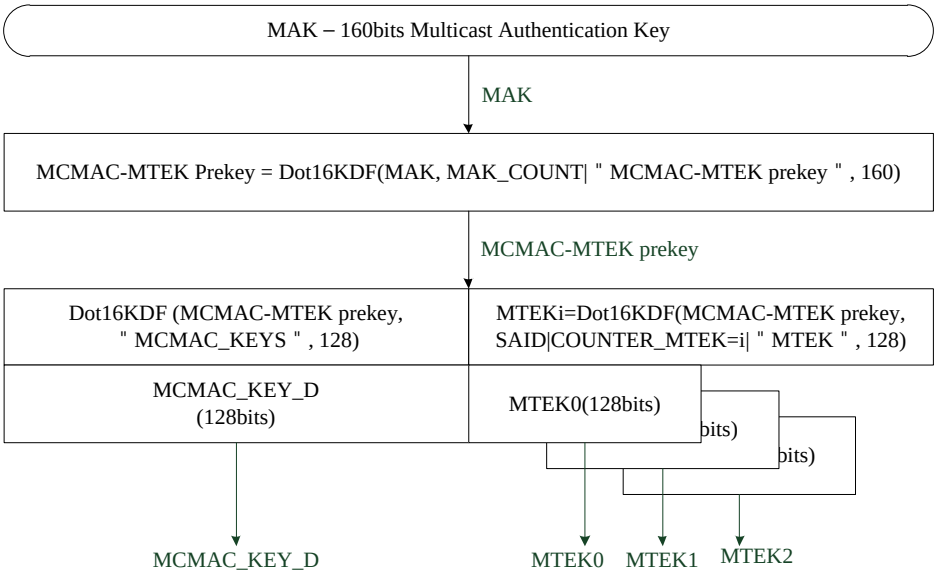


Figure 934—MCMAC Key and MTEK derivation from MAK

Shared security association (i.e., Multicast Security Association; MSA) is an SA for the multicast transport/control flow and it provides keying material. Security key related to parameter to support multicast and the context is secured till the key expires.

6.12.10.2.1 Security context for multicast communication

The multicast security context is a set of parameters linked to a key in each hierarchy that defines the scope while the key usage is considered to be secure.

Examples of these parameters are key lifetime and counters ensuring the same encryption will not be used more than once. When the context of the key expires, a new key should be obtained to continue working. The purpose of this sub clause is to define the context that belongs to each key, how it is obtained and the scope of its usage.

6.12.10.2.1.1 MAK context

The MAK context includes all parameters associated with the MAK. This context is created whenever a new MAK is derived.

This context shall be deleted whenever the MAK is no longer valid or used.

The MAK context is described in Table 1233.

Table 1233—The MAK context

Parameter	Size (bit)	Usage
MAK	160	Shared by HR-MSs in a multicast group
MAK Lifetime	32	MAK Lifetime
MAKID	64	Identifies the authorization key.
MAK_COUNT	16	A value used to derive the MCMAC key and MTEK
MCMAC_KEY_D	128	The key which is used for signing DL MAC control messages.
MCMAC_PN_D	24	Used to avoid DL replay attack on the control connection before this expires, reauthorization is needed. The initial value of MCMAC_PN_D is zero and the value of MCMAC_PN_D is reset to zero whenever MAK_COUNT is increased.
Next available counter_MTEK	16	The counter value to be used in next MTEK derivation, after derivation this is increased by 1.

6.12.10.2.1.2 MSA context

The MSA context is the set of parameters managed by each MSA in order to ensure MTEK management and usage in secure way.

The MSA context holds MTEK context and additional information that belongs to the MSA itself.

6.12.10.2.1.2.1 MTEK context

The MTEK context includes all relevant parameters of a single MTEK and is described in Table 1234.

Table 1234—The MTEK context

Parameter	Size (bit)	Usage
MTEK	128	Key used for encryption or decryption of MAC PDUs from FIDs associated with the corresponding MSA
MEKS	2	Encryption key sequence number
COUNTER_MTEK	16	The counter value used to derive this MTEK
MTEK lifetime	32	MTEK lifetime
MTEK_PN_D	22	The PN used for encrypting DL packets. After each MAC PDU transmission, the value shall be increased by 1. (0x000000-0x1FFFFF)

PN Window Size	As negotiated in key agreement	The receiver shall track the PNs received inside PN window

6.12.10.2.1.2.2 MSA context

The MSA context is described in Table 1235.

Table 1235—The MSA context

Parameter	Size (bit)	Usage
MSAID	8	The identifier of this MSA, which describes the applied en/ decryption method and MTEK contexts.
$MTEK_{DLE}$ context	Sizeof(MTEK Context)	MTEK context used for downlink encryption and decryption.

6.12.11 Support for self-coexistence

6.12.11.1 Self-coexistence cycle

A self-coexistence cycle of consists of twelve superframes. Structure of superframe is described in WirelessMAN Advanced, i.e., each superframe consists of 4 frames and duration of each frame is 5 ms.

6.12.11.1.1 Self-coexistence cycle structure in normal mode

When an HR cell operates in normal mode, it occupies all frames of a superframe, and transmits SA-preamble, PA-preamble, and SFH (superframe header) in every superframe of a self-coexistence cycle as that described in WirelessMAN Advanced.

In addition to transmitting SA-preambles and PA-preamble as described in WirelessMAN Advanced, an HR cell transmits an SA-preamble in the first symbol of the fourth frame of each superframe.

An example is shown in Figure 935. Cell_1 operates in normal mode and it occupies all frames. It transmits an SA-preamble in the first symbol of the first frame of each superframe, a PA-preamble in the first symbol of the second frame of each superframe, an SA-preamble in the first symbol of the third frame of each superframe, an additional SA-preamble in the first symbol of the fourth frame of each superframe, and SFH in the first subframe of the first frame of each superframe of a self-coexistence cycle.

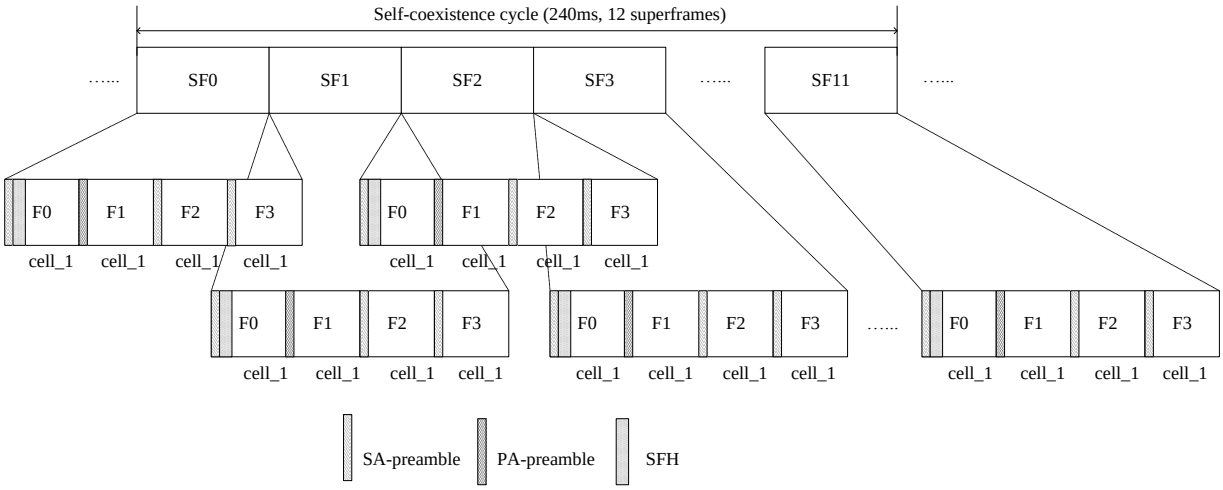


Figure 935 – Example of self-coexistence cycle structure for HR cell operating in normal mode.

6.12.11.1.2 Self-coexistence structure in self-coexistence mode

TBD

6.12.11.2 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 networks overlapped in coverage and have to operate on the same frequency channel.

The structure of self-coexistence zone in WirelessMAN HR Advanced networks is described below.

A self-coexistence zone occupies the last subframe of a frame, if the last subframe contains 7 symbols. The first symbol of the last subframe is used as guard time. In the second symbol, SA-preamble shall be transmitted. The rest 5 symbols forms a type-3 AAI subframe and the self-coexistence beacon protocol (SCBP) MAC PD is transmitted. An example is shown in Figure 936.

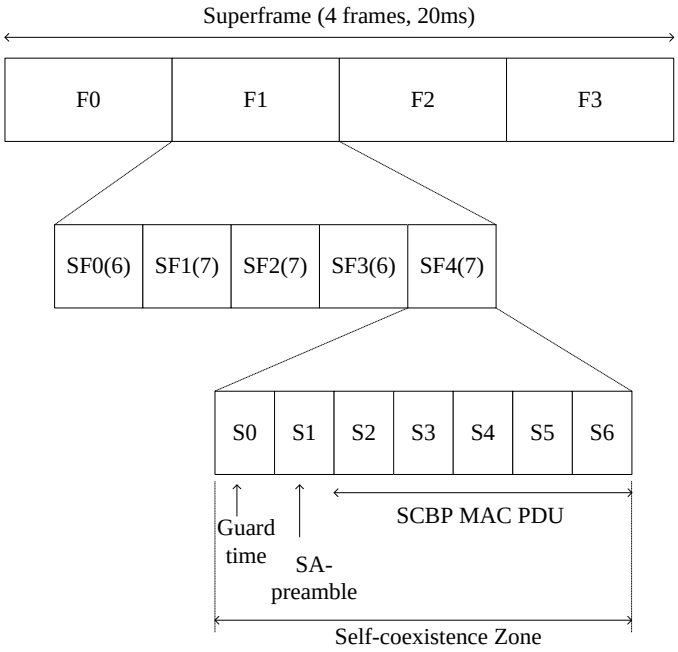


Figure 936 – Example of TDD frame structure for self-coexistence. The channel bandwidth is 7 MHz and CP is 1/8. The last subframe of a frame contains 7 symbols.

If the last subframe of a frame contains 6 symbols, the self-coexistence zone occupies the last subframe and the last symbol of the second last subframe. The last symbol of the subframe of the second last subframe is used as guard time. In the first symbol of the last subframe, SA-preamble shall be transmitted. The rest 5 symbols of the last subframe forms a type-3 AAI subframe and transmits SCBP MAC PDU. The rest 5 symbols of the second last subframe forms a type-3 AAI subframe, too. An example of the first option is shown in **Figure 937**.

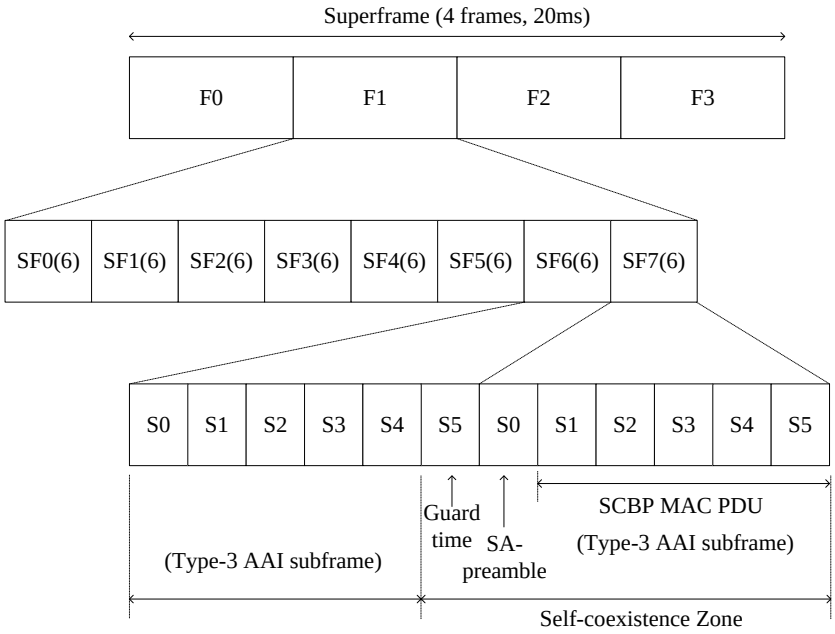


Figure 937 – Example of TDD frame structure for self-coexistence. The channel bandwidth is 5/10/20 MHz and CP is 1/8. The last subframe of a frame contains 6 symbols. The self-coexistence zone occupies S0 of SF6 and SF7.

6.12.11.3 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.

6.12.11.4 Self-coexistence beacon protocol (SCBP)

6.12.11.4.1 SCBP burst structure

Figure 938 shows the structure of SCBP burst. It consists of a preamble portion and an SCBP MAC PDU portion. The duration of the preamble portion is one symbol and the duration of the SCBP MAC PDU portion is five symbols. SA-preamble shall be transmitted in the preamble symbol. In the following symbol(s) SCBP MAC PDU as described in TBD shall be transmitted.

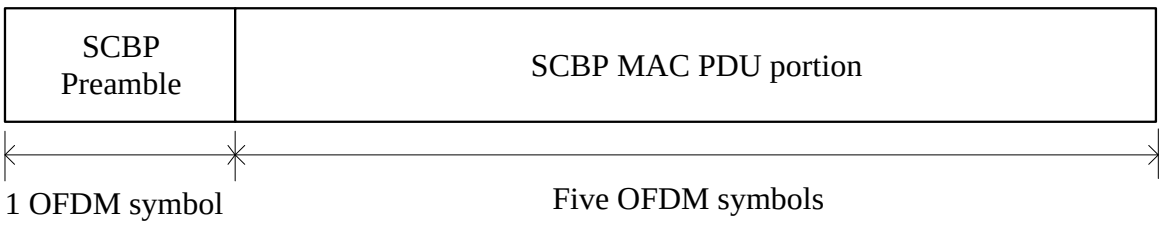


Figure 938 – SCBP burst structure of WirelessMAN HR-Advanced network.

6.12.11.4.2 Transmission of SCBP burst

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

6.12.11.4.3 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.

6.12.11.5 Mechanism for self-coexistence of multiple HR cells

6.12.11.5.1 Execution flow of self-coexistence mechanism

HR network shall follow the operation procedure shown in Figure 939 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 6.12.11.4.3. 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).

(s1.3) Superframe 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. Superframe assignment is also performed.

<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.

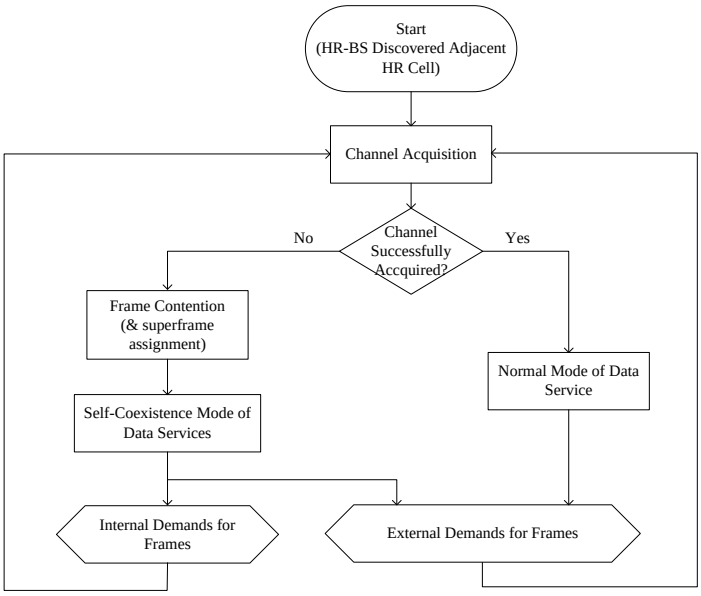


Figure 939 – Execution flow of self-coexistence mechanism of HR cells.

6.12.11.5.2 Frame contention

6.12.11.5.2.1 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.

6.12.11.5.2.2 Message flow

Figure 940 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.

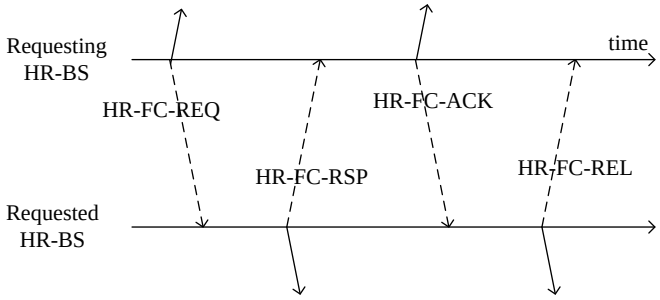


Figure 940 – Message flow of frame contention. Messages may be exchanged through middle subordinate HR stations.

6.12.11.5.2.3 Frame contention protocol

6.12.11.5.2.3.1 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 941.

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

6.12.11.5.2.3.2 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 942. 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. The FCD also assigns superframe occupancy in a self-coexistence cycle.

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 superframe.

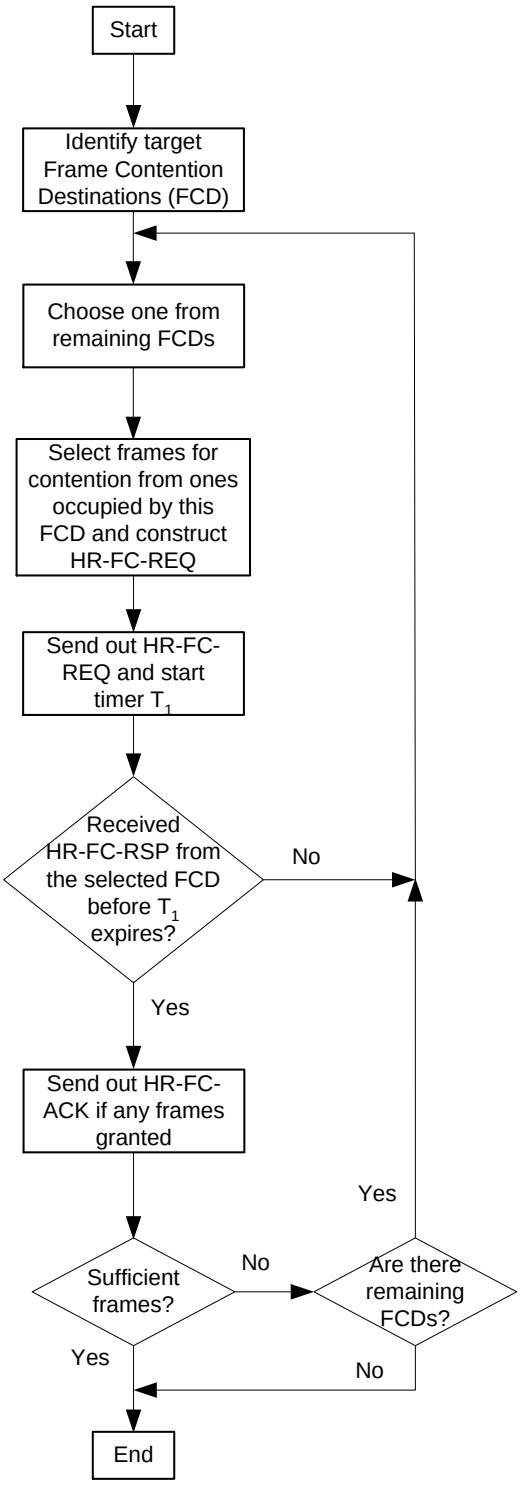


Figure 941 – Procedure of frame contention at an FCS

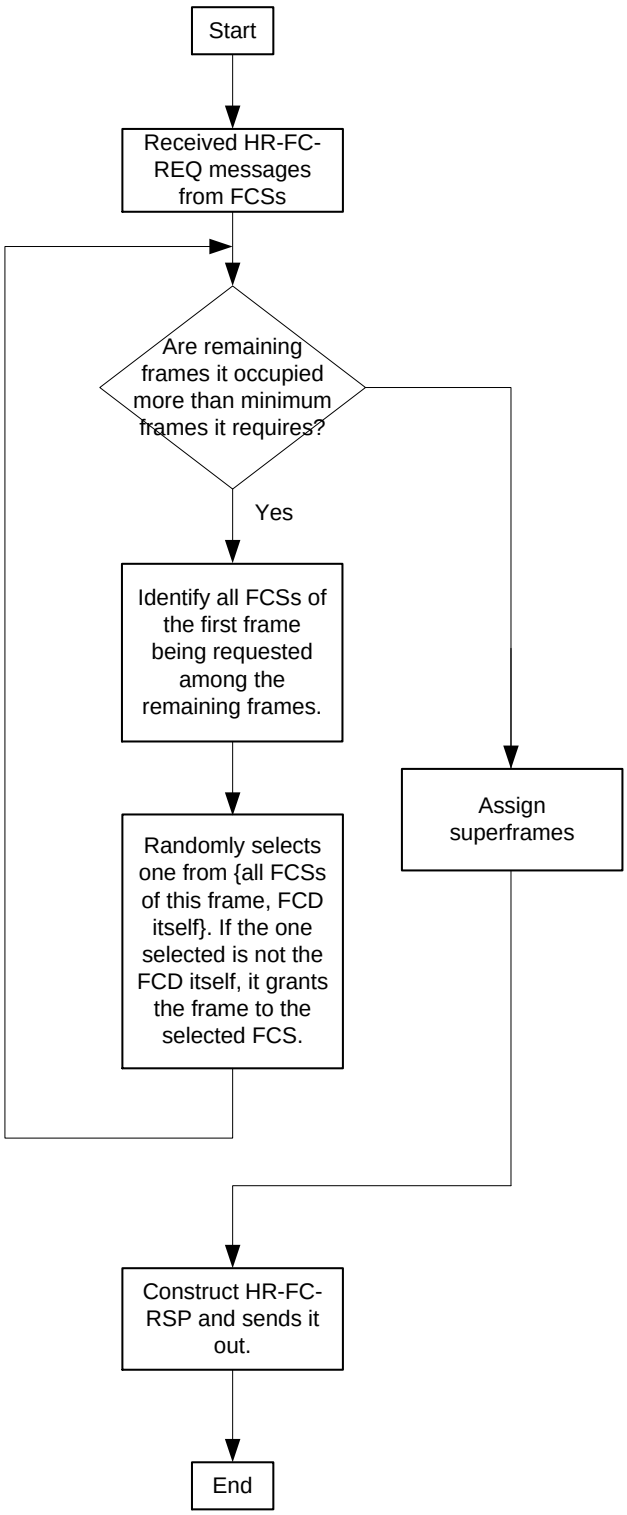


Figure 942 – Procedure of frame contention at an FCD.

6.12.11.6 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.